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"Global Challenges and Local Wisdom in Sustainable Digital Transformation: Strengthening Education, Law, Technology and Management for Human Capital Development Toward Golden Indonesia 2045"

Education | Law | Technology | Management | Information Systems

Kudus, Indonesia · 5 August 2026



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"Global Challenges and Local Wisdom in Sustainable Digital Transformation: Strengthening Education, Law, Technology and Management for Human Capital Development Toward Golden Indonesia 2045"

Kudus, Indonesia · Wednesday, 5 August 2026

EDITORS

Dr. Henry Suryo Bintoro, S.Pd., M.Pd.

Dr. Fitri Budi Suryani, S.Pd., M.Pd.

Dr. Eka Zuliana, S.Pd., M.Pd.

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Conference at a Glance

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Workshop: Strategies for Securing Scholarships, Student & Lecturer Exchanges
Mrs. Laura Tanase, Stefan cel Mare University of Suceava, Romania

Sub-themes (Master of Basic Education)

Learning Innovation · Curriculum · Educational Technology · Assessment · Inclusive Education

Foreword

From the Chairman of the Organizing Committee

Distinguished keynote speakers, respected scholars, researchers, practitioners, policymakers, and esteemed guests, Ladies and Gentlemen,

It is with great honor and sincere pleasure that Universitas Muria Kudus presents the International Conference on Interdisciplinary Studies for Future Society (ICISFS-UMK) 2026. This year's conference carries the theme, "Global Challenges and Local Wisdom in Sustainable Digital Transformation: Strengthening Education, Law, Technology and Management for Human Capital Development Toward Indonesia Emas 2045." This theme reflects the urgent need to address global challenges through sustainable digital transformation while embracing local wisdom as a foundation for inclusive, resilient, and human-centered development.

In an era characterized by rapid technological advancement, artificial intelligence, digitalization, and profound socioeconomic change, the development of high-quality human capital has become a strategic priority for nations worldwide. Indonesia's aspiration to achieve Indonesia Emas 2045 requires more than technological innovation; it calls for an integrated approach that strengthens education, ensures legal certainty, advances technological capabilities, and promotes effective and adaptive management. These interconnected dimensions are essential for preparing a generation that is innovative, competitive, ethical, and capable of responding to the complexities of the future.

At the same time, local wisdom represents a valuable source of knowledge, cultural identity, ethical values, and social resilience. Integrating local wisdom into digital transformation can help ensure that technological progress remains relevant to community needs, respects cultural diversity, and promotes sustainable development. The synergy between global perspectives and local values is therefore essential to creating digital solutions that are not only technologically advanced but also socially responsible, inclusive, and beneficial to society.

ICISFS-UMK 2026 serves as an international academic platform that brings together scholars, researchers, professionals, practitioners, and policymakers from diverse disciplines to exchange ideas, present research findings, and explore innovative approaches to contemporary challenges. Through interdisciplinary dialogue and collaboration, this conference seeks to strengthen the contribution of education, law, technology, and management to sustainable digital transformation and human capital development. It also aims to encourage research and practical initiatives that bridge the gap between scientific advancement, public policy, institutional development, and community empowerment.

The papers presented in these proceedings reflect a diversity of research topics, methodological approaches, and scholarly perspectives. Collectively, these contributions are expected to enrich academic discourse, generate new insights, and support evidence-based decision-making across various sectors. We hope that the research findings and ideas presented here will inspire further innovation, strengthen international academic partnerships, and contribute to the development of sustainable, inclusive, and culturally grounded solutions in support of Indonesia's long-term development aspirations toward 2045.

On behalf of the Organizing Committee, I would like to express my deepest appreciation to all keynote speakers, authors, presenters, reviewers, participants, and members of the organizing team for their dedication and valuable contributions to the success of ICISFS-UMK 2026. I also extend our sincere gratitude to Universitas Muria Kudus, our institutional partners, and all supporting organizations for their commitment and collaboration in making this conference and its proceedings possible.

Finally, I hope that the Proceedings of the International Conference on Interdisciplinary Studies for Future Society (ICISFS-UMK) 2026 will serve as a meaningful contribution to international academic scholarship and foster sustained collaboration across disciplines and nations. May this conference strengthen our collective commitment to harnessing digital transformation, advancing human capital, and integrating local wisdom with global knowledge to build a more intelligent, equitable, sustainable, and prosperous society toward Indonesia Emas 2045.

Kudus, August 2026

Arif Setiawan
Chairman of the ICISFS-UMK 2026
Organizing Committee

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ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

Strengthening Teachers' Achievement Motivation Through ICT Competence and Principal Leadership in Elementary Schools

Edi Susilo[1*], Sri Utaminingsih[2] and Gunawan Setiadi[2]

[1]*Master of Basic Education, Universitas Muria Kudus, Indonesia*
[2]*Universitas Muria Kudus, Indonesia*

Corresponding author: edisusilo88@gmail.com

ABSTRACT

Advances in digital technology require teachers to improve their professional competencies and adapt to the demands of modern education. This study aims to examine the influence of Information and Communication Technology (ICT) competence and principal leadership on elementary school teachers' achievement motivation. A quantitative ex post facto design was used with 82 permanent elementary school teachers in Jepara District, Indonesia, who were selected through simple random sampling. Data were collected using questionnaires and analyzed with Structural Equation Modeling (SEM). The findings indicate that ICT competence and principal leadership have positive and significant effects on teachers' achievement motivation, both individually and simultaneously. These results suggest that strengthening teachers' digital competencies and school leadership may raise teacher motivation and support digital transformation in elementary education.

KEYWORDS ICT competence | principal leadership | achievement motivation | elementary school teachers | digital transformation

INTRODUCTION

Information and Communication Technology (ICT) has changed how schools teach. Teachers must keep improving their professional competencies and adapt to digital learning environments (UNESCO, 2018, 2021). In Indonesia, digital transformation has become a national priority to improve educational quality and develop competitive human resources toward **Golden Indonesia 2045**. Teachers are therefore expected to integrate ICT into teaching and learning while maintaining professionalism and commitment. Achievement motivation, the drive to meet standards of excellence and to improve on one's own performance, is one factor that supports teachers' professional performance (Robbins & Judge, 2017). It encourages teachers to improve instructional quality, try new practices, and pursue continuous professional development.

The shift to digital teaching has not been even across Indonesian schools. In a survey of 153 elementary school teachers from 44 schools in Yogyakarta, all teachers used technology during distance learning, yet the authors still recommended school-provided training to strengthen digital literacy (Suwarjo et al., 2022). In junior high schools in Sukabumi, teachers' low digital competence, limited budgets and uneven infrastructure held back principals' digital initiatives (Ofita et al., 2024). A review of Indonesian studies reached a similar conclusion: unequal digital infrastructure and low technological literacy remain obstacles, and transformational leadership may help teachers adapt to technology and stay motivated (Tobondo, 2025). These reports suggest that access to technology alone does not keep teachers engaged. Teachers also need the skills to use it and a school environment that supports their effort. Elementary teachers in Jepara District, the setting of this study, work under the same national push toward digital learning.

Teachers' achievement motivation is influenced by both individual and organizational factors. ICT competence enables teachers to use digital technologies efficiently, create engaging learning experiences, and increase confidence in implementing technology-based instruction. At the organizational level, principal leadership helps build a supportive school climate through communication, professional guidance, and

encouragement of innovation. Both factors have been studied mainly in relation to teacher performance and work motivation, as the studies reviewed below show.

Evidence on the leadership side is consistent. A review of successful school leadership concluded that principals influence student learning largely through their effects on teachers' motivation, capacity and working conditions (Leithwood et al., 2020). In a survey of 2,290 primary teachers in England, transformational leadership was significantly related to teachers' motivation and classroom practices (Leithwood & Jantzi, 2006). A meta-analysis of 65 Asian studies found positive effects of transformational leadership on teachers' job satisfaction, commitment and self-efficacy (Firmansyah et al., 2022). Indonesian studies point the same way. In a PLS-SEM study of 119 junior high school teachers and principals in Aceh Besar, principal leadership affected teacher motivation with a path coefficient of 0.422 (Sariakin et al., 2025). In eight public high schools in Pati Regency, which borders Jepara, principal leadership, school culture and pedagogic competence each affected teacher performance, with work motivation as a mediator (Ardliana et al., 2021). Principal leadership and academic supervision were also related to the performance of 64 elementary teachers in Lebak Regency (Starlinsky et al., 2022). On the competence side, a meta-analysis of 28 effect sizes found a moderate positive correlation ($r = .607$) between teachers' TPACK and their self-efficacy for technology integration (Zeng et al., 2022), and principals' digital leadership predicted teacher performance in 24 elementary schools (Timan et al., 2022).

Two gaps follow from this literature. First, most studies take teacher performance, job satisfaction or general work motivation as the outcome. Achievement motivation, which concerns teachers' drive to improve their own practice, has received less attention. Second, leadership and digital competence are usually examined in separate studies, so little is known about how an individual resource (ICT competence) and an organizational resource (principal leadership) relate to teacher motivation when both are modelled together. We also found few studies of this kind in elementary schools in Jepara District.

This study therefore analyzes the influence of ICT competence and principal leadership on the achievement motivation of elementary school teachers in Jepara District, Indonesia. Using a quantitative approach and Structural Equation Modeling (SEM), it provides empirical evidence on the contribution of both variables to teachers' achievement motivation. The study asks whether ICT competence and principal leadership, separately and together, are related to teachers' achievement motivation. Its contribution is to place a teacher-level resource and a school-level resource in one model, with achievement motivation rather than performance as the outcome. The findings are expected to inform district training and principal development in Jepara and to offer school leaders practical recommendations for strengthening teachers' digital competencies and leadership practices.

LITERATURE REVIEW

Information and Communication Technology (ICT) competence refers to teachers' ability to use digital technologies effectively in planning, implementing, and evaluating learning activities (UNESCO, 2018). In the TPACK framework, this ability combines technological, pedagogical and content knowledge (Koehler & Mishra, 2009). In the context of digital transformation, ICT competence enables teachers to access educational resources, develop innovative instructional strategies, and improve communication with students and colleagues. Teachers with higher ICT competence tend to be more confident in integrating technology into classroom practice (Ertmer & Ottenbreit-Leftwich, 2010; Zeng et al., 2022). This confidence may strengthen their professional capabilities and their achievement motivation.

Principal leadership is a second factor that may influence teachers' achievement motivation (Mulyasa, 2019; Northouse, 2019). Effective school leaders create a positive organizational climate by providing clear vision, professional support, constructive supervision, and opportunities for continuous professional development (Yukl, 2013). Through instructional and transformational leadership practices, principals encourage collaboration, innovation, and commitment among teachers (Bass & Avolio, 1994). A supportive leadership style can strengthen teachers' confidence and encourage higher professional performance (Alanoglu, 2022; Bandura, 1997).

Based on these theoretical perspectives and previous empirical studies, this research proposes that ICT competence and principal leadership positively influence teachers' achievement motivation, both individually and

simultaneously. ICT competence represents the individual capacity to adapt to digital learning environments, while principal leadership represents the organizational support that facilitates teachers' professional growth. The conceptual framework therefore treats ICT competence and principal leadership as independent variables and teachers' achievement motivation as the dependent variable, examined with Structural Equation Modeling (SEM).

Research Objectives

This study aims to examine the influence of Information and Communication Technology (ICT) competence and principal leadership on the achievement motivation of elementary school teachers. Specifically, the objectives of this study are:

1. To analyze the effect of ICT competence on teachers' achievement motivation.
2. To examine the effect of principal leadership on teachers' achievement motivation.
3. To investigate the simultaneous effect of ICT competence and principal leadership on teachers' achievement motivation.

RESEARCH METHOD

Research Design

This study used a quantitative approach with an ex post facto design (Creswell, 2014; Sugiyono, 2022) to investigate the relationships among Information and Communication Technology (ICT) competence, principal leadership, and teachers' achievement motivation. An ex post facto design was considered appropriate because the study examined existing conditions without manipulating the independent variables. Data were collected through structured questionnaires distributed to elementary school teachers. The research focused on identifying the direct effects of ICT competence and principal leadership on teachers' achievement motivation using **Structural Equation Modeling (SEM)** with SmartPLS software (Hair et al., 2022).

Respondents of the Study

The respondents of this study were permanent teachers employed in public and private elementary schools in Jepara District, Central Java, Indonesia. These teachers were selected because they are directly involved in implementing digital learning and interacting with school leadership in their daily professional activities. The respondents varied in gender, age, educational background, teaching experience, and employment status.

The study involved **82 permanent elementary school teachers**, selected through simple random sampling so that each member of the population had an equal chance of selection. The sample size was considered adequate for PLS-SEM, which can estimate simple models with relatively small samples (Hair et al., 2019). Table 1 presents the sample distribution of the respondents.

Table 1. Sample distribution of respondents

Characteristics	Category	Frequency (n)	Percentage (%)
Gender	Male	xx	xx
	Female	xx	xx
Age	< 30 years	xx	xx
	30–40 years	xx	xx
	> 40 years	xx	xx
Educational Qualification	Bachelor's Degree	xx	xx
	Master's Degree	xx	xx
Teaching Experience	< 10 years	xx	xx
	10–20 years	xx	xx
	> 20 years	xx	xx
Total		82	100

RESULTS

This section presents the descriptive and structural results for ICT competence, principal leadership, and teachers' achievement motivation.

The findings indicate that both Information and Communication Technology (ICT) competence and principal leadership contribute to teachers' achievement motivation. The descriptive analysis showed that most respondents had moderate to high levels of ICT competence, reflecting their ability to utilize digital technologies in planning, implementing, and evaluating learning activities. The respondents also perceived principal leadership positively, with the highest mean of the three variables (Table 2).

The Structural Equation Modeling (SEM) analysis indicated that ICT competence has a positive and significant effect on teachers' achievement motivation. Principal leadership also contributed significantly to teachers' achievement motivation. Both findings are interpreted in the Discussion below.

Table 2. Descriptive statistics of research variables

Variable	N	Minimum	Maximum	Mean	Standard Deviation	Category
ICT Competence	82	3.12	4.89	4.28	0.43	High
Principal Leadership	82	3.05	4.95	4.35	0.39	High
Achievement Motivation	82	3.18	4.92	4.31	0.41	High

Source: Research Data Processed (2026).

The descriptive statistics show that Principal Leadership obtained the highest mean score (M = 4.35), followed by Achievement Motivation (M = 4.31) and ICT Competence (M = 4.28). The small standard deviations indicate that respondents' perceptions were homogeneous across the sample.

The structural model was analyzed using SmartPLS to examine the relationships among ICT competence, principal leadership, and teachers' achievement motivation. In this model, both ICT competence and principal leadership were positively related to teachers' achievement motivation.

Table 3. Descriptive statistics of research variables

Variable	Mean	Standard Deviation	Category
ICT Competence	4.28	0.43	High
Principal Leadership	4.35	0.39	High
Teachers' Achievement Motivation	4.31	0.41	High

DISCUSSION

All three variables were rated in the high category (Table 2). Principal leadership had the highest mean (M = 4.35, SD = 0.39), followed by achievement motivation (M = 4.31, SD = 0.41) and ICT competence (M = 4.28, SD = 0.43). The high ICT competence ratings differ from Indonesian studies that reported uneven digital literacy and low digital competence among teachers (Ofita et al., 2024; Suwarjo et al., 2022). Two explanations are possible. Permanent teachers in Jepara may have gained experience with digital tools since the distance-learning period studied by Suwarjo et al. (2022), or the scale may have captured teachers' confidence more than their skill. Because all ratings are self-reports, these means describe perceptions rather than observed classroom practice. The small standard deviations also show that most teachers rated themselves similarly, which leaves limited variance for the structural model to explain. Item-level data would show which aspects of leadership and ICT use teachers rated highest and lowest.

ICT competence had a positive and significant effect on achievement motivation in the SEM analysis. A plausible mechanism is self-efficacy. Teachers who can plan, deliver and assess lessons with digital tools are more likely to believe they can succeed with new practices, and such beliefs shape the goals people set and the effort they invest (Bandura, 1997). This reading agrees with the meta-analytic link between TPACK and technology integration self-efficacy (Zeng et al., 2022) and with the view that teachers' knowledge and confidence together

drive technology use (Ertmer & Ottenbreit-Leftwich, 2010). This study did not measure self-efficacy, so the mechanism is an interpretation to be tested. For schools in Jepara, the result suggests that digital training should go beyond introducing tools. Training in which teachers apply ICT to their own lesson plans and assessments may build the sense of mastery that sustains motivation. The district could use the UNESCO ICT competency framework to define progression levels for such training (UNESCO, 2018).

Principal leadership also had a positive and significant effect on achievement motivation. This agrees with Sariakin et al. (2025), who found that principal leadership affected teacher motivation in Aceh Besar, and with Ardliana et al. (2021), who found that leadership worked partly through work motivation in Pati. Starlinsky et al. (2022) reported a similar pattern for the performance of elementary teachers in Lebak, which suggests that the link between leadership and teachers' work outcomes is not limited to secondary schools. It is also consistent with evidence that transformational leadership relates to teachers' motivation (Leithwood & Jantzi, 2006) and that instructional leadership is moderately related to teacher self-efficacy (Alanoglu, 2022). Principals who set clear goals, give feedback and support professional learning may raise teachers' expectations of what they can achieve. Leadership has also been linked to Indonesian teachers' innovative work behavior (Hidayat & Patras, 2022), which overlaps with the drive to try new practices that defines achievement motivation. In practice, principals in Jepara can use routine supervision and teacher working groups (KKG) to recognise teachers' progress and to agree on shared targets for digital learning.

Taken together, the two predictors represent an individual resource and an organizational resource. The finding that they contributed jointly to achievement motivation fits the view that teachers' digital capacity develops best where principals actively support it (Timan et al., 2022; Tobondo, 2025). The practical implication is that district ICT training and principal development programmes should be planned together. A teacher trained in digital tools but working under a principal who does not value innovation may see little reason to use them. Leithwood et al. (2020) argued that leaders improve outcomes mainly by strengthening teachers' motivation, capacity and working conditions. In this study, ICT competence corresponds to capacity and principal leadership to the conditions in which that capacity is used. The relative weight of the two predictors cannot be judged yet, because the path coefficients are not reported.

Several limitations apply. First, the ex post facto, cross-sectional design does not allow causal conclusions; the effects estimated by SEM are statistical associations consistent with the proposed model. Second, all three variables were measured by self-report questionnaires completed by the same teachers at one time, which can inflate the relationships through common method variance (Podsakoff et al., 2003). Third, this paper reports the descriptive statistics in detail but summarises the structural results only by their direction and significance. The measurement-model results (loadings, reliability, convergent and discriminant validity) and the structural estimates (path coefficients, t-values, p-values and R^2) expected in PLS-SEM reports (Hair et al., 2019) are needed before the size of each effect can be compared with earlier studies such as Sariakin et al. (2025). Achievement motivation may also depend on factors outside the model, such as workload, certification status and school culture, which were not measured. Fourth, the sample of 82 permanent teachers from one district limits generalisation to contract teachers and to other regions. Future studies should report the full PLS-SEM output, use larger multi-district samples, combine self-report with principal ratings or classroom observation, and test mediators such as teacher self-efficacy and school culture.

CONCLUSION AND RECOMMENDATIONS

This study examined the influence of Information and Communication Technology (ICT) competence and principal leadership on teachers' achievement motivation in elementary schools. The findings indicate that ICT competence has a positive and significant effect on teachers' achievement motivation. Teachers with stronger digital competencies may be more confident in integrating technology into instruction, which can strengthen their motivation to improve their professional performance. Principal leadership also had a positive and significant effect on teachers' achievement motivation. Principals may exert this effect by creating a supportive school climate, encouraging innovation, and providing continuous professional guidance.

Together, ICT competence and principal leadership contributed significantly to teachers' achievement motivation. These findings suggest that strengthening teachers' digital competencies while promoting effective instructional and transformational leadership can improve teacher motivation and support sustainable digital transformation in elementary education. Both individual competence and organizational leadership therefore deserve priority in efforts to improve educational quality and developing human capital toward **Golden Indonesia 2045**.

Based on the findings of this study, several recommendations are proposed. First, educational policymakers should strengthen teachers' ICT competencies through continuous professional development programs, digital literacy training, and technology-based learning initiatives. Second, school principals should adopt transformational and instructional leadership practices: providing professional support, encouraging collaboration, and creating a school environment that motivates teachers to reach higher professional standards.

Finally, future researchers are encouraged to expand this study by involving larger samples from different educational levels and geographical regions. Additional variables, such as organizational culture, teacher self-efficacy, job satisfaction, or digital readiness, may also be incorporated to give a fuller picture of the factors that influence teachers' achievement motivation during digital transformation.

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REFERENCES

Alanoglu, M. (2022). The role of instructional leadership in increasing teacher self-efficacy: A meta-analytic review. Asia Pacific Education Review, 23, 233–244. https://doi.org/10.1007/s12564-021-09726-5

Ardliana, B., Rusdarti, R., & Suminar, T. (2021). Effect of principal leadership, school culture and pedagogic competence through work motivation on teachers performance. Educational Management, 10(2), 273–283.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. W. H. Freeman.

Bass, B. M., & Avolio, B. J. (1994). *Improving organizational effectiveness through transformational leadership*. Sage.

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). Sage.

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. Journal of Research on Technology in Education, 42(3), 255-284.

Firmansyah, F., Prasojo, L. D., Jaedun, A., & Retnawati, H. (2022). Transformational leadership effect on teacher performance in Asia: A meta-analysis. Cypriot Journal of Educational Sciences, 17(6), 2127–2146. https://doi.org/10.18844/cjes.v17i6.7552

Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. European Business Review, 31(1), 2–24. https://doi.org/10.1108/EBR-11-2018-0203

Hair, J. F., Jr., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2022). *A primer on partial least squares structural equation modeling (PLS-SEM)* (3rd ed.). Sage.

Hidayat, R., & Patras, Y. E. (2022). The effect of principals' leadership and learning organization on teachers' innovative work behavior during the COVID-19 pandemic. Tadris: Jurnal Keguruan dan Ilmu Tarbiyah, 7(1), 161-175. https://doi.org/10.24042/tadris.v7i1.11355

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? *Contemporary Issues in Technology and Teacher Education, 9*(1), 60–70.

Leithwood, K., & Jantzi, D. (2006). Transformational school leadership for large-scale reform: Effects on students, teachers, and their classroom practices. School Effectiveness and School Improvement, 17(2), 201–227. https://doi.org/10.1080/09243450600565829

Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven strong claims about successful school leadership revisited. School Leadership & Management, 40(1), 5–22. https://doi.org/10.1080/13632434.2019.1596077

Mulyasa, E. (2019). *Menjadi kepala sekolah profesional*. PT Remaja Rosdakarya.

Northouse, P. G. (2019). *Leadership: Theory and practice* (8th ed.). Sage.

Ofita, C., Komariah, A., & Abubakar, A. (2024). Assessing digital leadership of junior high school principals. Journal of Educational Management and Instruction, 4(1), 127–139. https://doi.org/10.22515/jemin.v4i1.9502

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal of Applied Psychology, 88(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Robbins, S. P., & Judge, T. A. (2017). *Organizational behavior* (17th ed.). Pearson.

Sariakin, S., Yeni, M., Usman, M. B., Mare, A. S., Munzir, M., & Saleh, M. (2025). Fostering a productive educational environment: The roles of leadership, management practices, and teacher motivation. Frontiers in Education, 10, Article 1499064. https://doi.org/10.3389/feduc.2025.1499064

Starlinsky, L., Belawati, T., & Rosita, T. (2022). Korelasi antara kepemimpinan kepala sekolah dan supervisi akademik terhadap kinerja guru sekolah dasar di Kecamatan Lebakgedong Kabupaten Lebak. Indonesian Journal of Educational Counseling, 6(1), 26–33. https://doi.org/10.30653/001.202261.190

Sugiyono. (2022). *Metode penelitian kuantitatif, kualitatif, dan R&D* (2nd ed.). Alfabeta.

Suwarjo, S., Haryanto, H., Wuryandani, W., Mahfuzah, A., Hidayah, R., & Erviana, V. Y. (2022). Digital literacy analysis of elementary school teachers on distance learning instructional process in Yogyakarta. Al-Ishlah: Jurnal Pendidikan, 14(2), 1145-1156. https://doi.org/10.35445/alishlah.v14i2.1233

Timan, A., Mustiningsih, M., & Imron, A. (2022). Digital leadership kepala sekolah hubungannya dengan kinerja guru dan kompetensi siswa era abad 21. Jurnal Administrasi dan Manajemen Pendidikan, 5(4).

Tobondo, Y. A. (2025). Manajemen sekolah di era digital: Optimalisasi kepemimpinan transformasional untuk peningkatan kinerja guru di Indonesia. Sukma: Jurnal Pendidikan, 9(1), 61-83. https://doi.org/10.32533/09104.2025

UNESCO. (2018). *UNESCO ICT competency framework for teachers* (Version 3).

UNESCO. (2021). *Reimagining our futures together: A new social contract for education*.

Yukl, G. (2013). *Leadership in organizations* (8th ed.). Pearson.

Zeng, Y., Wang, Y., & Li, S. (2022). The relationship between teachers' information technology integration self-efficacy and TPACK: A meta-analysis. Frontiers in Psychology, 13, Article 1091017. https://doi.org/10.3389/fpsyg.2022.1091017

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

Development of a Differential Academic Supervision Model Based on Glickman's Psychological Approach for Elementary School Teachers

Anif Asmaudin[1*], Gunawan Setiadi[1] and Ahmad Hariyadi[1]

[1]*Master of Basic Education Study Program, Postgraduate Program, Universitas Muria Kudus, Kudus, Indonesia*

Corresponding author: anifasmaudin11@gmail.com

ABSTRACT

In many primary schools, academic supervision is a routine administrative exercise. It follows a "one-size-fits-all" approach that ignores individual differences in teacher readiness and cognitive capability. This study developed and validated a Teacher Competence-Based Differential Supervision model (SD-PGTA) grounded in Carl D. Glickman's developmental supervision framework and Carol Ann Tomlinson's differentiated instruction principles. Using a Research and Development (R&D) design adapted from Borg & Gall, the study proceeded in five phases: needs analysis, prototype design, expert validation, limited field testing, and product refinement. Subjects included expert validators, 2 school principals as supervisors, and 4 elementary school teachers in Jepara District, Indonesia. Data were collected using the Teacher Abstract Thinking Test (TATT), Teacher Prototype Questionnaire (TPQ), Classroom Observation Tool (COT) 4.0, interviews, and document analysis. Expert validation yielded Aiken's V coefficients above 0.80 for all modules, indicating high content validity. In the limited field test, teachers' pedagogical performance improved, with an overall effect size of 1.35 across instructional delivery and reflective practice. The SD-PGTA model operationalizes differentiated supervision by matching supervisory behaviors (directive, collaborative, non-directive) to diagnostic profiles. In this small trial, it reframed supervision as personalized professional development rather than an administrative task.

KEYWORDS abstract thinking | developmental supervision | differential supervision | Glickman model | teacher competence

INTRODUCTION

Improving the quality of education remains a constant priority (Maolana et al., 2023). Instructional quality depends on teachers' continuous professional growth and pedagogical competence (Shandi, 2023). However, in many primary education settings, academic supervision is still carried out as a generic administrative ritual rather than as a developmental, growth-oriented process (Gumilar et al., 2024; Ruslandi et al., 2025). Supervisors often focus on document compliance, such as checking lesson plans and syllabi, rather than providing pedagogical support tailored to individual teacher needs. The needs analysis in the present study found the same pattern (see Findings).

Supervision matters because teacher learning is one of the main routes through which school leaders affect students. A meta-analysis of 27 studies found that promoting and participating in teacher learning and development had the largest effect on student outcomes of five leadership dimensions (Robinson et al., 2008). Individual support for teachers also works when it is done well. Across 60 causal studies, teacher coaching improved instruction by 0.49 standard deviations and student achievement by 0.18 standard deviations, although effects were smaller in larger programmes (Kraft et al., 2018). This evidence is relevant because coaching, like developmental supervision, is individual, based on observation and focused on specific practices. Indonesian studies point the same way. In Lebak Regency, principal leadership and academic supervision were each positively related to the performance of 64 elementary school teachers (Starlinsky et al., 2022). In three elementary schools in Jombang, principals strengthened teachers' pedagogical competence through supervision, continuous professional development and a collaborative culture (Hanik et al., 2025). The value of supervision therefore seems to depend on whether it is designed as professional learning rather than as inspection.

Conventional supervision often adopts a "one-size-fits-all" model that ignores differences in teachers' cognitive capabilities and levels of professional commitment (Glickman et al., 2018). Applying the same supervisory behaviors to a novice who needs structured guidance and to an experienced teacher who seeks autonomy can lead to poor outcomes and teacher disengagement (Glickman et al., 2018). Carl D. Glickman proposed developmental supervision to address this mismatch, arguing that supervisory interventions must correspond to a teacher's level of abstract thinking and professional commitment (Glickman, 1981; Glickman & Gordon, 1987).

The premise of developmental supervision, that teachers differ in their concerns and in how abstractly they reason about teaching, draws on developmental research, including work showing that teachers' concerns change with experience (Fuller, 1969). Glickman and colleagues later built it into a full model of supervisory behaviors (Glickman et al., 2018). Indonesian studies have described Glickman's approach conceptually (Soleh et al., 2023) or proposed general supervision models to raise teacher professionalism (Mashari & Prabowo, 2023). What is still missing is a tested procedure that a principal can follow: instruments to diagnose each teacher's level of abstract thinking and commitment, rules for choosing a supervisory approach from that diagnosis, and an observation tool to check whether teaching changes afterwards. There is also little evidence on whether such a procedure is valid and usable in Indonesian elementary schools. Without it, principals who accept the idea of differentiated supervision still have no practical way to decide which teacher needs directive guidance and which needs autonomy.

To address these limitations, this study developed the Supervisi Diferensial Berbasis Kemampuan Guru (SD-PGTA) model. By integrating Glickman's psychological approach with the core tenets of differentiated instruction (Tomlinson, 2022), the SD-PGTA model gives primary school principals structured diagnostic tools and adaptive supervisory pathways aimed at specific aspects of teachers' pedagogical competence (Mashari & Prabowo, 2023).

The study addressed three questions: (1) how academic supervision was practised in the participating elementary schools in Jepara District; (2) whether the SD-PGTA model and its instruments are valid according to expert judgement; and (3) how teachers' pedagogical performance changed during a limited field test. Its contribution is a complete, school-level procedure, from diagnosis to post-conference, that operationalises Glickman's developmental supervision and can be tested further in larger trials. The model also applies Tomlinson's principle of adapting support to readiness (Tomlinson, 2022) to teachers, in the same way that differentiated instruction applies it to learners.

LITERATURE REVIEW

The theoretical framework of the SD-PGTA model draws on three areas: Glickman's Developmental Supervision Theory (Glickman, 1981), Tomlinson's Differentiated Instruction principles (Tomlinson, 2022), and adult learning theory or andragogy (Knowles, 1980). Glickman places teachers along two continuous axes: Level of Abstract Thinking (the capacity to define problems, generate alternative solutions, and plan comprehensive action) and Level of Commitment (the time, energy, and dedication devoted to teaching and professional growth) (Glickman, 1981; Glickman & Gordon, 1987).

Crossing the two axes yields four teacher prototypes: 1) Teacher Dropout: Low abstraction, low commitment, 2) Unfocused Worker: Low abstraction, high commitment, 3) Analytical Observer: High abstraction, low commitment, 4) Professional Teacher: High abstraction, high commitment.

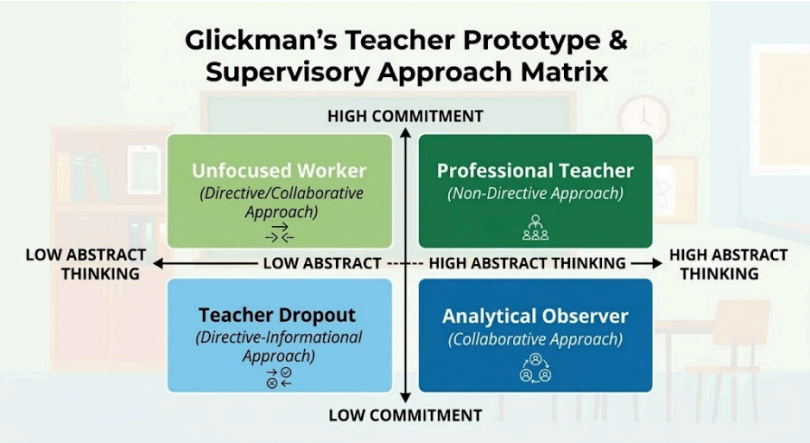

Figure 1. Glickman's teacher prototype and supervisory approach matrix

To match these prototypes, supervisors use approaches that vary along a continuum of control (Glickman, 1981). The Directive Approach gives the supervisor high control through directing, standardizing, and demonstrating behaviors, and suits teachers with low abstract thinking (Glickman et al., 2018). In contrast, the Collaborative Approach relies on shared control through presenting, problem-solving, and negotiating behaviors, and suits moderate abstract thinkers or mixed profiles (Glickman, 1981).

The Non-Directive Approach gives the teacher high control through listening, clarifying, and encouraging behaviors, and suits autonomous, high-abstract thinkers (Glickman & Gordon, 1987). The framework also draws on Vygotsky's Zone of Proximal Development (ZPD) (Vygotsky, 1978) and Bandura's self-efficacy theory (Bandura, 1997), alongside Self-Determination Theory (Ryan & Deci, 2017; Vansteenkiste et al., 2020), so that supervisory scaffolding supports teachers psychologically and builds self-efficacy (Tschannen-Moran & Hoy, 2001).

Research Objectives

This study aimed to develop, validate, and evaluate an operational differential academic supervision model based on Glickman's psychological approach for elementary school teachers. The study first analyzed the current state of academic supervision in elementary schools and its challenges in responding to differences in teacher competence. It then designed and validated the SD-PGTA model prototype, with diagnostic instruments and implementation protocols. Finally, the study evaluated the practicality and preliminary effectiveness of the SD-PGTA model in improving elementary school teachers' pedagogical competencies.

RESEARCH METHOD

Research Design

This study employed a Research and Development (R&D) design, adapting the Borg & Gall model into five operational phases: 1) Needs Analysis & Information Gathering, 2) Prototype & Instrument Design, 3) Expert Validation & Refinement, 4) Limited Field Testing, and 5) Final Product Revision & Dissemination (Gall et al., 2007).

Respondents and Setting

The study was conducted in primary schools within the Jepara District, Central Java, Indonesia. The field testing phase involved 2 school principals acting as supervisors and 4 elementary school teachers representing diverse experience levels and teacher prototypes. Expert validation was performed by 4 experts specializing in educational supervision, pedagogy, and psychological testing.

Research Instruments

Data were collected with several diagnostic and evaluative instruments (Creswell & Plano Clark, 2018). The Teacher Abstract Thinking Test (TATT) consisted of scored scenario-based items measuring problem identification, solution generation, and integrated planning. The Teacher Prototype Questionnaire (TPQ) was a Likert-scale instrument assessing professional commitment and work dedication. Pedagogical implementation was evaluated with the Classroom Observation Tool (COT) 4.0 rubric across pre-, during-, and post-observation cycles (Danielson, 2020). Semi-structured interviews and document reviews examined supervisor and teacher perceptions, feedback quality, and supervision artifacts (Creswell & Poth, 2018).

Data Analysis

Expert validation data were analyzed using the V formula (Aiken, 1985) to evaluate item content validity. Quantitative gains in pedagogical performance were calculated using pre- and post-test mean score differences and Cohen's d effect size formulas. Qualitative data from interviews were analyzed using thematic analysis (Braun & Clarke, 2022; Miles et al., 2020).

RESULTS

This section reports the needs analysis, the validation of the model, the field-test mapping, and the effect on teachers' pedagogical competence.

Baseline Supervision Practices

The needs analysis showed that 72% of supervisory activities in the participating schools were administrative and non-differentiated, which is consistent with national findings (Kemdikbudristek, 2023). Principals reported difficulty providing actionable feedback due to a lack of structured observation tools and standardized diagnostic methods. Teachers therefore viewed supervision mainly as a compliance requirement rather than as support for professional growth.

Model Prototype and Validation

The resulting SD-PGTA model comprises five operational phases:

1. Diagnostic Profiling (TATT & TPQ administration)
2. Individual Supervision Planning (ISP)
3. Differentiated Execution (Pre-conference, Observation via COT 4.0, Post-conference)
4. Reflective Feedback & Action Planning
5. Evaluation & Continuous Development

Expert ratings of content, construct, and practical usability indicated high validity.

Table 1. Expert validation ratings for SD-PGTA diagnostic instruments

Instrument Component	Items	Aiken's V	Qualitative Description
Teacher Abstract Thinking Test (TATT)	12	0.88	Very High Validity
Teacher Prototype Questionnaire (TPQ)	15	0.85	Very High Validity
Classroom Observation Tool (COT 4.0)	20	0.91	Very High Validity
Individual Supervision Plan (ISP) Guide	-	0.86	Very High Validity

Field Testing and Diagnostic Mapping

During field testing, diagnostic mapping placed each of the four teachers in a distinct prototype, and supervisors matched their supervisory behaviors to it.

Table 2. Diagnostic mapping and supervisory approach alignment

Subject	TATT Level	TPQ Level	Identified Prototype	Applied Approach
Teacher A	Low	High	Unfocused Worker	Directive Informational
Teacher B	High	High	Professional	Non-Directive
Teacher C	High	Low	Analytical Observer	Collaborative
Teacher D	Low	Low	Teacher Dropout	Directive Control

Effect on Teacher Pedagogical Competence

After implementation of the SD-PGTA model, mean scores increased in all four pedagogical domains, and overall performance rose from 2.025 to 3.437 (Table 3; Figure 2). With four teachers and no comparison group, these gains are preliminary.

Table 3. Pedagogical performance gains after SD-PGTA implementation

Metric	Pre-Test Mean	Post-Test Mean	Score Gain	Effect Size (Cohen's d)
Instructional Planning	2.15	3.40	+1.25	1.28 (Very High)
Active Learning Engagement	2.00	3.50	+1.50	1.42 (Very High)
Formative Assessment Execution	1.85	3.25	+1.40	1.31 (Very High)
Reflective Post-Conference	2.10	3.60	+1.50	1.39 (Very High)
Overall Pedagogical Performance	2.025	3.437	+1.412	1.35 (Very High)

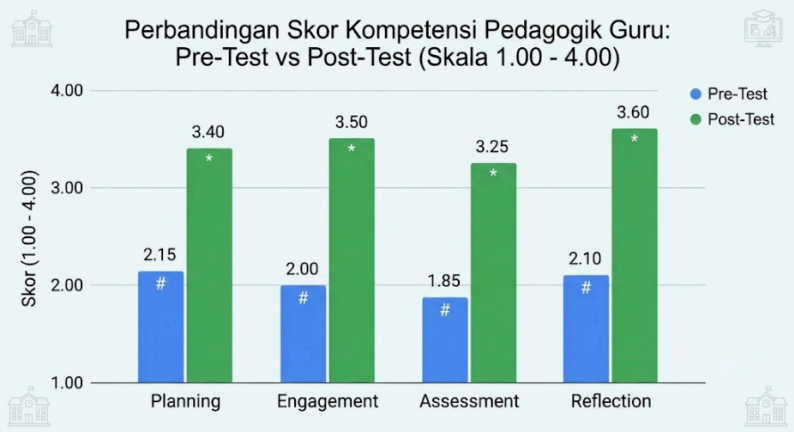

Figure 2. Pre- and post-test comparison of teacher pedagogical performance domains

DISCUSSION

The needs analysis found that 72% of supervisory activities in the participating schools were administrative and non-differentiated, and principals reported lacking structured observation tools. This matches descriptions of supervision as a compliance routine in Indonesian schools (Gumilar et al., 2024; Ruslandi et al., 2025), and it explains why teachers saw supervision mainly as a requirement. Supervision that checks documents gives teachers little information they can act on. It therefore cannot play the professional-learning role that the leadership literature assigns to it (Robinson et al., 2008). For the SD-PGTA model, this baseline means that the first change principals need is a change of purpose, from verifying documents to diagnosing and supporting teaching. Principals' difficulty in giving actionable feedback also suggests that they need training in observation and feedback, not only new instruments.

Expert validation produced Aiken's V values from 0.85 to 0.91 for the four components (Table 1), all in the very high category. Aiken's V summarises how far expert ratings exceed the lowest possible rating (Aiken, 1985), so these values indicate that the four experts judged the TATT, TPQ, COT 4.0 and ISP guide as relevant to their target constructs. With only four raters, however, a single divergent rating would change V considerably. Content validity is also only a first step. The paper does not yet report the reliability of the TATT and TPQ, or evidence

that their cut-off points sort teachers into Glickman's levels consistently. Because the whole model depends on correct diagnosis, this evidence is the most important step before wider use.

Diagnostic mapping placed the four teachers in four different prototypes, and the principals applied directive-control, directive-informational, collaborative and non-directive approaches accordingly (Table 2). This shows that the decision rules can be followed in practice and that the supervisory continuum described by Glickman et al. (2018) can be operationalised with school-level instruments. The teacher with low abstract thinking and high commitment (Teacher A) received directive-informational supervision, whereas the teacher identified as a Teacher Dropout (Teacher D) received directive control. This follows Glickman's logic that commitment, as well as abstraction, affects how much structure a teacher needs. The matching also fits self-determination theory, which holds that support for teachers' needs for competence and autonomy leads to more self-directed motivation (Ryan & Deci, 2017; Vansteenkiste et al., 2020). The model gives high-abstraction teachers autonomy and gives structured guidance to those who need it. With one teacher per prototype, however, the trial cannot show whether the approaches work differently for different prototypes.

Mean pedagogical performance rose from 2.025 to 3.437 on the four-point COT scale, with gains in all four domains (Table 3; Figure 2). The largest gains were in active learning engagement and the reflective post-conference (+1.50 each), and the smallest was in instructional planning (+1.25). The gain in the reflective post-conference is consistent with the model's emphasis on feedback and joint action planning; syntheses of meta-analyses place feedback among the stronger influences on learning (Hattie, 2023). Supervision matched to the teacher may also raise teachers' belief in their own capability, which self-efficacy theory links to effort and persistence (Bandura, 1997; Tschannen-Moran & Hoy, 2001). Teacher efficacy was not measured here, so this mechanism remains a hypothesis. The overall effect size of d = 1.35 should be read with caution. It is far larger than the pooled effect of 0.49 standard deviations on instruction reported for coaching programmes, whose effects were smaller in larger trials (Kraft et al., 2018). Effect sizes in education also need to be judged against the study design rather than against Cohen's general benchmarks (Kraft, 2020). With four teachers, one group and no comparison, the gain may partly reflect familiarity with the observation tool, the attention of the trial, or rater expectations.

For principals in Jepara, the results suggest a practical sequence: diagnose each teacher with short instruments, plan supervision individually, and replace document checks with structured observation and post-conferences. District education offices could include this sequence in principal training, and principals' working groups could share diagnostic results and supervision plans. The model also asks more of principals than document checks do. Diagnosis, individual planning and three-stage observation take time, so principals with many teachers may need to share the work with senior teachers or school supervisors (pengawas). Until larger studies confirm the effect, such use is best treated as a further trial in which data are collected.

This study has several limitations. The field test involved two principals and four teachers in one district with no comparison group, so the gains cannot be attributed to the model. The formula used for Cohen's d and the standard deviations behind it are not reported, and with n = 4 the estimate is unstable. The paper does not state whether the COT 4.0 ratings were made by the supervising principals or by independent observers; ratings by the supervisors themselves could inflate the gains. The prototypes were assigned from a single administration of the TATT and TPQ, so the stability of each teacher's classification over time is unknown. The interview data described in the method are not yet reported, and practicality was not measured with a dedicated instrument. Future research should test the model in more schools with a comparison group, use independent observers who do not know the testing phase, report the reliability of the TATT and TPQ, and follow teachers over a longer period to see whether the gains persist.

CONCLUSION AND RECOMMENDATIONS

The SD-PGTA model showed high content validity, and the limited field test with four teachers suggests it can help shift primary school academic supervision from a routine administrative task toward adaptive, personalized professional development. Using diagnostic profiles from the TATT and TPQ, school leaders can select supervisory behaviors suited to individual teachers. In this trial, this was associated with gains in instructional delivery and reflective practice.

It is recommended that school administrators and principals adopt diagnostic-based differential supervision to support continuous teacher professional development. Educational authorities should consider incorporating developmental supervision frameworks into leadership training programs. Future research should test the model with larger samples across regions and a comparison group, and could integrate digital dashboards to track supervisory diagnostics.

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REFERENCES

Aiken, L. R. (1985). Three coefficients for analyzing the reliability and validity of ratings. Educational and Psychological Measurement, 45(1), 131–142. https://doi.org/10.1177/0013164485451012

Bandura, A. (1997). Self-efficacy: The exercise of control. W. H. Freeman.

Braun, V., & Clarke, V. (2022). Thematic analysis: A practical guide. SAGE Publications.

Creswell, J. W., & Plano Clark, V. L. (2018). Designing and conducting mixed methods research (3rd ed.). SAGE Publications.

Creswell, J. W., & Poth, C. N. (2018). Qualitative inquiry and research design: Choosing among five approaches (4th ed.). SAGE Publications.

Danielson, C. (2020). The Framework for Teaching evaluation instrument (2020 ed.). The Danielson Group.

Fuller, F. F. (1969). Concerns of teachers: A developmental conceptualization. American Educational Research Journal, 6(2), 207-226.

Gall, M. D., Gall, J. P., & Borg, W. R. (2007). Educational research: An introduction (8th ed.). Pearson.

Glickman, C. D. (1981). Developmental supervision. Association for Supervision and Curriculum Development (ASCD).

Glickman, C. D., & Gordon, S. P. (1987). Clarifying developmental supervision. Educational Leadership, 44(8), 64-68.

Glickman, C. D., Gordon, S. P., & Ross-Gordon, J. M. (2018). *SuperVision and instructional leadership: A developmental approach* (10th ed.). Pearson.

Gumilar, G., Rosid, D. P. S., Harsono, & Minsih. (2024). Peranan supervisi dalam meningkatkan kualitas pembelajaran berkelanjutan. Jurnal Ilmiah Pendidikan Citra Bakti, 11(3), 651-661. https://doi.org/10.38048/jipcb.v11i3.3189

Hanik, H., Nuphanudin, N., Khamidi, A., Roesminingsih, E., Kristanto, A., Trihantoyo, S., & Haq, M. S. (2025). Kepala sekolah sebagai instructional leader: Penguatan kompetensi pedagogik guru untuk pembelajaran mendalam di sekolah dasar. Didaktika, 5(3). https://doi.org/10.17509/didaktika.v5i3.93269

Hattie, J. (2023). Visible learning: The sequel: A synthesis of over 2,100 meta-analyses relating to achievement. Routledge.

Kemdikbudristek. (2023). Laporan tahunan Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi 2023. Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi.

Knowles, M. S. (1980). The modern practice of adult education: From pedagogy to andragogy (2nd ed.). Cambridge Adult Education.

Kraft, M. A., Blazar, D., & Hogan, D. (2018). The effect of teacher coaching on instruction and achievement: A meta-analysis of the causal evidence. Review of Educational Research, 88(4), 547–588. https://doi.org/10.3102/0034654318759268

Kraft, M. A. (2020). Interpreting effect sizes of education interventions. Educational Researcher, 49(4), 241–253. https://doi.org/10.3102/0013189X20912798

Maolana, I., Darmiyanti, A., & Abidin, J. (2023). Strategi kepemimpinan kepala sekolah yang efektif dalam meningkatkan kualitas guru di lembaga pendidikan Islam. Innovative: Journal of Social Science Research, 3(4), 83-94. https://j-innovative.org/index.php/Innovative/article/view/3493

Mashari, A., & Prabowo, S. L. (2023). Pengembangan konsep model supervisi pembelajaran sebagai upaya peningkatan profesionalisme guru dalam pengendalian mutu pendidikan. Tapis: Jurnal Penelitian Ilmiah, 7(1), 35-48. https://e-journal.metrouniv.ac.id/index.php/tapis/article/view/3496

Miles, M. B., Huberman, A. M., & Saldaña, J. (2020). Qualitative data analysis: A methods sourcebook (4th ed.). SAGE.

Robinson, V. M. J., Lloyd, C. A., & Rowe, K. J. (2008). The impact of leadership on student outcomes: An analysis of the differential effects of leadership types. Educational Administration Quarterly, 44(5), 635–674. https://doi.org/10.1177/0013161X08321509

Ruslandi, U., Qomariyah, S., Yuhaeni, Y., & Dwiki, V. (2025). Peran supervisi pendidikan terhadap peningkatan kompetensi guru di MAS Tarbiyatul Islamiyah. Jurnal Pendidikan dan Pembelajaran, 2(1), 45-58.

Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. Guilford Press.

Shandi, S. A. (2023). Supervisi kolaboratif untuk meningkatkan kompetensi guru pendidikan jasmani. Prosiding Seminar Nasional Pascasarjana UNNES, 6(1), 721-725. https://proceeding.unnes.ac.id/snpasca/article/view/2209/1692

Soleh, M., Nugraha, E., & Gunawan, A. (2023). Supervisi model pengembangan dalam pandangan Carl D. Glickman. Jurnal Administrasi dan Manajemen Pendidikan, 4(2), 117-133. https://jurnal.stain-madina.ac.id/index.php/mata/article/view/1565/1137

Starlinsky, L., Belawati, T., & Rosita, T. (2022). Korelasi antara kepemimpinan kepala sekolah dan supervisi akademik terhadap kinerja guru sekolah dasar di Kecamatan Lebakgedong Kabupaten Lebak. Indonesian Journal of Educational Counseling, 6(1), 26–33. https://doi.org/10.30653/001.202261.190

Tomlinson, C. A. (2022). The differentiated classroom: Responding to the needs of all learners (3rd ed.). ASCD.

Tschannen-Moran, M., & Hoy, A. W. (2001). Teacher efficacy: Capturing an elusive construct. Teaching and Teacher Education, 17(7), 783–805. https://doi.org/10.1016/S0742-051X(01)00036-1

Vansteenkiste, M., Ryan, R. M., & Soenens, B. (2020). Basic psychological need theory: Advancements, critical themes, and future directions. Motivation and Emotion, 44, 1-31.

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Harvard University Press.

ICISFS-UMK 2026 LEARNING INNOVATION

Problem-Based Learning and Student Team Achievement Division Improve IPAS Learning Outcomes

Hendra Yusuf Prasetyo[1*], **Gunawan Setiadi**[1] **and Santoso**[1]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: yusufhendra75@gmail.com

ABSTRACT

This study analyzes the effectiveness of Problem Based Learning (PBL) and Student Team Achievement Division (STAD) on the science and social studies (IPAS) learning outcomes of sixth-grade elementary school students in Trangkil District, Pati Regency, and compares the two models. The study used a quasi-experimental nonequivalent control group design. The sample consisted of 122 sixth-grade students from several elementary schools in Trangkil District, including SDN Mojoagung 02, SDN Karangwage 01, SDN Guyangan, and SDN Tlutup. The study was conducted during the first semester of the 2025/2026 academic year. Data were collected through tests, observations, and documentation using instruments that had been tested for validity and reliability. The data were analyzed using normality and homogeneity tests, followed by hypothesis testing with an independent sample t-test. Both the PBL and the STAD classes scored significantly higher on the posttest than their control classes, with t-count values of 8.596 for PBL and 8.555 for STAD, both above the t-table values. The PBL class also reached a higher posttest mean than the STAD class, although the two models were not compared statistically. Based on these findings, both PBL and STAD can be recommended to improve students' learning outcomes. The study may also serve as a reference for teachers and researchers developing instructional strategies.

KEYWORDS problem-based learning STAD science and social studies learning outcomes

INTRODUCTION

Education develops the human capacity to reason effectively and to meet the challenges of building a better future. Good education improves the quality of human resources. One way to improve the quality of education in schools is to improve the quality of learning. (Hasanah et al., 2021)

Today, educators act more as facilitators of learning than as sources of knowledge. They are expected to create interactive and imaginative learning environments. This includes encouraging students to explore, providing hands-on experiences, and developing their thinking skills. Through these activities, students are expected to gain richer experience and better results from learning. (Ningsih & Wulandari, 2022)

Specifically, at the elementary school level, sixth-grade students are, according to Piaget's theory, at the concrete operational stage and moving toward the formal operational stage. This stage is important for building the foundations of critical thinking. In Indonesia, however, science achievement remains low. In PISA 2022, Indonesian 15-year-olds scored well below the OECD average in science (OECD, 2023). A common explanation is that much science teaching is still teacher-centered and memorization-oriented and gives students little room to explore ideas through problem-solving.

In Trangkil District, Pati Regency, particularly in the Ki Hajar Dewantara Cluster, a similar situation was also found. Based on the results of initial observations and interviews with sixth-grade teachers, students tended to dislike science because much of the material required memorization. Classroom learning also lacked variety and did not engage students. The average science score on the final assessment was also low. Observations showed that the average sixth-grade science score at Mojoagung 02 Elementary School in the 2024/2025 academic year was 68.5 (KKM 70) with classical completeness of 45.5% (10 students); 54.5% (12 students) did not reach the KKM. In addition, based on the results of student observations during learning activities, the average student performance was 58.5%, in the sufficient category.

Low student grades in science are influenced by a lack of student activity during learning activities. During lessons, students tend to pay less attention to teacher explanations and become noisy. Students tend to be passive and uninterested in the material, and some talk with friends about matters unrelated to the lesson. Monotonous learning activities make students lose focus and become bored easily. Therefore, improvements in learning are needed to address these issues.

Teachers need learning models that develop student creativity and engage students actively. Problem-based learning is one such model. In this model, students are presented with real-world problems to be solved through group collaboration. Problem-based learning (PBL) develops students' thinking and problem-solving skills and their independence. (Hasanah et al., 2021)

Cooperative learning is an instructional approach that emphasizes collaboration among students in small groups to achieve shared learning goals. In this model, students are responsible for their own learning outcomes and for the success of their group members. The key principles of cooperative learning are positive interdependence, individual accountability, face-to-face interaction, interpersonal and small-group skills, and group evaluation. (Johnson & Johnson, 2009)

Problem-Based Learning is a form of learning based on the constructivist paradigm, oriented toward student-centered learning. Problem-Based Learning focuses on presenting a problem (real or simulated) to students, and asks them to find a solution through investigation based on theories, concepts, and principles from various disciplines. The problem serves as the focus, stimulus, and guide for the learning process, while the teacher acts as a facilitator and guide. (Mayasari et al., 2022)

In addition to the Problem Based Learning model, the STAD model is also suitable for increasing student creativity through small-group learning. According to Artini (in Wahyunal & Gazali, 2022) the STAD model has the advantage that students can help each other with existing problems. The method encourages students to discuss in pre-arranged groups. In addition, according to (Amelia et al., 2022) the STAD learning model has the following advantages: (1) students work together to achieve goals by upholding group norms, (2) students actively help and motivate one another to succeed together, (3) students act as peer tutors to increase group success, (4) improve individual and group skills, and (5) the model is not competitive.

Evidence on both models is substantial. Meta-analyses of Indonesian elementary school studies report large effects of PBL on critical thinking, with a mean effect size of 1.065 across 12 studies (Setyowati & Sutikno, 2024) and a strong effect across 25 SINTA-indexed studies (Sa'diyah et al., 2024). In science specifically, PBL had large effects on critical thinking and problem-solving (ES = 0.798 across 42 studies; Aripin et al., 2025) and on science problem-solving skills (ES = 1.33; Yanto et al., 2026). In IPAS, a classroom action study in a fourth-grade class in Padang raised mastery to at least 85% after two PBL cycles (Amelia et al., 2026). For cooperative learning, a meta-analysis of 59 classroom studies found a medium effect on achievement (ES = 0.54), with stronger effects in science and mathematics (Kyndt et al., 2013). A meta-analysis of STAD in elementary social studies reported a mean increase in learning outcomes of 34.61% (Rifai, 2019).

Problem Based Learning (PBL) and Student Team Achievement Division (STAD) are learning models expected to improve the quality of learning processes and outcomes. PBL emphasizes real-world problem-based learning that can train students' critical thinking and problem-solving skills, while STAD emphasizes collaboration in heterogeneous groups to achieve shared learning goals. Most of the PBL evidence above concerns critical thinking or problem-solving rather than achievement tests, and most STAD studies come from other subjects. Few studies have tested both models on the integrated IPAS subject introduced by the Kurikulum Merdeka, and their use in sixth-grade IPAS in Trangkil District, Pati Regency, is still limited. It is therefore not known how much each model improves IPAS learning outcomes in this setting compared with direct instruction.

Research is therefore needed on the effectiveness of the Problem Based Learning and Student Team Achievement Division models on sixth-grade science learning outcomes. This study tested PBL and STAD, each against a control class taught with direct instruction, in sixth-grade IPAS classes in Trangkil District. It provides local evidence that teachers in the Ki Hajar Dewantara Cluster can use when choosing a learning model.

LITERATURE REVIEW

A learning model is a conceptual framework that describes a systematic procedure for organizing learning experiences to achieve specific learning objectives and serves as a guideline for learning designers and teachers in planning learning activities. (Asmara, 2023)

Problem-Based Learning (PBL) is a learning approach that uses real-world problems as a context for students to learn critical thinking and problem-solving skills, as well as to acquire essential knowledge and concepts from the subject matter. PBL is a learning approach based on cognitive theory, including constructivist learning theory. According to constructivist theory, students develop thinking and problem-solving skills when they discover knowledge independently and transfer it to complex situations. (Hermansyah, 2020)

The Problem-Based Learning model is defined as an instructional approach that engages students in solving problems through various stages of the scientific method; consequently, students are expected to acquire knowledge related to the problem while simultaneously developing problem-solving skills. (Atmasari & Murniati, 2024)

The problem-based learning model is an instructional approach that presents problems to stimulate student learning. In the classroom, students collaborate in teams to solve problems and seek solutions to real-world issues. (Ishlahul & Haryanti, 2023)

Slavin (in Adnyana, 2020) explains that in the STAD cooperative learning model, students are divided into study groups with varying ability levels, genders, and backgrounds. The teacher delivers the material, then students work in groups, ensuring that all members have mastered the material. Next, all students work on problems related to the material individually, and while working, they are not allowed to help each other.

Learning outcomes are the results achieved by students after participating in learning activities. These outcomes can include abilities related to knowledge, attitudes, and skills acquired after undergoing learning experiences. (Rahman, 2021)

According to (Ridho'i, 2022), factors influencing learning outcomes include internal factors, such as biological and psychological condition, maturity, intelligence, training, motivation, and student attitudes toward learning. External factors are influences from outside the individual, such as the family, community, and school environment.

IPAS (Natural and Social Sciences) combines two subjects, natural science and social science, into one. The integration is intended to help students understand and manage their natural and social environments within one framework. By collaborating natural science with social science, it is hoped that the values or elements contained in the Pancasila student profile can be effectively implemented by students. (Benu & Mbuik, 2024)

IPAS is a field of study that examines living beings and their interactions with the environment and the universe. Humans, for instance, are living beings that cannot survive in isolation. In short, IPAS blends Natural Sciences (IPA) and Social Sciences (IPS). (Meylovvia & Julianto, 2023)

According to Iskandar (in Fadila & Fitriyani, 2024), the Merdeka (independent) curriculum differs from the previous curriculum in that science and social studies are combined into IPAS (Natural and Social Sciences). Combining the two subjects aims to develop inquiry skills and students' understanding of themselves and their environment. In IPAS learning, teachers help students develop curiosity about phenomena around them.

Research Objectives

This study aimed to determine the effectiveness of PBL and of STAD on the IPAS learning outcomes of sixth-grade elementary school students in Trangkil District, Pati Regency, and to compare the two models.

RESEARCH METHOD

Research Design

The research design used was a quasi-experimental design with a nonequivalent control group design. Quasi-experimental designs, like true experiments, aim to test causal relationships with a treatment in an intervention group. This design requires a control group, but the grouping is not randomized. Quasi-experimental designs identify a control group that is as similar as possible to the intervention group in terms of baseline characteristics (pre-intervention). (Shadish et al., 2002)

This design uses two intact groups that are not formed by random assignment. One group receives a treatment, while the other group does not. At the end of the experiment, both groups take the same test. In this study, both groups also took a pretest before the treatment (Shadish et al., 2002).

Respondents of the Study

The population consisted of 332 sixth-grade elementary school students in Trangkil District, Pati Regency, Indonesia. Cluster sampling was used, in which sample members are drawn from the population by regional group. The research instrument consisted of two parts: multiple-choice test items (Part I) and a process skills checklist (Part II).

RESULTS

The learning outcomes analyzed in this study were pretest and posttest scores. Before the treatment, the sampled students took a pretest consisting of 20 multiple-choice questions to test their initial understanding of the learning material. The pretest and posttest scores are presented below.

Table 1. Pretest and posttest results of science learning outcomes for experimental class 1

No	Class	Average Pre Test	Average Post Test
1.	Experiment 1 (SDN Mojoagung 02)	60.34	85.17
2.	Control 1 (SDN Karangwage 01)	58.44	69.31

Table 1 shows that the average pre-test score in control class 1 was 58.44. After the pre-test, the control class was taught as usual with a direct learning model, and its average post-test score was 69.31. Meanwhile, the average pre-test score in experimental class 1 was 60.34. After learning with the Problem Based Learning model, its average post-test score was 85.17. These descriptive results suggest that Problem Based Learning is effective for grade VI science learning, which the t-test below examines.

Table 2. Results of the effectiveness test of Problem-Based Learning on grade VI science learning outcomes

		Levene's Test for Equality of Variances		t-test for Equality of Means					
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% CI of the Difference (Lower)
Score	Equal variances assumed	.244	.623	8.596	56	.000	15.850	1.844	12.157
	Equal variances not assumed			8.596	55.943	.000	15.850	1.844	12.156

Table 2 shows that the calculated t value is 8.596 > t table 1.699, and the 2-tailed significance is 0.000 < 0.05, so H0 is rejected. The Problem Based Learning model therefore has a significant effect on the science learning outcomes of grade VI students of elementary schools in Trangkil sub-district, Pati district.

Table 3 presents the pretest and posttest scores of the STAD experimental class and its control class.

Table 3. Pretest and posttest results of science learning outcomes for experimental class 2

No	Class	Average Pre Test	Average Post Test
1.	Experiment 2 (SDN Guyangan)	57.18	82.50
2.	Control 2 (SDN Tlutup)	55.46	67.03

Table 3 shows that the average pre-test score in control class 2 was 55.46. After the pre-test, the control class was taught as usual with a direct learning model, and its average post-test score was 67.03. Meanwhile, the average pre-test score in experimental class 2 was 57.18. After learning with the Student Team Achievement Division model, its average post-test score was 82.50. These descriptive results suggest that Student Team Achievement Division is effective for grade VI science learning, which the t-test below examines.

Table 4. Results of the effectiveness test of Student Team Achievement Division on grade VI science learning outcomes

		Levene's Test for Equality of Variances		t-test for Equality of Means					
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% CI of the Difference (Lower)
Score	Equal variances assumed	.010	.921	8.555	62	.000	15.469	1.808	11.854
	Equal variances not assumed			8.555	61.989	.000	15.469	1.808	11.854

Table 4 shows that the calculated t value is 8.555 > t table 1.693, and the 2-tailed significance is 0.000 < 0.05, so H0 is rejected. The STAD model therefore has a significant effect on the science learning outcomes of grade VI students of elementary schools in Trangkil sub-district, Pati district.

DISCUSSION

The first finding is that the PBL class outperformed its control class. The PBL class reached a posttest mean of 85.17 against 69.31 in the control class, a difference of 15.85 points ($t = 8.596$, $df = 56$, $p < .05$; Tables 1 and 2), and classical mastery was 86% against 59%. PBL starts from a problem that students must investigate in groups, so students have to retrieve, discuss and apply IPAS concepts instead of memorizing them. This fits the constructivist account of PBL (Hermansyah, 2020) and addresses the problem identified in the preliminary observations, where students found memorization-heavy science boring. The result agrees with Indonesian studies that reported higher learning outcomes after PBL (Marwah et al., 2021) and with the PBL cycles in fourth-grade IPAS reported by Amelia et al. (2026). It is also consistent with the large effects in meta-analyses of PBL in science (Aripin et al., 2025; Yanto et al., 2026), although those reviews mostly measured critical thinking and problem-solving, whereas this study used a 20-item achievement test. The present result adds evidence that PBL can also raise achievement scores in the integrated IPAS subject.

The second finding is that the STAD class also outperformed its control class. The STAD class reached a posttest mean of 82.50 against 67.03, a difference of 15.47 points ($t = 8.555$, $df = 62$, $p < .05$; Tables 3 and 4), with classical mastery of 72% against 44%. In STAD, students study in mixed-ability teams but take quizzes individually, and team recognition depends on each member's improvement (Adnyana, 2020). Positive interdependence and individual accountability of this kind are the conditions under which cooperative learning raises achievement (Johnson & Johnson, 2009). The result agrees with the medium average effect of cooperative learning on achievement, which was stronger in science and mathematics (Kyndt et al., 2013), with the gains reported for STAD in elementary social studies (Rifai, 2019), and with STAD studies in Indonesian elementary schools (Amelia et al., 2022; Ningsih & Wulandari, 2022).

The third question was how the two models compare. The PBL class reached a higher posttest mean than the STAD class (85.17 against 82.50) and higher classical mastery (86% against 72%). This difference should not be

read as evidence that PBL is more effective. The two models were taught in different schools, the PBL class started from a higher pretest mean (60.34 against 57.18), and measured from pretest to posttest the two experimental classes gained by similar amounts (Tables 1 and 3). The two experimental-control differences were also almost the same size (15.85 and 15.47 points). The data therefore support a more modest conclusion: both models produced clearly higher IPAS outcomes than direct instruction, and the study gives no evidence that one is better than the other. A direct comparison would require an analysis of covariance on the posttest with the pretest as covariate, or a test of gain scores between the PBL and STAD classes.

For teachers in Trangkil District, these findings are useful because the baseline was weak. Before the study, the sixth-grade science mean at SDN Mojoagung 02 was 68.5, below the KKM of 70, and fewer than half of the students reached it. Both models moved most students above that level. Teachers can choose between them by topic and class. PBL suits IPAS topics that can be framed as local problems, such as waste, water or energy use in the village, while STAD suits topics that require mastering a body of concepts, where team quizzes and improvement points keep all students accountable. Teacher working groups (KKG) could share problem scenarios and STAD team materials so that teachers do not have to prepare them alone. Both models need more preparation and class time than direct instruction. PBL in particular depends on the teacher's skill in guiding inquiry without giving answers away, so short training or peer observation within the cluster would help teachers adopt it. Principals can support this by timetabling longer IPAS blocks for problem-based units.

The study has several limitations. The nonequivalent control group design used intact classes, and each model was taught in a different school, so school, teacher and class differences are confounded with the treatment (Shadish et al., 2002). Pretest equivalence between the experimental and control classes was not tested, and only posttests were compared. The t-table values reported (1.699 and 1.693) do not correspond to the degrees of freedom in Tables 2 and 4, although the conclusions would not change. Effect sizes were not reported; in education research they are needed to judge practical importance against the design of the study (Kraft, 2020). The validity and reliability results for the 20-item test and the class sizes are not reported, and the process-skills checklist and observation data mentioned in the method were not analyzed. Future studies should compare PBL and STAD directly within the same schools, adjust for pretest scores, report effect sizes, and add measures of critical thinking and delayed retention.

CONCLUSION

Problem-Based Learning was effective in improving the science learning outcomes of sixth-grade elementary school students in Trangkil District, Pati Regency. The average learning outcome of experimental class 1 was 85.17 with a classical completion rate of 86%, while control class 1 obtained an average score of 69.31 with a classical completion rate of 59%. The t-test gave a calculated t value of 8.596 > t table 1.699, with a 2-tailed significance of 0.000 < 0.05, so H0 is rejected.

Student Team Achievement Division was effective in improving the science learning outcomes of sixth-grade elementary school students in Trangkil District, Pati Regency. The average learning outcome of experimental class 2 was 82.5 with a classical completion rate of 72%, while control class 2 obtained an average score of 67.03 with a classical completion rate of 44%. The t-test gave a calculated t value of 8.555 > t table 1.693, with a 2-tailed significance of 0.000 < 0.05, so H0 is rejected.

Problem-Based Learning produced higher science learning outcomes than Student Team Achievement Division among sixth-grade elementary school students in Trangkil District, Pati Regency. Experimental class 1 obtained an average score of 85.17 with a classical completion rate of 86%, while control class 1 obtained an average score of 69.31 with a classical completion rate of 59%. The t-test of PBL against its control class gave a t-value of 8.596 > t-table 1.699, with a 2-tailed significance of 0.000 < 0.05, so H0 is rejected. This test compares PBL with its control class, not with STAD, so the advantage of PBL over STAD is descriptive and has not been tested statistically.

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REFERENCES

Adnyana, M. E. (2020). Implementasi model pembelajaran STAD untuk meningkatkan motivasi dan prestasi belajar. *Indonesian Journal of Educational Development*, *1*(3), 496–505.

Amelia, E., Attalina, S., & Widiyono, A. (2022). Pengaruh model kooperatif tipe STAD berbantuan media manipulatif terhadap hasil belajar siswa di sekolah dasar. *Jurnal Pendidikan Dan Konseling*, *4*(3), 543–547.

Amelia, C., Zuryanty, Fitria, Y., & Fitri, U. (2026). Peningkatan hasil belajar peserta didik pada pembelajaran IPAS menggunakan model problem based learning (PBL) di kelas IV SDN 21 Bandar Buat Kota Padang. Pendas: Jurnal Ilmiah Pendidikan Dasar, 11(1), 33-44. https://doi.org/10.23969/jp.v11i01.42240

Aripin, N., Festiyed, Yerimadesi, Alberida, H., Ahda, Y., & Mufit, F. (2025). The impact of problem-based learning on science learning to improve students' critical thinking and problem-solving skills: A meta-analysis. Jurnal Penelitian Pendidikan IPA, 11(6), 45-57. https://doi.org/10.29303/jppipa.v11i6.10051

Asmara. (2023). Model pembelajaran berkonteks masalah (M. Suardi, Ed.). CV Azka Pustaka.

Atmasari, R., Murniati, N. A. N., & Resmiwati. (2024). Implementasi model pembelajaran problem based learning (PBL) dengan media flipchart pada pembelajaran bahasa Indonesia: Studi pada peserta didik kelas V sekolah dasar. *Jurnal Inovasi, Evaluasi, dan Pengembangan Pembelajaran*, *4*(2), 251–259. http://journal.ainarapress.org/index.php/jiepp

Benu, A. Y., & Mbuik, H. B. (2024). Analisis peran IPAS mewujudkan profil pelajar Pancasila sebagai gambaran ideal pembentukan karakter siswa sekolah dasar. *HINEF: Jurnal Rumpun Ilmu Pendidikan*, *3*(1), 76.

Fadila, F., & Fitriyani. (2024). Implementasi Kurikulum Merdeka pada pembelajaran IPAS di sekolah dasar. *Didaktika: Jurnal Kependidikan*, *13*(4), 4357–4366.

Hasanah, U., Sarjono, S., & Hariyadi, A. (2021). Pengaruh model problem based learning terhadap prestasi belajar IPS SMP Taruna Kedung Adem. *Aksara: Jurnal Ilmu Pendidikan Nonformal*, 7(1), 43–52. https://doi.org/10.37905/aksara.7.1.43-52.2021

Hermansyah. (2020). Problem based learning in Indonesian learning. *Workshop Nasional Penguatan Kompetensi Guru Sekolah Dasar SHEs: Conference Series*, *3*(3), 2257–2262.

Ishlahul, I., & Haryanti. (2023). Pengaruh model problem based learning terhadap kemampuan berpikir kreatif siswa pada pembelajaran IPA. *Papanda Journal of Mathematics and Sciences Research*, *2*(1), 49–56.

Johnson, D. W., & Johnson, R. T. (2009). An educational psychology success story: Social interdependence theory and cooperative learning. *Educational Researcher*, *38*(5), 365–379. https://doi.org/10.3102/0013189X09339057

Kraft, M. A. (2020). Interpreting effect sizes of education interventions. Educational Researcher, 49(4), 241–253. https://doi.org/10.3102/0013189X20912798

Kyndt, E., Raes, E., Lismont, B., Timmers, F., Cascallar, E., & Dochy, F. (2013). A meta-analysis of the effects of face-to-face cooperative learning: Do recent studies falsify or verify earlier findings? Educational Research Review, 10, 133-149. https://doi.org/10.1016/j.edurev.2013.02.002

Marwah, H., Suchyadi, Y., & Mahajani, T. (2021). Pengaruh model problem based learning terhadap hasil belajar subtema manusia dan benda di lingkungannya. *Journal Of Social Studies, Arts And Humanities (JSSAH)*, 1(1), 42–45.

Mayasari, A., Arifudin, O., & Juliawati, E. (2022). Implementasi model problem based learning (PBL) dalam meningkatkan keaktifan pembelajaran. *Jurnal Tahsinia*, *3*(2), 167–175.

Meylovvia, D., & Julianto, A. (2023). Inovasi pembelajaran IPAS pada Kurikulum Merdeka Belajar di SDN 25. *Jurnal Pendidikan Islam Al-Affan*, *4*(1), 84–91.

Ningsih, E., & Wulandari, R. (2022). Pengaruh model pembelajaran student team achievement division (STAD) terhadap hasil belajar serta kemampuan berpikir kritis siswa. *Edukatif : Jurnal Ilmu Pendidikan*, *4*(3), 4828–4838. https://doi.org/10.31004/edukatif.v4i3.3073

OECD. (2023). PISA 2022 results (Volume I): The state of learning and equity in education. OECD Publishing. https://doi.org/10.1787/53f23881-en

Rahman, S. (2021). Pentingnya motivasi belajar dalam meningkatkan hasil belajar. *Prosiding Seminar Nasional Pendidikan Dasar "Merdeka Belajar Dalam Menyambut Era Masyarakat 5.0,"* 289–302.

Ridho'i, M. (2022). Analisis faktor-faktor yang mempengaruhi hasil belajar matematika siswa MTs Miftahul Ulum Pandanwangi. *Jurnal E-DuMath*, *8*(2), 118–128.

Rifai, M. (2019). Meta-analisis keefektifan model pembelajaran student team achievement division (STAD) dalam meningkatkan hasil belajar IPS siswa SD. Primary: Jurnal Pendidikan Guru Sekolah Dasar, 8(2), 173-179. https://doi.org/10.33578/jpfkip.v8i2.7119

Sa'diyah, H., Umalihayati, Hidayah, R., Salimi, M., Fajari, L. E. W., Mashudi, & Aini, S. (2024). The effect of problem based learning model on critical thinking skills in elementary school: A meta analysis study. Jurnal Iqra': Kajian Ilmu Pendidikan, 9(1). https://doi.org/10.25217/ji.v9i1.4456

Setyowati, N., & Sutikno, P. Y. (2024). Meta analisis: Model pembelajaran problem based learning (PBL) terhadap keterampilan berpikir kritis siswa sekolah dasar. Jurnal Inovasi Pendidikan dan Pembelajaran Sekolah Dasar, 8(2), 587-599. https://doi.org/10.24036/jippsd.v8i2.127679

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). Experimental and quasi-experimental designs for generalized causal inference. Houghton Mifflin.

Wahyunal, W., & Gazali, N. (2022). Kajian penelitian: Model student teams achievement division (STAD) dalam penjas. *Journal Of Sport Education (JOPE)*, 5(1), 11–18. https://doi.org/10.31258/jope.5.1.11-18

Yanto, F., Sulistianingsih, M., Erfani, D., Nisa, K., Aini, N., & Dito. (2026). Effectiveness of problem-based learning on science problem-solving skills: A meta-analysis. Journal of Turkish Science Education, 23(1), 91-108. https://doi.org/10.36681/tused.2026.005

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

The Influence of Principal Leadership and Teacher Professionalism on the Quality of Learning in Elementary Schools

Lilian Maharani[1*], Gunawan Setiadi[1] and Ahmad Hariyadi[1]

[1]*Postgraduate Program in Elementary Education, Universitas Muria Kudus, Indonesia*

ABSTRACT

This study aims to analyze the role of principal leadership and teacher professionalism in improving the quality of learning at elementary schools in Kaliwungu District, Kudus Regency. The main focus of this study is the extent to which principal leadership as an educational manager is able to create a conducive school environment, and how the level of teacher professionalism in carrying out pedagogical, professional, social, and personal duties contributes to the quality of the learning process and outcomes. This study used a quantitative method with an ex-post facto approach. The sample comprised 109 elementary school teachers. Data collection was conducted through a questionnaire that had been tested for validity and reliability. Data were analyzed with PLS-SEM in SmartPLS version 4.0. Principal leadership and teacher professionalism had significant effects on learning quality and together explained 57.3% of its variance. Principal leadership had a small effect: it contributes to learning quality, but its contribution is limited. Teacher professionalism had a very large effect and is the main predictor of learning quality.

KEYWORDS principal leadership | teacher professionalism | learning quality

INTRODUCTION

Elementary education lays the foundation of students' cognitive, affective, and psychomotor abilities (Sidik et al., 2024). At this level, the learning process is key to developing basic competencies that will support success at the next level. Studies show that the quality of learning in elementary schools strongly influences student achievement at the next level (Marlena et al., 2023; Nugroho et al., 2022). Therefore, improving the quality of elementary education is a serious concern for all stakeholders, including the central government, regional governments, and educational institutions (Karwono & Susetyo, 2021). One important aspect is how principals and teachers lead in creating meaningful learning experiences for students. Research shows that educational success depends heavily on the ability of school leaders to empower educators and develop innovations in teaching methods (Afridoni et al., 2022; Sidik et al., 2024; Triwiyanto et al., 2023).

The principal acts as the implementer of autonomy in educational institutions, with the primary task of supporting the government in achieving the Educational Goals as stipulated in Law Number 20 of 2003 concerning the National Education System. Given these responsibilities, a principal needs the personality and leadership qualities to lead and to care for school resources, including teachers, so that their performance is maintained and improved. In practice, principals often simply follow orders from above without considering the needs of their school, which suggests a lack of initiative in developing school programs (Ndoen & Manurung, 2021).

In Kudus Regency, particularly in Kaliwungu District, there are various elementary schools, both public and private, each with distinct characteristics and educational quality achievements. Monitoring and evaluation results conducted by the Kudus Education and Culture Office in 2025 showed a marked gap in the quality of learning between these schools. Some schools demonstrated satisfactory academic achievements and active and effective learning activities, while others still faced a number of serious challenges. Some of these challenges include low student learning outcomes that fall short of expectations, a lack of innovation in teaching methods, and a weak school culture that should support effective and enjoyable learning.

The quality of learning in elementary schools still faces various challenges. National accreditation data have also been used to map wide differences in quality between schools (Karwono & Susetyo, 2021). Principal leadership and teacher professionalism are considered key determinants of learning quality. As educational leaders, principals mobilize, direct, and develop teacher potential to create a school climate conducive to learning. Teachers, who carry out the educational process directly, need professional competencies encompassing mastery of subject matter, learning methodologies, pedagogical skills, and personal integrity.

However, in several elementary schools in Kaliwungu District, the role of principals tends to be limited to administrative aspects. Many principals are not optimally fulfilling their role as leaders who can drive change and innovation in learning. This focus on administration leaves little attention for learning strategies and for strengthening teacher capacity, and teachers may receive little support for innovative teaching.

In addition to principal leadership, teacher professionalism is also a crucial factor in determining the quality of learning in elementary schools. Teacher professionalism involves more than formal education; it also covers the extent to which the teacher has mastered the various competencies necessary to support an effective learning process (Memet, 2020). These competencies include pedagogical competence, which encompasses the ability to design and implement learning that meets student needs (Eliza et al., 2022); professional competence, which requires mastery of learning materials (Firmadani, 2022); social competence, which encompasses the ability to interact with students, colleagues, and the community (Rismayanti et al., 2021); and personality competence, which reflects attitudes and behaviors based on moral and ethical values as educators (Permatasari & Arianto, 2022).

Teacher professionalism is also closely linked to the managerial environment created by the principal. The principal's leadership helps create a conducive work climate, providing motivation, and guiding teachers to improve their competence (Eddy et al., 2017; Saingo, 2023). Research shows that effective principals have the ability to improve the school climate and collaborate with teachers to create an atmosphere that supports quality learning (Werang, 2018). The relationship between principal leadership and teacher competence is therefore central to improving educational quality. This aligns with findings that conclude that principal support significantly influences teacher work commitment, which in turn can improve the quality of teaching in elementary schools (Rapang et al., 2022).

Quantitative studies support these links. International reviews conclude that principals affect student learning mainly through their effects on teachers' motivation, capacity and working conditions (Leithwood et al., 2020). A meta-analysis of 27 studies found that the leadership dimension most strongly related to student outcomes was promoting and participating in teacher learning and development (Robinson et al., 2008). In Indonesia, a PLS-SEM study of 119 junior high school teachers and principals in Aceh Besar found that principal leadership affected teacher motivation (0.422) and teacher performance (0.388) (Sariakin et al., 2025). Among 163 elementary teachers in Sukabumi, principals' transformational leadership correlated with job satisfaction ($r = 0.694$) (Nurhadidjah et al., 2023). On the teacher side, the professional competence of junior high school teachers has been linked to the quality of learning (Rismayanti et al., 2021), and principals' leadership has been linked to elementary teachers' performance (Ndoen & Manurung, 2021).

However, studies and teacher training data obtained through the local Education Coordinator indicate that many teachers still face challenges in implementing more innovative learning concepts. Most teachers still struggle to design and implement learning based on the Independent Curriculum, which requires greater flexibility in developing lesson plans that focus on student needs and interests. Many teachers have also not taken part in ongoing professional development or fully adopted student-centered learning, which suggests that they need more support through training, coaching and access to resources.

Most of these studies take teacher performance, motivation or job satisfaction as the outcome. Fewer place principal leadership and teacher professionalism in one model with learning quality as the outcome, and few report effect sizes that show how much each predictor contributes. We found no study of this kind in elementary schools in Kudus Regency, where monitoring has shown wide differences in learning quality between schools.

Improving the quality of learning in elementary schools therefore depends on both effective principal leadership and high teacher professionalism. Both play complementary roles in creating a productive learning environment oriented towards developing student potential. This study therefore examines the influence of principal leadership and teacher professionalism on the quality of learning in elementary schools in Kaliwungu District, Kudus Regency. Using PLS-SEM, it estimates the significance and the effect size (f^2) of each predictor and their joint explanatory power (R^2), so that schools and the Education Office can see where improvement efforts are likely to matter most.

LITERATURE REVIEW

Principal Leadership

Principal leadership is the ability and authority of a principal to influence, motivate, and direct the actions of all school components, such as teachers, staff, and students, to effectively achieve educational goals. The principal acts as the official leader and manager, driving school activities and ensuring the achievement of the institution's vision and mission. Principal leadership shapes the direction of the school and its culture of quality.

Leadership in the educational context is inseparable from the development of an organizational culture that supports the active participation of all members (Leithwood et al., 2020). Good leadership can create an environment that is conducive to learning and that stimulates the professional growth of educators (Wahyudi et al., 2021). Leadership is thus key to an effective and sustainable learning environment and to achieving educational goals (Robinson et al., 2008; Saefurridja et al., 2023).

Indicators of principal leadership include: (1) formulating a clear vision and mission that is understandable to all school members; (2) developing a learning-oriented school culture; (3) conducting systematic academic supervision; (4) encouraging teacher professional development; (5) providing resource support to support learning; and (6) building collaborative relationships between teachers and staff (Glickman et al., 2018).

Teacher Professionalism

Teachers are a key determinant of success in education and improving the quality of human resources. Teachers also impart knowledge and provide guidance, direction, and motivation, preparing students to become the nation's next generation. Teacher competence determines how effectively teachers carry out their roles. A teacher's professional competence is the foundation of the discipline they study or specialize in, encompassing theoretical and practical mastery, didactic, methodological, and psychological skills, planning and management skills, and the ability to evaluate teaching and learning outcomes. At school, the teacher acts as a second parent and a role model who can win students' sympathy. Teachers must be able to motivate their students to actively engage in learning activities in and outside the classroom, and independently at home. The teacher's role in the community sector is to educate and teach the community to become responsible citizens who uphold moral, social, and religious values, and to help the community develop (Sari et al., 2025).

Indicators of teacher professional competence include: (a) mastering the material, structure, concepts, and scientific thought patterns that support the subjects taught; (b) mastering the competency standards and basic competencies (SK/KD) of the subjects taught; (c) having the ability to develop learning materials creatively; (d) being able and willing to act reflectively to develop professionalism as a teacher in a sustainable manner; and (e) being able and willing to use Information and Communication Technology in the learning process to meet current challenges (Kementerian Pendidikan Nasional, 2007).

Learning Quality

The quality of learning depends not only on what is taught but also on how learning activities are designed. The quality of education is not solely assessed by the final outcome, but also by the educational process itself (Afifa, 2024). This process involves various inputs, such as the competence of teachers, educational staff, the curriculum, and the availability of facilities and infrastructure. In this context, the quality of learning reflects the overall quality of the learning experience provided to students. The quality of learning is also closely related to the teacher's mastery of knowledge and teaching skills (Rismayanti et al., 2021). A professional teacher is expected to be able to deliver material effectively, in accordance with the professional code of ethics, and so contribute to the quality of education in the classroom. Learning quality indicators generally include three main aspects, namely: (1) thorough, standard-compliant learning planning, (2) effective, interactive and contextual learning implementation, and (3) comprehensive, objective and continuous learning evaluation (Susila, 2023).

Research Objectives

This study aims to (a) analyze the influence of principal leadership on the quality of learning in elementary schools in Kaliwungu District, Kudus Regency; (b) analyze the influence of teacher professionalism on the quality of learning in elementary schools in Kaliwungu District, Kudus Regency; and (c) analyze the influence of principal leadership and teacher professionalism on the quality of learning in elementary schools in Kaliwungu District, Kudus Regency.

RESEARCH METHOD

Research Design

This research is a quantitative correlational study of the relationship of principal leadership and teacher professionalism with the quality of learning in elementary schools. The design used is ex post facto, which is research conducted to examine events that have already occurred and then trace them back to identify the factors that may have caused them.

Respondents of the Study

The population in this study was elementary school teachers in Kaliwungu sub-district, Kudus Regency. The sample size was determined with the Slovin formula. The population size in this study was 150 people (N = 150), with a margin of error set at 5% or 0.05.

$$n = N / (1 + N \times e^2) = 150 / (1 + 150 \times 0.05^2) = 150 / 1.375 \approx 109.09$$

Because the sample size must be an integer, the sample size was 109.

Data were collected through a questionnaire and documentation. The questionnaire consisted of 15 items/statements on principal leadership, 15 on teacher professionalism, and 15 on learning quality. The measurement scale used was a Likert scale with a continuous range of 1–5.

This study employed a quantitative approach using Structural Equation Modeling based on Partial Least Squares (SEM-PLS) analysis to determine the relationship between the independent variables (principal leadership and teacher professionalism) and the dependent variable (learning quality).

RESULTS

The data were analyzed with the Structural Equation Modeling (SEM) PLS approach, which estimates the relationships between latent variables and their indicators simultaneously. Convergent validity tests are shown in Table 1 below.

Table 1. Convergent validity test

	Average variance extracted (AVE)	
Principal Leadership	0.599	Valid
Teacher Professionalism	0.651	Valid
Learning Quality	0.635	Valid

The AVE values were 0.599 for principal leadership, 0.651 for teacher professionalism, and 0.635 for learning quality. All three exceed 0.50, which indicates adequate convergent validity.

Cronbach's alpha values were used to assess the reliability of the constructs (Table 2).

Table 2. Cronbach's alpha

	Cronbach's alpha	
Principal Leadership	0.916	Reliable
Teacher Professionalism	0.893	Reliable
Learning Quality	0.928	Reliable

The analysis results in the table show that the Cronbach's alpha value for the principal leadership construct is 0.916, the teacher professionalism variable is 0.893, and the learning quality variable is 0.928. All Cronbach's alpha values are ≥ 0.70, so all variables have good reliability.

Model Fit Test

The model fit test was conducted by comparing the estimated output results of Smart PLS version 4.0 with the criteria described in the following table.

Table 3. Model fit test results

	Rule of Thumb	Estimated model	
SRMR	< 0.10	0.092	Fit
d_ULS	> 0.05	2.523	Fit
d_G	> 0.05	1.531	Fit
Chi-square	X^2 statistic ≥ X^2 table	625.401	Unfit
NFI	Approaching the value 1	0.668	Fit

The SRMR (Standardized Root Mean Square Residual) value of 0.092 is below the maximum limit of 0.1, which indicates acceptable fit: the difference between the observed covariance matrix and the model covariance matrix is small.

1. d-ULS (Unweighted Least Squares): the d-ULS value was 2.523 (criterion used: > 0.05).
2. d_G: the d_G value was 1.531 (criterion used: > 0.05).
3. Chi-square: the statistic was 625.401, greater than the Chi-square table value of 49.802, so the model does not fit by this test. This indicates that the proposed structural model does not fit the empirical data or there is a discrepancy between the theoretical model and the observed data. The Chi-square test is sensitive to sample size and can reject reasonably fitting models when samples are large. With the present sample size, however, this explanation carries limited weight.
4. NFI (Normed Fit Index): the NFI value of 0.668 is well below the ideal value of 1, which indicates only modest fit.
5. Overall, the fit indices are mixed, so the global model fit should be interpreted with caution.

Inner Model (Hypothesis Testing)

The direct effects were tested by bootstrapping.

The significance tests from the inner model are summarized below.

Table 4. Significance test results

	T statistics (|O/STDEV|)	P values	
Principal leadership -> quality of learning	3.193	0.001	proven
Teacher professionalism -> quality of learning	8.480	0.000	proven

1. The test results show that principal leadership has a significant effect on learning quality, with a T-statistic of 3.193 and a P-value of 0.001. Since the T-statistic is > 1.96 and the P-value is < 0.05, it can be concluded that the hypothesis is accepted. Higher ratings of principal leadership are thus associated with higher learning quality.
2. The analysis also shows that teacher professionalism has a significant effect on learning quality, with a T-statistic of 8.480 and a P-value of 0.000.
3. The T-statistic is well above the threshold of 1.96, so the hypothesis is supported. Teacher professionalism therefore appears to be the stronger predictor of learning quality in this model.
4. The test results indicate that both principal leadership and teacher professionalism significantly influence learning quality. Teacher professionalism showed a stronger influence than principal leadership, as its larger effect size (f^2) indicates.

R-Square (R^2)

R-square (R^2) is used to measure the extent to which independent variables explain the variation in the dependent variable. In this context, the dependent variable is learning quality, while the independent variables are principal leadership and teacher professionalism. The R-square values for this analysis are as follows:

Table 5. R-square results

	R-square	R-square adjusted
Teacher Professional Competence	0.573	0.563

The analysis results showed an R-square value of 0.573 and an adjusted R-square of 0.563. This indicates that:

1. 57.3% of the variation in learning quality can be explained by principal leadership and teacher professionalism simultaneously.
2. The remaining 42.7% is explained by factors outside the model, which may include government policies and educational regulations, academic supervision, the school work environment, and parent and community involvement.
3. The adjusted R-square value (0.563) is slightly lower than the pure R-square because it has been adjusted for the number of predictors in the model, providing a more accurate picture of the model's fit, especially when there is more than one predictor.
4. The R-square value of 0.573 falls in the range $0.50 \leq R^2 < 0.75$, which common PLS-SEM guidelines classify as moderate. Both independent variables (principal leadership and teacher professionalism) are significant predictors of learning quality.

Effect Size (f^2)

In Partial Least Squares – Structural Equation Modeling (PLS-SEM) analysis, effect size (f^2) is used to determine the contribution of each independent variable individually to the dependent variable. The f^2 value indicates the strength of the direct influence of an independent variable on the dependent variable.

Table 6. Effect size results

	Principal Leadership	Teacher Professionalism	Learning Quality	
Principal Leadership			0.039	Low
Teacher Professionalism			0.763	Strong

1. The influence of principal leadership on learning quality is shown with an f^2 value of 0.039. This value falls into the weak category ($f^2 \geq 0.02$), in accordance with effect size interpretation guidelines. Principal leadership therefore makes a small but statistically significant contribution to learning quality.
2. The influence of teacher professionalism on learning quality is shown with an f^2 value of 0.763. This value far exceeds the threshold for a large effect size ($f^2 \geq 0.35$), so teacher professionalism has a large effect on learning quality.
3. Teacher professionalism is the dominant factor in explaining variation in learning quality, with a very strong effect ($f^2 = 0.763$). Principal leadership also plays a role, although its contribution is small ($f^2 = 0.039$).

DISCUSSION

The Influence of Principal Leadership on Learning Quality

The analysis of the path from principal leadership to learning quality shows a T-statistic of 3.193 and a P-value of 0.001, indicating statistical significance ($T > 1.96$ and $P < 0.05$). However, the effect size (f^2) of 0.039 indicates that the magnitude of this influence is small. This finding implies that principal leadership contributes to learning quality but is not the only factor.

Although the effect was significant, the small effect size (0.039) indicates that the principal's leadership role is complementary, not dominant. Stronger principal leadership is associated with higher learning quality, but most of the variation in learning quality is explained by other factors, chiefly teacher professionalism. The principal's influence nevertheless remains important in providing a learning environment and infrastructure that support improved learning quality.

The small direct effect agrees with research showing that leaders influence learning mostly indirectly, through teachers' motivation, capacity and working conditions (Leithwood et al., 2020). It also fits Indonesian findings that link principal leadership to teacher outcomes, such as teacher motivation and performance (Sariakin et al., 2025) and job satisfaction (Nurhadidjah et al., 2023). Because the present model estimated only direct paths, part of the principal's influence may be carried by teacher professionalism and so appear as a small direct effect. A mediation model with teacher professionalism between leadership and learning quality would test this. The administrative focus of many Kaliwungu principals described in the Introduction may also play a part. The leadership practice most strongly related to student outcomes is promoting and taking part in teacher learning (Robinson et al., 2008), and administrative routines leave little time for it.

The Influence of Teacher Professionalism on Learning Quality

The results of the study indicate that teacher professionalism has a significant influence on learning quality, with a T-statistic of 8.480 and a P-value of 0.000. The effect size (f^2) is large, since values ≥ 0.35 are classified as large effects. This indicates that teacher professionalism is a dominant internal factor in shaping and improving learning quality. Higher teacher professionalism is associated with higher learning quality.

The results of this study indicate that teacher professionalism has a strong influence on learning quality (effect size = 0.763). This f^2 value (0.763) far exceeds Cohen's threshold for a large effect. This indicates that although external factors such as school leadership are important, teacher professionalism is more decisive in improving learning quality. The result is consistent with research on certified teachers' professional competence and learning effectiveness (Jumrawati & Karoluslina, 2025) and on teachers' professional competence and learning quality (Rismayanti et al., 2021). Learning quality will improve if teachers demonstrate consistent professionalism in planning, implementing, and evaluating learning.

Part of this very large effect may, however, come from the measurement design. Teacher professionalism and learning quality were both rated by the same teachers in one questionnaire, and the learning-quality indicators (planning, implementation and evaluation) overlap with what the professionalism items ask about. Shared method variance and conceptual overlap can inflate such relationships (Podsakoff et al., 2003). The f^2 of 0.763 is therefore

best read as an upper estimate until learning quality is measured independently, for example through classroom observation or supervisors' ratings.

The Influence of Principal Leadership and Teacher Professionalism on Learning Quality

Data analysis results indicate that principal leadership and teacher professionalism jointly have a significant effect on learning quality, with a coefficient of determination (R-square) of 0.573. This means that 57.3% of the variation in learning quality can be explained by the combination of these two variables, while the remaining 42.7% is explained by variables outside the research model. This R-square value indicates moderate explanatory power. Principal leadership and teacher professionalism are therefore two important predictors of learning quality in these schools.

This finding indicates that successful improvement in learning quality cannot depend solely on one variable, but rather on the synergy between principal leadership and teacher professionalism. Visionary, democratic, and quality-oriented principal leadership can create a conducive work climate, motivate teachers, and support them. In this positive climate, teachers have the opportunity to improve their professionalism through learning innovation, mastery of material, utilization of technology, and the ability to conduct appropriate evaluations.

These results are consistent with the view that effective principal leadership, both transformational and instructional, may strengthen teacher professionalism, although this path was not tested in the present model. High teacher professionalism, in turn, is strongly associated with learning quality. The findings are consistent with studies in which principal leadership was related to teachers' motivation and performance (Sariakin et al., 2025).

For Kaliwungu District, the results suggest two priorities. Because teacher professionalism was the strongest predictor, the Education Office and schools can invest in teacher working groups (KKG), lesson study and Kurikulum Merdeka training that address lesson planning, implementation and evaluation directly. The small direct effect of principals does not mean that leadership is unimportant. It suggests that principals add most value when they move from administrative tasks to academic supervision and to organising teachers' professional learning, which is the channel through which leadership is expected to work (Leithwood et al., 2020). Principal training could therefore focus on classroom observation, feedback and joint planning of professional development.

Several limitations apply. The ex post facto, cross-sectional design does not support causal conclusions, so the effects reported are statistical associations. All constructs were measured by teacher self-report, which raises the risk of common method bias (Podsakoff et al., 2003). The paper reports AVE and Cronbach's alpha but not outer loadings, composite reliability, discriminant validity (HTMT), collinearity (VIF) or path coefficients, which current PLS-SEM guidelines expect (Hair et al., 2022). The global fit indices were mixed: SRMR was 0.092, but NFI was 0.668 and the chi-square test rejected the model. The sample of 109 teachers from one district also limits generalisation. Future research should report the full measurement model, test teacher professionalism as a mediator of principal leadership, measure learning quality through observation or student outcomes, and add factors such as school culture and academic supervision.

CONCLUSION AND RECOMMENDATIONS

The conclusions of this study are; (1) principal leadership has a significant influence on the quality of learning with a T-statistic of 3.193 and a P-value of 0.001. However, the effect size (f^2) value of 0.039 indicates that the magnitude of the influence is small. Principal leadership therefore contributes to the quality of learning, but its contribution is limited; (2) teacher professionalism has a significant and dominant influence on the quality of learning, with a T-statistic of 8.480 and a P-value of 0.000. The effect size (f^2) value of 0.763 indicates that the influence is classified as very large. Teacher professionalism is therefore the main predictor of the quality of learning; and (3) principal leadership and teacher professionalism together explain 57.3% of the variance in the quality of learning. These two factors are thus key elements in improving the quality of learning.

Based on these conclusions, it is recommended that improving the quality of learning be carried out through an integrative approach that focuses on two main lines: the Education Office and school principals need to shift instructional leadership from administration toward academic facilitation, while teachers are required to prioritize

professional competency development (e.g., through KKG/MGMP and digital training) considering their very dominant role. Since the two together explain 57.3% of the variance in learning quality, school policies must synergize leadership programs and teacher professional development simultaneously, while for further researchers it is recommended to examine factors outside the model, which account for the remaining 42.7% of the variance, such as school culture, infrastructure, or student motivation.

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REFERENCES

Afifa, A. (2024). Peningkatan mutu pendidikan menurut Dr. W. Edward Deming. *Neraca Jurnal Pendidikan Ekonomi*, *9*(2), 84–96. https://doi.org/10.33084/neraca.v9i2.6152

Afridoni, A., Putra, S., Hasri, S., & Sohiron, S. (2022). Manajemen akreditasi sekolah upaya peningkatan mutu pendidikan. *Jurnal Pendidikan Tambusai*, *6*(3), 13832–13838. https://doi.org/10.31004/jptam.v6i3.4402

Eddy, A., Syafruddin, S., & Sudirman, S. (2017). Kepemimpinan kepala sekolah dalam menciptakan iklim sekolah yang kondusif di SMK Negeri 2 Mataram. *Jurnal Ilmiah Profesi Pendidikan*, 2(2), 191–205. https://doi.org/10.29303/jipp.v2i2.64

Eliza, D., Sriandila, R., Fitri, D. A. N., & Yenti, S. (2022). Membangun guru yang profesional melalui pengembangan profesionalisme guru dalam penerapan profesinya. *Jurnal Basicedu*, *6*(3), 5362–5369. https://doi.org/10.31004/basicedu.v6i3.2878

Firmadani, F. (2022). Strategi pengembangan kompetensi profesional guru sekolah menengah atas. *Jurnal Manajemen Pendidikan Jurnal Ilmiah Administrasi Manajemen Dan Kepemimpinan Pendidikan*, *3*(2), 192–207. https://doi.org/10.21831/jump.v3i2.48045

Glickman, C. D., Gordon, S. P., & Ross-Gordon, J. M. (2018). *SuperVision and instructional leadership: A developmental approach* (10th ed.). Pearson.

Hair, J. F., Jr., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2022). A primer on partial least squares structural equation modeling (PLS-SEM) (3rd ed.). Sage.

Jumrawati, & Karoluslina. (2025). Tinjauan kompetensi profesional guru bersertifikat pendidik terhadap efektivitas pembelajaran. Transformasi: Jurnal Penelitian dan Pengembangan Pendidikan Non Formal Informal, *11*(1), 150–160. https://doi.org/10.33394/jtni.v*11*i1.16867

Karwono, H., & Susetyo, B. (2021). Peta mutu satuan pendidikan di Indonesia (Studi pilotting project akreditasi 2020). *Jurnal Penelitian Kebijakan Pendidikan*, *14*(1), 1–10. https://doi.org/10.24832/jpkp.v14i1.434

Kementerian Pendidikan Nasional. (2007). *Peraturan Menteri Pendidikan Nasional Nomor 16 Tahun 2007 tentang standar kualifikasi akademik dan kompetensi guru*. Kementerian Pendidikan Nasional.

Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven strong claims about successful school leadership revisited. School Leadership & Management, 40(1), 5–22. https://doi.org/10.1080/13632434.2019.1596077

Marlena, S. A., Supangat, S., & Yuliantoro, A. T. (2023). Mutu pembelajaran tematik di tingkat pendidikan dasar kelas rendah sekolah dasar. *Attadrib Jurnal Pendidikan Guru Madrasah Ibtidaiyah*, *5*(2), 76–83. https://doi.org/10.54069/attadrib.v5i2.279

Memet, M. (2020). Peningkatan profesionalitas guru dalam pemanfaatan lingkungan sekolah sebagai sumber belajar melalui in house training. *Jurnal Ilmiah Pendidikan Profesi Guru*, *3*(2), 318. https://doi.org/10.23887/jippg.v3i2.28991

Ndoen, E., & Manurung, A. S. (2021). Pengaruh kepemimpinan kepala sekolah terhadap kinerja guru sekolah dasar negeri di Kecamatan Balaraja. *Jurnal Inovasi Penelitian*, *2*(3), 1025–1036. https://stp-mataram.e-journal.id/JIP/article/view/810

Nugroho, A. S., Suryanti, S., & Wiryanto, W. (2022). Peningkatan kualitas guru, sebanding dengan peningkatan pendidikan? *Jurnal Basicedu*, *6*(5), 7758–7767. https://doi.org/10.31004/basicedu.v6i5.3354

Nurhadidjah, A., Rusti, E. R., & Hidayat, Z. (2023). Hubungan gaya kepemimpinan transformasional kepala sekolah dan budaya organisasi sekolah dengan kepuasan kerja guru SD di Kecamatan Cidahu. Journal of Contemporary Issue in Elementary Education, 1(1), 62–71. https://doi.org/10.33830/jciee.v1i1.5111

Permatasari, F., & Arianto, Y. (2022). Urgensi kompetensi kepribadian guru sebagai upaya pengembangan karakter siswa. *Idea Jurnal Psikologi*, *6*(1), 76–82. https://doi.org/10.32492/idea.v6i1.748

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal of Applied Psychology, 88(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Rapang, R., Yunus, M., & Apriyanti, E. (2022). Peran kepala sekolah dalam menerapkan peraturan-peraturan di sekolah dasar. *Edukatif Jurnal Ilmu Pendidikan*, 4(3), 3419–3423. https://doi.org/10.31004/edukatif.v4i3.2596

Rismayanti, E., Kania, I., & Trisnawati, E. (2021). Pengaruh kompetensi profesional tenaga pendidik terahadap peningkatan mutu pembelajaran di sekolah menengah pertama. *Jurnal Pembangunan Dan Kebijakan Publik*, *12*(2), 28–35. https://doi.org/10.36624/jpkp.v12i2.82

Robinson, V. M. J., Lloyd, C. A., & Rowe, K. J. (2008). The impact of leadership on student outcomes: An analysis of the differential effects of leadership types. Educational Administration Quarterly, 44(5), 635–674. https://doi.org/10.1177/0013161X08321509

Saefurridja, A., Mujab, S., & Amarullah, M. M. S. (2023). Model kepemimpinan pendidikan masa depan: Sebuah tinjauan berlandaskan perspektif agama, filsafat, psikologi dan sosiologi. *Edukatif Jurnal Ilmu Pendidikan*, *5*(2), 849–857. https://doi.org/10.31004/edukatif.v5i2.4615

Saingo, Y. A. (2023). Mewujudkan iklim belajar kondusif melalui sinergitas kepala sekolah dan guru pendidikan agama Kristen di Sekolah Menengah Kejuruan Kristen Soe. *Jurnal Abdiel Khazanah Pemikiran Teologi Pendidikan Agama Kristen Dan Musik Gereja*, *7*(2), 152–171. https://doi.org/10.37368/ja.v7i2.596

Sari, S. P., Daulay, M. I., & Samsurijal, S. (2025). Pengaruh kepemimpinan visioner kepala sekolah terhadap profesional guru dan kemampuan menggunakan media ajar Wordwall. *Journal of Education Research*, 6(4), 1205–1212. https://doi.org/10.37985/jer.v6i4.3308

Sariakin, S., Yeni, M., Usman, M. B., Mare, A. S., Munzir, M., & Saleh, M. (2025). Fostering a productive educational environment: The roles of leadership, management practices, and teacher motivation. Frontiers in Education, 10, Article 1499064. https://doi.org/10.3389/feduc.2025.1499064

Sidik, W. P., Rahmatuloh, R., Nurohmah, V. S., Setiawan, A., & Nurmalasari, N. (2024). Upaya peningkatan mutu sekolah. *Cendib*, *1*(3), 220–226. https://doi.org/10.59996/cendib.v1i3.274

Susila, R. (2023). Keunggulan dan kelemahan manajemen mutu pembelajaran di SMA Negeri 1 Sitiung Kabupaten Dharmasraya. *Jurnal Pendidikan Dan Kewirausahaan*, *11*(3), 840–863. https://doi.org/10.47668/pkwu.v11i3.880

Triwiyanto, T., Nurabadi, A., Sumarsono, R. B., Kusumaningrum, D. E., Arafik, M., & Pramono, P. (2023). Sistem manajemen pembiayaan pendidikan, partisipasi masyarakat, kepemimpinan, dan mutu sekolah dasar. *Jurnal Penelitian Dan Pengembangan Pendidikan*, *7*(1), 117–125. https://doi.org/10.23887/jppp.v7i1.54509

Wahyudi, D., Kamila, C. A., & Agustin, S. W. (2021). Peran kepemimpinan dalam pengembangan mutu pendidikan Islam. *Jurnal Syntax Transformation*, *2*(07), 949–957. https://doi.org/10.46799/jst.v2i7.334

Werang, B. R. (2018). Pengaruh keterampilan managerial kepala sekolah dan iklim sekolah terhadap komitmen kerja guru sekolah dasar Kristen di Kabupaten Boven Digoel. *Al Ibtida Jurnal Pendidikan Guru Mi*, *5*(2), 159. https://doi.org/10.24235/al.ibtida.snj.v5i2.2650

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

The Influence of the Relationship Between Principal Leadership and Teacher Performance on Improving the Quality of Education at Elementary Schools in Juwana

Tiara Novita Mahardika[1*], Wawan Shokib Rondli[1] and Ahmad Hariyadi[1]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: 202403153@std.umk.ac.id

ABSTRACT

This study analyzed the influence of principal leadership and teacher performance on educational quality in public elementary schools in Juwana District, Pati Regency. The research questions were: (1) Does principal leadership influence educational quality? (2) Does teacher performance influence educational quality? (3) Do principal leadership and teacher performance simultaneously influence educational quality? This study used a quantitative approach with a correlational design. Using proportional stratified random sampling, 177 of the 315 teachers in 35 public elementary schools were selected. Data were collected using a questionnaire and analyzed using the Partial Least Squares Structural Equation Modeling (PLS-SEM) method in SmartPLS. Principal leadership had a positive and significant effect on educational quality (path coefficient = 0.382, $p < 0.001$), as did teacher performance (path coefficient = 0.451, $p < 0.001$). Together, principal leadership and teacher performance explained 58.7% of the variance in education quality ($R^2 = 0.587$); the remaining 41.3% is attributable to factors outside the research model. These results suggest that improving education quality in elementary schools depends on effective school leadership together with continued improvement in teacher performance.

KEYWORDS PLS-SEM | SmartPLS | principal leadership | teacher performance | education quality

INTRODUCTION

Improving the quality of basic education remains a pressing task in Indonesia. In PISA 2022, Indonesian students again scored well below the OECD average in mathematics, reading and science (OECD, 2023). National policy has therefore shifted attention from school inputs to the quality of learning in each school. Schools now plan their improvement programmes from Education Report Card (Rapor Pendidikan) data (Utaminingsih et al., 2026), which requires principals and teachers to interpret the evidence and act on it together. Public elementary schools in Juwana District, Pati Regency, work under the same expectations. In these schools, much of the responsibility for turning quality targets into daily practice rests with two groups: the principal and the teachers.

The quality of elementary school education depends on student academic achievement and also on the quality of teaching and school management. Principal leadership contributes to quality improvement through managerial functions, supervision, decision-making, innovation, and motivation. Instructional leadership theory positions the principal as a leader oriented towards improving the quality of learning and developing a supportive school climate (Hallinger, 2011). Teacher effectiveness contributes directly to the educational process through skills in designing, implementing, and assessing learning, and teaching quality is closely linked to student learning outcomes (Darling-Hammond, 2000).

International evidence supports both links. A meta-analysis of 27 studies found that the effect of instructional leadership on student outcomes was three to four times that of transformational leadership, and that promoting and participating in teacher learning and development had the largest effect of the five leadership dimensions examined (Robinson et al., 2008). A later review reaffirmed that school leadership is a major influence on student learning and that it works largely through teachers' motivation, capacity and working conditions (Leithwood et al., 2020). In this view, leadership improves quality mainly through what teachers do in classrooms, which is a reason to study the two factors together.

Indonesian studies point in the same direction, although most of them treat teacher performance as the outcome rather than school quality. Principal leadership was positively related to teacher performance among elementary school teachers in Lebak Regency (Starlinsky et al., 2022) and in North Rupat, Riau (Kamalia et al., 2022). In Pati Regency, a path analysis of 114 public high school teachers found that principal leadership, school culture and pedagogic competence each directly affected teacher performance, with work motivation as a mediator (Ardliana et al., 2021). A PLS-SEM study in Aceh Besar reported a path coefficient of 0.388 from principal leadership to teacher performance (Sariakin et al., 2025). Other local studies have examined the principal's role in teacher performance (Darmawati et al., 2022; Paembonan et al., 2022; Ritonga et al., 2023; Setiadi & Annur, 2022) and in school or educational quality (Ahmad, 2022; Minsih et al., 2019; Nurunnahar et al., 2026; Thohirin et al., 2023). Fewer studies place principal leadership and teacher performance side by side as predictors of educational quality (Hadi & Iba, 2023; Wijaya et al., 2025), and teacher performance has also been examined as a component of school quality (Indriawati et al., 2023).

Although principal leadership and teacher performance are theoretically expected to improve educational quality, previous research has reported inconsistent results. In elementary schools in Batam, for example, principals' distributed leadership alone had no significant effect on education quality, whereas teacher leadership did (Yasrizal et al., 2022). We found no study that examined both variables as predictors of educational quality in public elementary schools in Juwana District. This leaves both an empirical and a contextual gap. Therefore, this study aims to analyze the impact of principal leadership and teacher performance on improving the quality of education at public elementary schools in Juwana District, both separately and simultaneously. This study is expected to provide empirical evidence for strategies that improve education quality by strengthening school leadership and teacher performance.

Three research questions guided the study: (1) Does principal leadership influence educational quality? (2) Does teacher performance influence educational quality? (3) Do principal leadership and teacher performance together explain educational quality? The study adds district-level evidence from 177 teachers in 35 public elementary schools and estimates both predictors in one PLS-SEM model, so that their contributions can be compared within the same sample. The results are intended to help principals, teachers and the Pati Regency Education Office set priorities for quality improvement.

LITERATURE REVIEW

Principal leadership (X1) is the principal's capacity to direct, motivate, supervise, and manage school resources to achieve educational goals. According to instructional leadership theory, the principal's role is to direct the learning process, enhance teacher professionalism, and create a school environment that supports quality improvement (Hallinger, 2011).

Teacher performance (X2) is a measure of a teacher's success in carrying out their professional responsibilities, which include planning, implementing, and evaluating learning, as well as professional development. Optimal teacher performance contributes directly to an efficient learning process and supports the achievement of student learning outcomes (Darling-Hammond, 2000).

Educational quality (Y) is the standard to which education is delivered, as reflected in the teaching process and student learning outcomes. From a quality management perspective, quality is improved collaboratively through the continuous management of all elements of education. Therefore, principal leadership and teacher performance are theoretically considered elements that influence educational quality, both individually and collectively (Hadi & Iba, 2023; Wijaya et al., 2025). Figure 1 shows the research model.

Research Objectives

This study aims to determine the separate and simultaneous influence of principal leadership and teacher performance on the quality of education at elementary schools in Juwana District, Pati Regency.

RESEARCH METHOD

Research Design

This study applies a quantitative approach with a correlational (associative) design (Creswell, 2014) to examine the influence of principal leadership and teacher performance on the quality of education at elementary schools in Juwana District, Pati Regency. The research data were obtained through a questionnaire with a Likert scale and analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) in SmartPLS (Hair et al., 2019; Hair et al., 2022) to test the relationship and influence between research variables.

Research Respondents

Participants were teachers from public elementary schools (SDN) in Juwana District, Pati Regency; principals were not included as research subjects. The study population consisted of 315 teachers distributed across 35 public elementary schools. Based on the Slovin formula with a 5% margin of error, the sample size was 176.22, rounded up to 177 teachers. Sampling was conducted using a proportional stratified random sampling method (Sugiyono, 2017) to ensure appropriate representation in each school. The questionnaire measured teachers' perceptions of principal leadership (X1), teacher performance (X2), and educational quality (Y).

The distribution of respondents is as follows:

The participants were 177 public elementary school teachers in Juwana District, Pati Regency: 70 male (39.55%) and 107 female (60.45%). Based on employment category, respondents consisted of 70 civil servant teachers and 107 PPPK teachers. By age, the largest group was 36 to 40 years old (51 teachers, 28.81%), followed by the 31–35 age group (42 teachers, 23.73%). Respondents' length of service varied among both civil servant and PPPK teachers, so they assessed principal leadership, teacher performance, and educational quality from diverse professional backgrounds.

Table 1. Characteristics of respondents

Characteristics	Category	Frequency (n)	Percentage (%)
Gender	Male	70	39.55
	Female	107	60.45
	Total	**177**	**100,00**
Employment Status	Civil Servant	70	39.55
	PPPK	107	60.45
	Total	**177**	**100,00**
Age	31–35 years	42	23.73
	36–40 years	51	28.81
	Other age groups	84	47.46
	Total	**177**	**100,00**
Service Period	1–10 years	—	—
	11–15 years	—	—
	16–20 years	—	—
	Total	**177**	**100,00**

RESULTS AND DISCUSSION

The first finding is that principal leadership (X1) had a positive and significant effect on educational quality (Y) in public elementary schools in Juwana District (path coefficient = 0.382, $p < 0.001$). Teachers who rated their principal higher on managerial, supervisory, innovative and motivating functions also tended to rate the quality of their school higher. A plausible mechanism is indirect: principals who give clear direction, organise teacher training and supervise instruction create conditions in which teachers can teach well. This reading is consistent with instructional leadership theory, which positions the principal as a key actor in improving the quality of learning and holds that leadership affects learning mainly through school conditions (Hallinger, 2011). It also agrees with the meta-analytic finding that promoting and participating in teacher learning and development is the leadership dimension most strongly associated with student outcomes (Robinson et al., 2008).

The result matches Indonesian studies that link principal leadership to teacher performance (Kamalia et al., 2022; Sariakin et al., 2025; Starlinsky et al., 2022) and studies of elementary school quality that place the principal at the centre of improvement (Minsih et al., 2019; Nurunnahar et al., 2026). It differs from the Batam study, in which principals' distributed leadership alone had no significant effect on education quality (Yasrizal et al., 2022). The difference may reflect what was measured. The instrument in this study covered managerial, supervisory, innovative and motivating functions that touch teachers' daily work, whereas distributed leadership concerns how leadership is shared among staff. For principals in Juwana, the practical implication is to give priority to supervision and teacher development that reach classroom practice, rather than to administrative compliance alone.

The second finding is that teacher performance (X2) had a positive and significant effect on educational quality (Y) (path coefficient = 0.451, $p < 0.001$). Teacher performance was measured through learning planning, learning implementation, evaluation of learning outcomes and professional development. Teachers who plan systematically, manage their classes well, use suitable strategies and act on assessment results are likely to raise the quality of both the learning process and its outcomes. This agrees with the view that teacher quality is one of the most important school factors in student learning (Darling-Hammond, 2000). It also agrees with the Batam finding that teacher leadership, unlike principals' distributed leadership, was significantly related to education quality (Yasrizal et al., 2022). For schools, the result points to professional development that targets planning, classroom implementation and assessment follow-up. The Pati Regency study of high school teachers suggests that work motivation is one channel through which such support translates into performance (Ardliana et al., 2021).

The third finding is that principal leadership and teacher performance together explained 58.7% of the variance in educational quality ($R^2 = 0.587$). By common PLS-SEM benchmarks, an R^2 of this size is moderate (Hair et al., 2022), and it is close to the 56% that principal and teacher leadership jointly explained in Batam elementary schools (Yasrizal et al., 2022). Educational quality therefore depends on more than one factor and reflects the combined contribution of school management and professional teaching. A principal who provides supervision, motivation and support may create conditions in which teachers carry out their duties more effectively, and good teacher performance may, in turn, help the school implement its policies and programmes. Leithwood et al. (2020) describe the same chain, in which leadership influences learning largely through teachers' motivation, capacity and working conditions. The model, however, estimated two direct paths and did not test this indirect route.

The path coefficient for teacher performance (0.451) was larger than that for principal leadership (0.382). Because no test of the difference between the two coefficients is reported, this difference should be read descriptively rather than as evidence that one factor matters more; both effects were significant. The R^2 value of 58.7% also means that 41.3% of the variance in educational quality is explained by factors outside the research model, possibly including school culture, facilities, parental support and student background. In practice, the results suggest that quality improvement in Juwana elementary schools needs action from both principals and teachers. Principals can use supervision results and Education Report Card data to plan targeted teacher

development (Utaminingsih et al., 2026), and the district Education Office can strengthen principals' capacity to run such programmes. Studies of school quality management point to the same combination of leadership and teacher work (Amelia & Siahaan, 2025; Edi et al., 2024; Purhasanah, 2024).

Several limitations apply. First, the design was cross-sectional and correlational, so the path coefficients describe associations and cannot establish that leadership or teacher performance causes changes in quality. Second, all three constructs were measured through the same teachers' questionnaire, and principals were not surveyed. Teachers rated their own performance, which may inflate that variable, and shared-method variance may have strengthened the observed relationships (Podsakoff et al., 2003). Third, the paper does not report the measurement model (outer loadings, composite reliability, average variance extracted and HTMT) or the bootstrapping settings, which PLS-SEM reporting guidelines expect before structural paths are interpreted (Hair et al., 2019). Fourth, the sample came from public elementary schools in one district, which limits generalisation to private schools, madrasahs and other regions. Future research could report the full measurement model, test whether teacher performance mediates the effect of principal leadership on educational quality, compare the two path coefficients formally, and add objective quality indicators such as Education Report Card scores or supervisors' ratings.

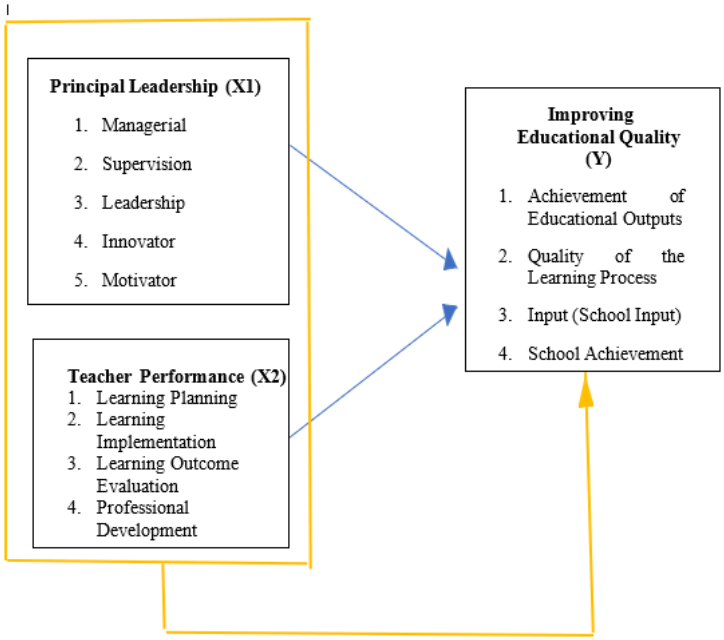

Figure 1. Research model

CONCLUSION AND RECOMMENDATIONS

The findings indicate that principal leadership and teacher performance each contribute to educational quality and that, together, they explain more than half of its variance at elementary schools in Juwana District. Improving educational quality therefore appears to require effective school leadership supported by strong teacher performance.

Principals are encouraged to strengthen their supervision, motivation, decision-making, and school management. Teachers are expected to continuously improve their professional performance in planning, implementing, and evaluating the learning process. The Education Office can use these findings as a reference in developing the capabilities of principals and teachers to support educational quality improvement.

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REFERENCES

Ahmad, D. S. (2022). Principal leadership in efforts to improve educational quality. ALACRITY: Journal of Education, 2(3). https://doi.org/10.52121/alacrity.v2i3.115

Amelia, & Siahaan, A. (2025). The principal's leadership in implementing performance to improve school quality. Thawalib: Journal of Islamic Education, 6(1). https://doi.org/10.54150/thawalib.v6i1.678

Ardliana, B., Rusdarti, R., & Suminar, T. (2021). Effect of principal leadership, school culture and pedagogic competence through work motivation on teachers performance. *Educational Management*, *10*(2), 273–283.

Creswell, J. W. (2014). Research design: Qualitative, quantitative, and mixed methods approaches (4th ed.). SAGE Publications.

Darling-Hammond, L. (2000). Teacher quality and student achievement: A review of state policy evidence. *Education Policy Analysis Archives*, *8*(1). https://doi.org/10.14507/epaa.v8n1.2000

Darmawati, D., Erfinawati, E., & Jalaluddin, J. (2022). Principal leadership in improving teacher performance at MAN 5 Aceh Besar. Jurnal Ilmiah Edunomika, 6(2), 1–12. https://doi.org/10.29040/jie.v6i2.4739

Edi, F., Sudadio, S., & Anriani, N. (2024). The effect of school-based quality improvement management and achievement motivation on teacher performance. Ideguru: Jurnal Karya Ilmiah Guru, 9(3). https://doi.org/10.51169/ideguru.v9i3.1004

Hadi, A., & Iba, Z. (2023). The influence of principal leadership, school policies, and teacher performance on the quality of elementary schools in Aceh Utara District. Management of Education: Journal of Islamic Education Management, 9(2). https://doi.org/10.18592/moe.v9i2.10937

Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2022). A primer on partial least squares structural equation modeling (PLS-SEM) (3rd ed.). SAGE Publications.

Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. European Business Review, 31(1), 2–24. https://doi.org/10.1108/EBR-11-2018-0203

Hallinger, P. (2011). Leadership for learning: Lessons from 40 years of empirical research. *Journal of Educational Administration*, *49*(2), 125–142. https://doi.org/10.1108/09578231111116699

Indriawati, P., Maulida, N., Erni, D. N., & Putri, W. H. (2023). Teacher performance in educational quality at SMAN 02 Balikpapan. Journal of Research, Education, and Teaching: JPPP, 4(1).

Kamalia, Ayub, D., & Sumarno, S. (2022). The influence of principal leadership and teacher work discipline on elementary school teacher performance. *Journal of Educational Sciences*, *6*(3), 444–458. https://doi.org/10.31258/jes.6.3.p.444-458

Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven strong claims about successful school leadership revisited. *School Leadership & Management*, *40*(1), 5–22. https://doi.org/10.1080/13632434.2019.1596077

Minsih, M., Rusnilawati, R., & Mujahid, I. (2019). Principal leadership in building quality elementary schools. Elementary Education Profession, 1(1), 29–40. https://doi.org/10.23917/ppd.v1i1.8467

Nurunnahar, I., Marlina, L., Oktaviani, V., Rosadi, R., & Sauri, R. S. (2026). Principal leadership in improving the quality of education in elementary schools. Didactics: Scientific Journal of Elementary School Teacher Education, STKIP Subang, 12(3), 349–362. https://doi.org/10.36989/didaktik.v12i03.16550

OECD. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education*. OECD Publishing. https://doi.org/10.1787/53f23881-en

Paembonan, S., Kailola, L. G., & Simbolon, B. R. (2022). The influence of the principal's leadership style on the performance of elementary school teachers at SDN 111 Inpres Bungin, North Makale District, Tana Toraja Regency. Tambusai Education Journal, 6(2), 13114–13119. https://doi.org/10.31004/jptam.v6i2.4529

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology, 88*(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Purhasanah, S. (2024). The power of principal leadership in boosting school quality. Munaddhomah: Journal of Islamic Education Management, 5(3). https://doi.org/10.31538/munaddhomah.v5i3.790

Ritonga, R., Aktar, S., & Dongoran, F. R. (2023). The influence of instructional leadership, school climate, and work motivation on the performance of Islamic Studies teachers in North Rantau District, Labuhanbatu Regency. EduTech Journal, 9(1), 49–60.

Robinson, V. M. J., Lloyd, C. A., & Rowe, K. J. (2008). The impact of leadership on student outcomes: An analysis of the differential effects of leadership types. *Educational Administration Quarterly, 44*(5), 635–674. https://doi.org/10.1177/0013161X08321509

Sariakin, S., Yeni, M., Usman, M. B., Mare, A. S., Munzir, M., & Saleh, M. (2025). Fostering a productive educational environment: The roles of leadership, management practices, and teacher motivation. *Frontiers in Education, 10*, Article 1499064. https://doi.org/10.3389/feduc.2025.1499064

Setiadi, D., & Annur, S. (2022). The leadership role of the principal of SMP Negeri 9 Talang Ubi, Pali Regency, in improving teacher performance effectiveness. Dirasah: Journal of Islamic Education Science and Management Studies, 5(1), 100–113.

Starlinsky, L., Belawati, T., & Rosita, T. (2022). Korelasi antara kepemimpinan kepala sekolah dan supervisi akademik terhadap kinerja guru sekolah dasar di Kecamatan Lebakgedong Kabupaten Lebak. *Indonesian Journal of Educational Counseling, 6*(1), 26–33. https://doi.org/10.30653/001.202261.190

Sugiyono. (2017). Quantitative, qualitative, and R&D research methods. Alfabeta.

Thohirin, A., Harris, T., & Faizin, A. (2023). Analysis of principal leadership styles in improving educational quality. *Reforma: Journal of Education and Learning, 13*(1). https://doi.org/10.30736/rf.v13i1.839

Utaminingsih, S., Widodo, G. A., & Najikhah, F. (2026). Planning based on Educational Report Card data for the numeracy and character literacy program. Journal of Elementary, Middle, and Higher Education Management (JMP-DMT), 7(1), 1–8. https://doi.org/10.30596/jmp-dmt.v7i1.18178

Wijaya, S. R., El Khuluqo, I., & Istaryatiningtias, I. (2025). School quality improvement through transformational leadership and teacher performance: A study in Cengkareng District. Tarbawi: Journal of Educational Management Science, 11(2). https://doi.org/10.32678/tarbawi.v11i02.11332

Yasrizal, Y., Dahlan, J. A., & Chandrawati, T. (2022). Pengaruh kepemimpinan distribusi kepala sekolah dan kepemimpinan guru terhadap mutu pendidikan sekolah dasar. *Lentera: Jurnal Ilmiah Kependidikan, 15*(1), 23–38.

ICISFS-UMK 2026 LEARNING INNOVATION

Factors Affecting the Quality of Deep Learning Among Elementary Teachers

Dwi Yuniarto[1*], Imaniar Purbasari[1] and Sri Utaminingsih[1]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: yuniarto136@gmail.com

ABSTRACT

The Indonesian Ministry of Primary and Secondary Education has introduced Deep Learning as an instructional approach to promote meaningful, reflective, and student-centered learning. However, empirical evidence on the factors that influence the quality of Deep Learning is limited. This study examined the effects of teacher competence, teachers' reflective ability, and classroom climate on the quality of Deep Learning among elementary school teachers in Grobogan Regency, Indonesia. A quantitative survey was conducted with 191 teachers, selected through proportional random sampling from a population of 363 teachers who had completed Deep Learning training. Data were collected using a validated Likert-scale questionnaire and analyzed using Structural Equation Modeling (SEM) with IBM SPSS AMOS 31. The structural model showed a satisfactory fit (CMIN/DF = 1.264, GFI = 0.943, AGFI = 0.913, CFI = 0.992, TLI = 0.989, RMSEA = 0.037). Teacher competence had a significant positive effect on the quality of Deep Learning (Estimate = 0.274; $p < 0.001$), while teachers' reflective ability (Estimate = 0.432; $p < 0.001$) and classroom climate (Estimate = 0.401; $p < 0.001$) had larger positive effects. Together, these variables explained 51.5% of the variance in the quality of Deep Learning. The findings suggest that strengthening teacher competence, reflective practice, and supportive classroom climates can improve the quality of Deep Learning in elementary schools.

KEYWORDS classroom climate | deep learning | reflective ability | teacher competence

INTRODUCTION

Deep Learning has recently been introduced by the Indonesian Ministry of Primary and Secondary Education as an instructional approach that promotes meaningful conceptual understanding, higher-order thinking, active student engagement, and reflective learning. Rather than emphasizing factual knowledge alone, Deep Learning encourages students to actively construct knowledge, reflect on their learning experiences, and apply concepts in authentic contexts. This approach integrates meaningful, mindful, and joyful learning experiences that support students' cognitive, social, and emotional development (Fullan et al., 2018; Feriyanto & Anjariyah, 2024). In this study, the quality of Deep Learning refers to the extent to which classroom instruction promotes meaningful conceptual understanding, higher-order thinking skills, active student engagement, and reflective learning. Teachers are therefore central to designing learning experiences with these characteristics.

Early Indonesian studies of the approach are mostly small and qualitative. Case studies in elementary classrooms report that Deep Learning grounded in mindful, meaningful and joyful learning improved fifth graders' conceptual understanding in IPAS (Wibowo et al., 2025) and made mathematics lessons more participatory and enjoyable, although limited time and uneven technology access constrained implementation (Mutmainnah et al., 2025). Conceptual work links the three principles to the constructivist theories of Langer, Ausubel and Dewey and argues that they should be applied together (Rosyidah et al., 2026). The only survey evidence we located comes from 33 physical education teachers in Sukabumi, who self-reported a very high level of implementation (89.81%); the authors themselves caution that self-report is not direct evidence of classroom practice (Kladika et al., 2026). Studies of school leadership suggest that teachers' pedagogical competence is the channel through which Deep Learning reaches classrooms. In three elementary schools in Jombang, principals' instructional leadership strengthened teachers' pedagogical competence and deep-learning practice through supervision, continuous professional development and a collaborative culture (Hanik et al., 2025). What these studies do not

yet show is which teacher and classroom factors account for differences in the quality of Deep Learning across teachers who have received the same training.

The quality of Deep Learning depends largely on teachers' professional competence to plan, implement, and evaluate instruction that supports meaningful learning. Teachers with strong pedagogical competence are better equipped to design meaningful learning experiences, select instructional strategies aligned with learning objectives, implement authentic assessment practices, and continuously improve instructional quality to promote students' conceptual understanding and higher-order thinking skills (König et al., 2021; Gore, 2021; Darling-Hammond et al., 2024). Teachers' reflective ability also contributes to the quality of Deep Learning. Reflective teachers continuously evaluate their instructional practices, identify students' learning difficulties, and refine their teaching strategies based on classroom experience. High-quality critical reflection has been linked to better pedagogical decision-making and professional growth (Philp-Clark & Grieshaber, 2024).

Classroom climate also affects Deep Learning. A positive classroom climate characterized by supportive teacher–student interaction, active student participation, and a safe learning environment promotes meaningful learning and encourages students to become actively involved in the learning process (Goagoses et al., 2024). A meta-analysis of 61 studies from kindergarten to high school found small-to-medium positive associations between classroom climate and students' social competence, motivation, engagement and achievement (Wang et al., 2020). Such learning conditions provide opportunities for students to develop critical thinking, collaboration, and reflective learning skills. The successful implementation of Deep Learning is therefore likely to depend on teacher-related and classroom-related factors as well as on curriculum reform.

Previous studies have shown the importance of teacher competence, reflective practice, and classroom climate in improving teaching quality and student learning outcomes (König et al., 2021; Gore, 2021; Goagoses et al., 2024; Zohrabi & Xodabande, 2024). However, these studies generally examined these factors separately or within different educational contexts. Empirical evidence on the combined influence of teacher competence, teachers' reflective ability, and classroom climate on the quality of Deep Learning among elementary school teachers remains limited. Identifying these factors may provide evidence-based recommendations for improving instructional quality in Indonesian elementary schools. This study therefore employs Structural Equation Modeling (SEM) to examine the simultaneous relationships among these three factors and the quality of Deep Learning in Indonesian elementary schools.

The study addressed three questions. Does teacher competence affect the quality of Deep Learning? Does teachers' reflective ability affect it? Does classroom climate affect it? It also asked how much of the variance in the quality of Deep Learning the three factors explain together. The setting is Grobogan Regency, where 363 elementary school teachers had completed the Ministry's Deep Learning training, so all respondents had received the same preparation. Estimating the three predictors in one covariance-based model allows their contributions to be compared within the same sample. The results are intended to inform how schools, teacher working groups (KKG) and the regency education office design follow-up support after the training.

LITERATURE REVIEW

This study is grounded in Biggs' Presage–Process–Product (3P) Model (Biggs, 1993), which holds that learning quality results from the interaction among presage factors (learner and teacher characteristics), instructional processes, and learning outcomes. Within this framework, teacher competence functions as a presage factor that shapes instructional quality, whereas teachers' reflective ability strengthens the instructional process through continuous improvement and so contributes to higher-quality learning outcomes (Li & Zhu, 2023). Teacher competence is the teacher's professional capacity to design systematic instruction, apply appropriate teaching strategies, and conduct effective assessments. Classroom climate provides a supportive learning environment that encourages active participation, meaningful interaction, collaboration, and student engagement. These conditions facilitate meaningful learning and improve learning outcomes (Goagoses et al., 2024).

The study also adopts Bloom's revised taxonomy, which emphasizes that meaningful learning should promote higher-order thinking skills through analysis, evaluation, and creation rather than simple memorization

(Krathwohl, 2002). Based on these theoretical perspectives, teacher competence (X_1), teachers' reflective ability (X_2), and classroom climate (X_3) are hypothesized to have direct positive effects on the quality of Deep Learning (Y). These relationships were tested with Structural Equation Modeling (SEM) to estimate the magnitude and significance of each path.

Research Objectives

This study analyzed the factors influencing the quality of Deep Learning among elementary school teachers in Grobogan Regency. Specifically, it examined the effects of teacher competence, teachers' reflective ability, and classroom climate on the quality of Deep Learning. It also investigated the simultaneous contribution of these three variables using Structural Equation Modeling (SEM). The findings are expected to provide empirical evidence for improving instructional quality and to contribute to the development of Deep Learning practices in elementary education.

RESEARCH METHOD

Research Design

This study employed a quantitative research design using covariance-based Structural Equation Modeling (CB-SEM) to examine the relationships among multiple latent variables while accounting for measurement error (Hair et al., 2019; Kline, 2023). Data were analyzed in IBM SPSS AMOS 31 to evaluate both the measurement and structural models.

Respondents of the Study

The study population comprised 363 elementary school teachers in Grobogan Regency who had participated in the Deep Learning training program organized by the Ministry of Primary and Secondary Education. A sample of 191 teachers was selected using proportional random sampling based on the Slovin formula with a 5% margin of error. All respondents were actively teaching during the 2025/2026 academic year and had experience implementing Deep Learning in elementary school classrooms.

Research Instrument

The research instrument was a structured questionnaire developed from the theoretical indicators of the four research variables: teacher competence (X_1), teachers' reflective ability (X_2), classroom climate (X_3), and quality of Deep Learning (Y). The questionnaire employed a five-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The instrument contained 39 items across the four latent variables. Teacher competence was measured through three indicators: systematic lesson planning, instructional strategy selection, and learning assessment. Teachers' reflective ability was measured through instructional evaluation, analysis of students' learning difficulties, and instructional improvement. Classroom climate was measured through classroom safety and comfort, positive teacher–student interaction, and students' active participation. The quality of Deep Learning was measured using four indicators: meaningful conceptual learning, higher-order thinking skills (HOTS), active student engagement, and reflective learning. Construct validity was evaluated through Confirmatory Factor Analysis (CFA), and reliability was assessed using Construct Reliability (CR) and Cronbach's Alpha.

Table 1. Likert scale used in the questionnaire

Scale	Interpretation
5	Strongly Agree
4	Agree
3	Neutral
2	Disagree
1	Strongly Disagree

Data Analysis

The collected data were analyzed using covariance-based Structural Equation Modeling (CB-SEM) with IBM SPSS AMOS version 31. The analysis was conducted in two stages. First, Confirmatory Factor Analysis (CFA) was performed to evaluate the validity and reliability of the measurement model before testing the structural relationships among the latent variables (Hair et al., 2019; Kline, 2023). Second, the structural model was examined to determine the direct effects of teacher competence, teachers' reflective ability, and classroom climate on the quality of Deep Learning.

Model fit was evaluated with the following Goodness-of-Fit indices: Chi-square, Probability, CMIN/DF, GFI, AGFI, CFI, TLI, NFI, RMSEA, and RMR, following commonly accepted evaluation criteria for covariance-based SEM (Hair et al., 2019; Hu & Bentler, 1999; Kline, 2023). Structural relationships were considered statistically significant when the Critical Ratio (C.R.) exceeded 1.96 and the p-value was less than 0.05. Construct reliability and convergent validity were assessed using Composite Reliability (CR) and Average Variance Extracted (AVE), where CR values above 0.70 and AVE values above 0.50 indicate acceptable reliability and convergent validity (Hair et al., 2019).

RESULTS

This section presents the results of the Structural Equation Modeling (SEM) analysis of the effects of teacher competence, teachers' reflective ability, and classroom climate on the quality of Deep Learning. Model fit, the structural model, and the hypothesis tests are reported first, followed by a discussion of their theoretical and practical implications.

Model Fit Evaluation

Before testing the proposed hypotheses, the structural model was evaluated using several Goodness-of-Fit (GOF) indices to determine whether the empirical data adequately fit the theoretical model.

Table 2. Goodness-of-fit indices of the structural model

Goodness-of-Fit Index	Recommended Value	Obtained Value	Interpretation
Chi-square	Small	74.573	Good
Probability	≥ 0.05	0.083	Good
CMIN/DF	≤ 2.00	1.264	Good
GFI	≥ 0.90	0.943	Good
AGFI	≥ 0.90	0.913	Good
CFI	≥ 0.95	0.992	Excellent
TLI	≥ 0.95	0.989	Excellent
NFI	≥ 0,90	0.962	Excellent
RMSEA	≤ 0.08	0.037	Excellent
RMR	≤ 0.05	0.018	Excellent

Table 2 shows that the proposed structural model achieved a satisfactory fit. The Chi-square value (74.573) and probability value (0.083) indicated no significant discrepancy between the observed and estimated covariance matrices. All Goodness-of-Fit indices met their recommended thresholds, including CMIN/DF (1.264), GFI (0.943), AGFI (0.913), TLI (0.989), CFI (0.992), NFI (0.962), RMSEA (0.037), and RMR (0.018). The model therefore represented the relationships among teacher competence, teachers' reflective ability, classroom climate, and the quality of Deep Learning adequately and was considered appropriate for hypothesis testing.

Structural Model and Hypothesis Testing

Following the confirmation of an acceptable model fit, the structural model was evaluated to examine the direct effects of teacher competence, teachers' reflective ability, and classroom climate on the quality of Deep Learning.

Table 3. Structural path coefficients

Structural Relationship	Estimate	Critical Ratio (CR)	p-value	Decision
Teacher Competence → Quality of Deep Learning	0.274	3.307	***	Supported
Teachers' Reflective Ability → Quality of Deep Learning	0.432	5.756	***	Supported
Classroom Climate → Quality of Deep Learning	0.401	5.109	***	Supported

All proposed hypotheses were supported: each exogenous variable had a statistically significant relationship with the quality of Deep Learning. Teacher competence had a positive and significant effect on the quality of Deep Learning (Estimate = 0.274, $p < 0.001$), indicating that teachers with stronger professional competence are more likely to implement meaningful learning practices. Teachers' reflective ability exhibited the largest positive effect among the three predictors (Estimate = 0.432, $p < 0.001$), which points to the contribution of reflective teaching practices to the quality of Deep Learning. Classroom climate also had a significant positive effect (Estimate = 0.401, $p < 0.001$), suggesting that a safe, supportive, and participatory classroom environment facilitates more meaningful learning experiences.

Overall, teacher competence, teachers' reflective ability, and classroom climate each had a significant positive effect on the quality of Deep Learning. These results suggest that strengthening the three dimensions may improve instructional quality in elementary schools.

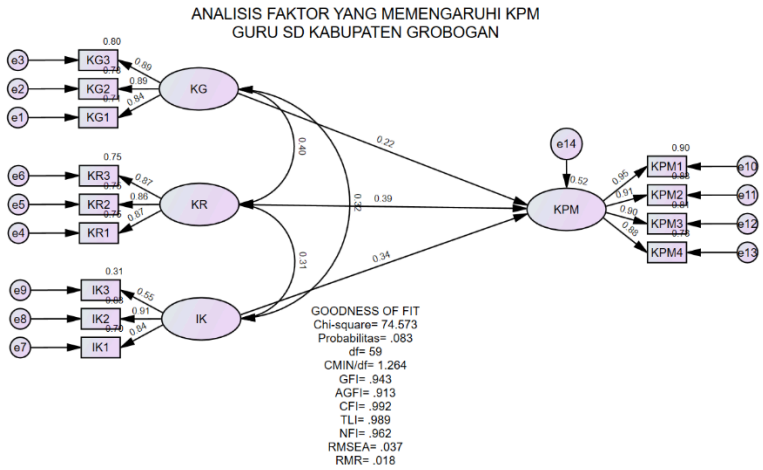

Figure 1. Final structural equation model with standardized estimates

DISCUSSION

Teacher Competence and the Quality of Deep Learning

The results indicate that teacher competence has a significant positive effect on the quality of Deep Learning. The coefficient (Estimate = 0.274, $p < 0.001$) suggests that higher professional competence is associated with better Deep Learning practices in elementary classrooms. This relationship is theoretically reasonable because teacher competence determines how learning objectives, instructional strategies, and assessment are integrated into coherent learning experiences that promote meaningful learning. These findings support the Presage component of Biggs' 3P (Presage–Process–Product) Model, which emphasizes that teacher characteristics influence the quality of instructional processes.

These findings are consistent with previous studies in Indonesian and international contexts. Utaminingsih et al. (2024) developed a model for building science teachers' professional competence through learning leadership, which is consistent with the present finding that competence is related to the quality of learning that teachers deliver. König et al. (2021) found that teachers' pedagogical competence was linked to instructional quality and, through it, to students' mathematics achievement. At the school level, Suratmin et al. (2025) related principals' instructional leadership to learning quality in Sekolah Penggerak senior high schools in Semarang, and Hanik et al. (2025) observed that principals' supervision and continuous professional development strengthened elementary

teachers' pedagogical competence for deep learning. Gore (2021) argued that continuous improvement in teaching practice is fundamental to teaching quality, and Darling-Hammond et al. (2024) emphasized that teachers' competence in planning, implementing, and assessing instruction is essential for promoting meaningful learning experiences.

Teacher competence nonetheless had the smallest of the three coefficients (Estimate = 0.274). One possible reason is that all respondents had completed the same Deep Learning training, which may have narrowed differences in planning and assessment skills, so that competence differentiated teachers less than reflection and classroom climate did. For schools and teacher working groups, the implication is that training should be followed by support that turns competence into classroom routines, such as joint lesson planning and assessment moderation.

Teachers' Reflective Ability and the Quality of Deep Learning

Among the three independent variables, teachers' reflective ability exhibited the largest positive effect on the quality of Deep Learning (Estimate = 0.432, $p < 0.001$). This suggests that teachers who continuously evaluate and improve their instructional practices are more likely to implement meaningful learning experiences that respond effectively to students' learning needs. Reflective teachers systematically analyze classroom situations, identify instructional weaknesses, evaluate students' responses, and modify teaching strategies accordingly.

This finding is consistent with recent studies reporting that reflective practice is a core component of teachers' professional learning and instructional improvement. Philp-Clark and Grieshaber (2024) concluded that high-quality teacher critical reflection strengthens pedagogical decision-making and continuous professional growth. Similarly, Zohrabi and Xodabande (2024) found that both individual and peer reflection enhance teachers' instructional competence and professional learning. These findings reinforce the importance of reflective ability in improving the quality of Deep Learning among elementary school teachers.

The size of this coefficient suggests that the post-training phase deserves as much attention as the training itself. Reflection is a habit that develops through repeated cycles of planning, teaching, observing and revising. A meta-analysis of 60 causal studies found that teacher coaching, which builds such observation and feedback cycles into practice, improved instruction by 0.49 SD and student achievement by 0.18 SD (Kraft et al., 2018). Lesson study, peer observation in KKG meetings and short structured reflection journals are practical ways to provide these cycles in Indonesian elementary schools. Because reflective ability was measured by self-report, however, the finding shows that teachers who describe themselves as reflective also report higher-quality Deep Learning; it does not show how often or how well they reflect in practice.

Classroom Climate and the Quality of Deep Learning

Classroom climate also has a significant positive effect on the quality of Deep Learning (Estimate = 0.401, $p < 0.001$). These results suggest that meaningful learning is more likely to occur in classrooms characterized by positive teacher–student relationships, mutual respect, psychological safety, and active student participation. This relationship is theoretically reasonable because a supportive classroom climate creates conditions in which students feel encouraged to ask questions, exchange ideas, collaborate with peers, and engage actively in learning without fear of making mistakes.

These findings are consistent with a meta-analysis of 61 studies, which found small-to-medium positive associations between classroom climate and students' motivation, engagement and academic achievement, with socioemotional support showing the strongest links to students' wellbeing (Wang et al., 2020). Goagoses et al. (2024) reached a similar conclusion in their review of social classroom climate in technology-enhanced primary and secondary classrooms, where positive climates supported interaction, collaboration and active participation. Classroom climate thus appears to be an important contextual factor that supports the successful implementation of Deep Learning. Therefore, schools should encourage teachers to create inclusive, supportive, and psychologically safe classroom environments that enable students to participate actively, collaborate with peers, and develop higher-order thinking through meaningful learning experiences.

Simultaneous Effects of Teacher Competence, Teachers' Reflective Ability, and Classroom Climate on the Quality of Deep Learning

Collectively, the findings show that teacher competence, teachers' reflective ability, and classroom climate have a significant positive influence on the quality of Deep Learning among elementary school teachers. Together, these three variables explained 51.5% of the variance in the quality of Deep Learning, so about half of the variance is explained by the model and the rest lies in factors not measured here. The quality of Deep Learning therefore appears to depend on several factors together: teachers' professional competence, reflective practice, and supportive classroom environments. This result is consistent with Biggs' Presage–Process–Product (3P) Model, which explains that learning quality emerges through the interaction between presage factors, instructional processes, and learning outcomes (Li & Zhu, 2023). Within this framework, teacher competence supports instructional planning, teachers' reflective ability promotes continuous instructional improvement, and classroom climate provides the conditions necessary for meaningful learning.

From a practical perspective, improving the quality of Deep Learning requires integrated efforts that simultaneously strengthen teachers' professional competence, cultivate reflective teaching practices, and foster positive classroom climates rather than relying solely on curriculum reform or instructional materials (Hanik et al., 2025). Reflective ability had the largest coefficient, followed by classroom climate and teacher competence, which suggests that reflective practice is central to instructional quality. No test of the difference between the coefficients is reported, so this ranking should be read descriptively. Unlike previous studies that examined these factors separately, this study estimated their joint contribution within a single Structural Equation Modeling (SEM) framework, which gives a fuller explanation of the factors influencing the quality of Deep Learning among elementary school teachers.

Several limitations should be noted. First, the design was cross-sectional, so the estimates describe associations; they cannot show that improving competence, reflection or climate will raise the quality of Deep Learning. Second, all four constructs, including the outcome, were rated by the same teachers. Self-reports of one's own practice may be inflated, and common-method variance may have strengthened the paths (Podsakoff et al., 2003). Classroom observation or student reports of Deep Learning would provide a stronger outcome measure. Third, the paper does not report the measurement model (standardised loadings, CR, AVE, Cronbach's alpha and discriminant validity), although the method states that these were assessed. It is also not stated whether Table 3 reports standardised or unstandardised estimates; Figure 1 shows standardised values (0.22, 0.39 and 0.34) that differ from Table 3. Fourth, the sample included only trained teachers in one regency, so the results may not hold for untrained teachers or other regions. Future research could combine teacher surveys with classroom observation and student outcomes, follow teachers over time after training, and test whether reflective ability mediates the link between competence and the quality of Deep Learning, as the 3P model would suggest.

CONCLUSION AND RECOMMENDATIONS

Conclusions

This study concludes that teacher competence, teachers' reflective ability, and classroom climate significantly influence the quality of Deep Learning among elementary school teachers. Teachers' reflective ability had the largest coefficient, followed by classroom climate and teacher competence, which points to the value of continuous reflective practice for instructional quality. Collectively, these variables explained 51.5% of the variance in the quality of Deep Learning, indicating that teacher-related competencies and supportive learning environments jointly contribute to meaningful learning.

This study adds empirical evidence to the literature on Deep Learning. Its results are consistent with treating teacher competence, reflective ability, and classroom climate as complementary determinants of instructional quality. Improving the quality of Deep Learning requires integrated strategies that simultaneously strengthen teachers' professional competence, promote reflective teaching practices, and build positive classroom climates.

The findings also have practical implications for school leaders and policymakers who design professional development programs that support the implementation of Deep Learning in elementary schools. Because this study was limited to elementary schools in Grobogan Regency, future research should examine additional contextual factors and broader educational settings to test the generalizability of the findings.

Recommendations

Four recommendations follow from the findings. First, elementary school teachers are encouraged to continuously strengthen their pedagogical and professional competence while cultivating reflective teaching practices through regular self-evaluation, peer discussion, lesson study, and professional learning communities. These efforts are expected to improve the quality of Deep Learning in classroom practice. Second, school principals should strengthen academic supervision by facilitating continuous professional development, encouraging collaborative learning among teachers, and building a positive school culture that supports reflective teaching practices and effective classroom management. Third, educational authorities should design professional development programs that integrate teacher competence, reflective practice, and classroom climate improvement as complementary components of Deep Learning rather than addressing these aspects separately. Such integrated programs are expected to produce more sustainable improvements in instructional quality. Finally, future research should examine additional factors that may influence the quality of Deep Learning, such as school leadership, teachers' digital literacy, self-efficacy, instructional technology integration, and school culture. Future studies may also employ mixed-methods or longitudinal research designs to clarify how these factors influence the quality of Deep Learning in elementary education over time.

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REFERENCES

Biggs, J. B. (1993). From theory to practice: A cognitive systems approach. *Higher Education Research & Development, 12*(1), 73–85. https://doi.org/10.1080/0729436930120107

Darling-Hammond, L., Schachner, A. C. W., & Wojcikiewicz, S. K. (2024). Educating teachers to enact the science of learning and development. *Applied Developmental Science, 28*(1), 1–21. https://doi.org/10.1080/10888691.2022.2130506

Feriyanto, F., & Anjariyah, D. (2024). Deep learning approach through meaningful, mindful, and joyful learning: A library research. *Electronic Journal of Education, Social Economics and Technology, 5*(2), 208–212.

Fullan, M., Quinn, J., & McEachen, J. (2018). Deep learning: Engage the world, change the world. Corwin.

Goagoses, N., Suovuo, T., Winschiers-Theophilus, H., Montero, C. S., Pope, N., Rötkönen, E., & Sutinen, E. (2024). A systematic review of social classroom climate in online and technology-enhanced learning environments in primary and secondary school. *Education and Information Technologies, 29*, 2009–2042. https://doi.org/10.1007/s10639-023-11705-9

Gore, J. M. (2021). The quest for better teaching. *Oxford Review of Education, 47*(1), 45–60. https://doi.org/10.1080/03054985.2020.1842182

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). Multivariate data analysis (8th ed.). Cengage Learning.

Hanik, H., Nuphanudin, N., Khamidi, A., Roesminingsih, E., Kristanto, A., Trihantoyo, S., & Haq, M. S. (2025). Kepala sekolah sebagai instructional leader: Penguatan kompetensi pedagogik guru untuk pembelajaran mendalam di sekolah dasar. *Didaktika, 5*(3). https://doi.org/10.17509/didaktika.v5i3.93269

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1–55. https://doi.org/10.1080/10705519909540118

Kladika, A. S., Wening, N., & Firman, S. (2026). Self-reported implementation of mindful, meaningful, and joyful learning among elementary school physical education teachers. *Journal of Holistic Sports and Physical Education, 1*(2), 1–10. https://doi.org/10.23917/jhspe.18528

Kline, R. B. (2023). *Principles and practice of structural equation modeling* (5th ed.). Guilford Press.

König, J., Blömeke, S., Jentsch, A., Schlesinger, L., Felske, C., Musekamp, F., & Kaiser, G. (2021). The links between pedagogical competence, instructional quality, and mathematics achievement in the lower secondary classroom. Educational Studies in Mathematics, 107(1), 189–212. https://doi.org/10.1007/s10649-020-10021-0

Kraft, M. A., Blazar, D., & Hogan, D. (2018). The effect of teacher coaching on instruction and achievement: A meta-analysis of the causal evidence. *Review of Educational Research, 88*(4), 547–588. https://doi.org/10.3102/0034654318759268

Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. *Theory Into Practice, 41*(4), 212–218. https://doi.org/10.1207/s15430421tip4104_2

Li, X., & Zhu, W. (2023). The influence factors of students' transferable skills development in blended-project-based learning environment: A new 3P model. *Education and Information Technologies*, 28(12). https://doi.org/10.1007/s10639-023-11892-5

Mutmainnah, N., Adrias, A., & Zulkarnaini, A. P. (2025). Implementasi pendekatan deep learning terhadap pembelajaran matematika di sekolah dasar. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 10*(1), 848–871. https://doi.org/10.23969/jp.v10i01.23781

Philp-Clark, C., & Grieshaber, S. (2024). Teacher critical reflection: What can be learned from quality research? *The Australian Educational Researcher*, *51*(2), 697–717. https://doi.org/10.1007/s13384-023-00619-7

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology, 88*(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Rosyidah, F., Parmiti, D. P., Sanjaya, D. B., & Jampel, I. N. (2026). The theories of principles in deep learning approach. *Pedagogia: Jurnal Pendidikan, 15*(1), 127–136. https://doi.org/10.21070/pedagogia.v15i1.2098

Suratmin, Soegeng Ysh, A. Y., & Kusumaningsih, W. (2025). Pengaruh kepemimpinan instruksional terhadap kualitas pembelajaran Sekolah Penggerak SMA Negeri Kota Semarang. JMPIS: Jurnal Manajemen Pendidikan dan Ilmu Sosial, 6(3), 2322–2328. https://doi.org/10.38035/jmpis.v6i3.4701

Utaminingsih, S., Sundari, S., & Mirana, A. E. (2024). The professional competency development model of science teachers through learning leadership. *Jurnal Pendidikan IPA Indonesia*, *13*(1), 40–54. https://doi.org/10.15294/jpii.v13i1.48477

Wang, M.-T., Degol, J. L., Amemiya, J., Parr, A., & Guo, J. (2020). Classroom climate and children's academic and psychological wellbeing: A systematic review and meta-analysis. *Developmental Review, 57*, Article 100912. https://doi.org/10.1016/j.dr.2020.100912

Wibowo, G. W., Gunawan, D., & Mardiana, D. (2025). Implementasi pendekatan pembelajaran mendalam (deep learning) dalam meningkatkan pemahaman konsep siswa di sekolah dasar. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 10*(3), 144–158. https://doi.org/10.23969/jp.v10i3.27960

Zohrabi, M., & Xodabande, I. (2024). Reflective practice as a tool for teacher education: A comparison between individual and peer reflection of Iranian EFL teachers. *Discover Education*, *3*(225), 1–15. https://doi.org/10.1007/s44217-024-00338-w

ICISFS-UMK 2026 EDUCATIONAL TECHNOLOGY & MEDIA

Development of BESTIE for Improving Scientific Literacy of Fifth-Grade Elementary Students

Hanim Mukhtiyani Mahmudah[1*], Khamdun[1] and Erik Aditia Ismaya[1]

[1]*Master of Basic Education, Universitas Muria Kudus, Indonesia*

Corresponding author: hanimmahmudah11@gmail.com

ABSTRACT

This study aimed to develop BESTIE, an interactive learning medium built with Smart Apps Creator for science material, to improve scientific literacy. The study was motivated by the limited use of learning media in elementary schools, which contributes to low scientific literacy. It used a research and development (R&D) design based on the ADDIE model. The research procedures included: (1) needs analysis; (2) design planning; (3) product development and expert validation; (4) implementation; and (5) evaluation. The participants were students in a limited trial class, an experimental class, and a control class; the fifth-grade teachers of the trial and experimental classes; and expert validators. Data were analyzed qualitatively and quantitatively.

The results were as follows. 1) Expert validation scores were 3.70 from the media expert (very feasible), 2.82 from material expert 1 (feasible), 3.27 from material expert 2 (very feasible), and 3.55 from the language expert (very feasible); 2) Response questionnaire scores were 3.53 for students and 3.60 for the teacher in the limited trial class, and 3.48 for students and 3.53 for the teacher in the experimental class, all in the very feasible category. 3) An independent t-test on the posttest scores gave Sig. (1-tailed) = 0.0005 < 0.05: the mean posttest score of the experimental class was higher than that of the control class. 4) A product-moment correlation showed a significant and strong relationship between scientific literacy and learning outcomes in the experimental class (r = 0.797, Sig. (2-tailed) = 0.000 < 0.05).

KEYWORDS Smart Apps Creator | media development | scientific literacy | science | elementary school

INTRODUCTION

Advances in science, technology, and digital transformation have shifted the paradigm of 21st-century education from learning oriented toward knowledge transfer to one that emphasizes student competency development. Beyond conceptual mastery, schools must also develop critical thinking, problem-solving, collaboration, communication, and responsible technology utilization skills. These competencies are the foundation for students to face increasingly complex global challenges, including scientific developments, environmental change, and technological disruption (Boeskens & Echazarra, 2025). In line with these demands, the implementation of the Independent Curriculum in Indonesia positions students as active subjects in the learning process. Learning is expected to accommodate student characteristics through contextual, meaningful experiences supported by digital technology. In practice, uneven teacher competence and underused ICT infrastructure still limit digital learning in elementary classrooms (Afrillia & Dafit, 2025).

Scientific literacy is one competency that receives considerable attention in 21st-century education. It covers both the mastery of scientific concepts and the ability to use scientific knowledge to explain phenomena, evaluate information based on evidence, design investigations, and make responsible decisions regarding various life issues. The latest Programme for International Student Assessment (PISA) framework expands this scope with an environmental science competency, in response to the Anthropocene, in which citizens need to understand and act on environmental issues based on scientific evidence (OECD, 2023b).

Strengthening scientific literacy has become more urgent as countries try to prepare a generation able to address climate change, environmental crises, the development of artificial intelligence, and the acceleration of technological innovation (Abdullah et al., 2025). Science learning needs to provide opportunities for students to observe phenomena, explore data, conduct simple investigations, and develop arguments based on evidence so

that scientific literacy skills develop holistically (Mardiyah et al., 2024; Simanjuntak et al., 2025; Yusmar & Fadilah, 2023).

At the elementary level, scientific literacy is developed through the Natural and Social Sciences (IPAS) subject. IPAS emphasizes mastery of facts and concepts and also develops scientific thinking skills, process skills, and scientific attitudes, which are the foundation for learning at subsequent levels of education (Aprina et al., 2024; Mutia & Admawati, 2023). The success of IPAS learning depends largely on learning strategies and media that provide concrete, interactive, and contextual learning experiences. Elementary school-aged students tend to grasp a concept more easily if they are directly involved in the learning process (Wahyuni & Fakhriyah, 2025).

However, evaluation results indicate that the scientific literacy of Indonesian students remains low (OECD, 2023a). Indonesian students' performance on international assessments remains below the OECD average, which suggests that many students have difficulty explaining scientific phenomena, interpreting evidence, and using scientific knowledge to solve contextual problems. Science learning in schools has therefore not yet developed the scientific literacy competencies expected in the curriculum and the PISA framework.

One factor contributing to low scientific literacy is the suboptimal use of digital technology as a learning medium (Yusmar & Fadilah, 2023). OECD analyses indicate that digital devices do not improve learning by themselves unless they are used with media that encourage interaction, exploration, and active engagement. Digital transformation in education therefore requires learning media suited to student characteristics and learning objectives, not only the provision of devices (Boeskens & Echazarra, 2025).

Interactive media are one way to address this gap. A meta-analysis of 15 Indonesian experimental studies found a mean effect size of 1.146 for interactive multimedia on learning outcomes, with the largest estimate at the elementary level (Khaeruman et al., 2023), and a meta-analysis of 110 studies found a moderate effect (0.523) for integrating mobile devices into teaching and learning (Sung et al., 2016). Smart Apps Creator (SAC) lets teachers build Android applications without programming and combine text, images, video, animation, audio, simulations and quizzes in one application. Recent SAC studies in Indonesian elementary schools report high expert feasibility and gains in learning outcomes or concept understanding (Anggraeni et al., 2025; Sya'adah et al., 2025), and SAC media have also been developed for IPAS and Pancasila education (Badriyah et al., 2025; Kurniawan & Muhibbin, 2024).

The low level of scientific literacy is also reflected in the implementation of science learning in elementary schools. Initial observations, interviews with fifth-grade teachers, and analysis of learning documents at Karangsari 01 Public Elementary School indicate that textbooks remain the primary learning resource. Teachers have tried to follow the Independent Curriculum, but they use few types of learning media, so learning activities do not fully encourage students to explore, investigate, or interpret scientific phenomena independently. The problem is reflected in learning outcomes. In the Mid-Semester Summative (STS), 10 of 16 students (62.50%) had not reached the Learning Objective Achievement Criteria (KKTP) of 75, and only 6 students (37.50%) had. Students' understanding of science, particularly ecosystems, therefore needs to be strengthened through learning strategies suited to elementary school students.

Latifah and Istianah (2024) developed Android-based SAC media on energy transformation for grade 4 and tested their validity, practicality and effectiveness for science learning outcomes, and Pasaribu et al. (2025) developed SAC-based media for IPAS. Like most SAC development studies, they measured learning outcomes or concept understanding. Studies that targeted scientific literacy used other media: STEAM-based worksheets improved fifth graders' scientific literacy in a pretest-posttest trial (Afrijal et al., 2023), and Articulate Storyline media produced a medium N-gain (0.69) in elementary students' science literacy (Ramadhani & Asrul, 2024). SAC media built around the PISA scientific literacy competencies for an elementary ecosystems topic have received little attention, and this is the gap the present study addresses.

The novelty of this research lies in: (1) the development of Smart Apps Creator (SAC)-based learning media specifically designed to improve elementary school students' scientific literacy; (2) the integration of scientific literacy indicators based on the OECD PISA 2025 framework, which includes the competencies of explaining scientific phenomena, evaluating and designing scientific investigations, interpreting scientific data and evidence,

and environmental competencies; (3) the development of media for ecosystems material presented through interactive Android-based simulations that can be accessed online and offline; and (4) learning activities that connect ecosystem concepts with real environmental problems in the surrounding area.

LITERATURE REVIEW

The research began by identifying problems at Karangsari 01 Public Elementary School. Learning observations, teacher interviews, and students' Mid-Semester Summative Test results revealed several problems. Learning was teacher-centered, and students were not enthusiastic or fully engaged. Teachers relied on textbooks and textbook practice questions, so the questions students worked on varied little. Teachers focused on completing the textbook and used it as the learning guideline without checking its fit with the learning outcomes (CP) and learning objectives (TP). Learning tended to be rote, with little contextual learning, so concepts remained abstract. Media use was minimal, and the learning atmosphere was monotonous. Students' reading skills, especially in science, were weak. Limited school time for a large amount of material led teachers to prioritize coverage, so students' understanding was shallow and poorly matched to their needs and characteristics. The STS (Mid-Semester Summative 1) results of the 16 fifth-grade students confirm this: 10 students (62.50%) had not reached the KKTP (75), and 6 students (37.50%) had. To address these problems, the researchers aimed to create an enjoyable and meaningful learning environment that builds students' awareness of their own learning. Because many students use gadgets at home, these devices can also be used to learn science interactively. The researchers therefore developed a learning medium based on SAC (Smart Apps Creator). Branch (2009) describes the ADDIE (Analysis, Design, Development, Implementation, Evaluation) development model, which this study followed (see also Sugiyono, 2022b).

The researchers began designing BESTIE by gathering the learning materials, images, videos, and quizzes needed for the application. The design was then validated by media, material, and language experts and revised. BESTIE was then tried out with a small group of students to collect their suggestions for improvement. This was followed by peer validation, a second revision, and field trials. The evaluation stage was used to analyze the effectiveness of the BESTIE media.

Research Objectives

1. Analyze the development needs of BESTIE (Learning Ecosystems Through Interactive & Educational Technology Simulations) media for fifth-grade elementary school students.
2. Describe the development design of BESTIE (Learning Ecosystems Through Interactive & Educational Technology Simulations) media for fifth-grade elementary school students.
3. Determine the feasibility of BESTIE (Learning Ecosystems Through Interactive & Educational Technology Simulations) media for fifth-grade elementary school students.
4. Test the effectiveness of BESTIE (Learning Ecosystems Through Interactive & Educational Technology Simulations) media for fifth-grade elementary school students.

RESEARCH METHOD

This study employed a Research and Development (R&D) approach to develop BESTIE (Belajar Ekosistem Melalui Simulasi Teknologi Interaktif dan Edukatif), a Smart Apps Creator (SAC)-based learning medium designed to improve the scientific literacy of elementary school students. The R&D approach was chosen because it covers both producing an educational product and evaluating its feasibility, practicality, and effectiveness before broader implementation (Gall et al., 2007; Sugiyono, 2022a).

The analysis phase was conducted to identify media development needs through learning observations, semi-structured interviews with fifth-grade teachers, and documentation studies. The analysis focused on science learning needs, student characteristics, the condition of school infrastructure, and the suitability of ecosystems material to the learning outcomes of the Independent Curriculum. Students' initial scientific literacy was also analyzed from school assessment results and the characteristics of the ecosystems material. The design phase

covered the BESTIE media design, material development, user interface design, application navigation, evaluation instrument development, and the integration of science literacy indicators based on the OECD PISA 2025 framework into learning activities. The media was designed to operate on Android devices, both online and offline, through the Smart Apps Creator application.

In the development phase, the media were built according to the design and then validated by media experts, material experts, and education practitioners, who gave input on aspects of content, language, appearance, interactivity, ease of use, and the media's suitability to the characteristics of elementary school students (Branch, 2009). The validation results were used as the basis for revisions until the media was declared suitable for implementation. The implementation stage began with a limited trial, which assessed the practicality of the media and their effectiveness in improving students' scientific literacy. Learning was conducted using BESTIE media on ecosystems material according to the developed teaching module. The final stage, evaluation, followed implementation. Formative evaluation drew on input from validators, teachers, and students to refine the media, while summative evaluation was conducted through analysis of the results of the media's effectiveness test on improving students' scientific literacy (Sugiyono, 2022b).

The research subjects consisted of six students from SDN Sumur 02 in the limited trial class, 16 students from SDN Karangsari 01 in the experimental class, and 19 students from SD Negeri Bleber in the control class; the fifth-grade teacher of the limited trial class; the fifth-grade teacher of the experimental class; and expert validators in media, materials, and language.

The research data included both qualitative and quantitative data. Qualitative data were obtained through observation, interviews, documentation, and suggestions from the validator during the media development process. Quantitative data were obtained through expert validation sheets, teacher and student response questionnaires, and post-test results. The research instruments consisted of observation sheets, interview guidelines, media expert and material expert validation sheets, teacher practicality questionnaires, student response questionnaires, and a science literacy test instrument compiled based on the OECD PISA 2025 indicators. All instruments were validated before being used in the study. Data analysis was conducted using quantitative and qualitative descriptive methods. Data from expert validation, practicality, and student responses were analyzed using a feasibility percentage. The feasibility criteria refer to the categories of very feasible (81–100%), feasible (61–80%), quite feasible (41–60%), less feasible (21–40%), and not feasible (≤20%). Media effectiveness was analyzed using independent t-tests and product moment correlation tests. Qualitative data were analyzed through the stages of data reduction, data presentation, and conclusion drawing.

RESULTS

The results cover three aspects: the feasibility of BESTIE, based on expert validation and user responses; students' learning outcomes; and students' scientific literacy.

BESTIE was developed through the stages of the ADDIE model described by Branch (2009): Analysis, Design, Development, Implementation, and Evaluation.

The validation questionnaire collected scores, feedback, and suggestions for improving the media. Media validation assessed the technical, instructional, and display aspects of BESTIE. Technical aspect indicators included ease of operation, smoothness and stability of the media during use, and its suitability to the device's technical specifications (RAM, screen, and operating system). Instructional indicators included ease of use of media on various platforms (multiplatform), media support for navigation systems, and media optimization for usage conditions (accessibility). Display indicators included 1) suitability of color proportions; 2) layout proportions (menu and text layout); 3) accuracy of background selection; 4) accuracy of font selection, font size, font color and spacing; 5) accuracy of illustration selection used in the media; 6) clear image quality; 7) navigation functionality; and 8) video and image quality. The media expert gave a score of 52 out of 56 (mean 3.70), which falls in the very feasible category.

Material validation assessed the feasibility of the Harmony in Ecosystems material in the BESTIE teaching module and media. Two material experts completed a validation questionnaire. Material expert 1 gave a score of 31 out of 44 (2.82, feasible), and material expert 2 gave 36 out of 44 (3.27, very feasible); the mean for experts 1 and 2 was 3.05 (feasible). The language expert gave 39 out of 44 (3.55, very feasible). The media, material, and language validation results are presented in Table 1.

Table 1. Results of media, material, and language expert validation

Validator Ahli	Hasil	Kategori
Media	3.70	Sangat layak
Materi 1	2.82	Layak
Materi 2	3.27	Sangat Layak
Bahasa	3.55	Sangat layak

After expert validation, the media were piloted with six students: two high-achieving, two middle-achieving, and two low-achieving students. On the limited trial questionnaire, the students gave a score of 212 out of 240 (3.53, very feasible), and the trial class teacher gave 54 out of 60 (3.60, very feasible).

The media were then used in the experimental class for three meetings. Student responses in this class averaged 3.48 (very feasible), and the teacher gave 53 out of 60 (3.53, 88.33%, very feasible). The results of the media feasibility test are presented in Table 2.

Table 2. Response questionnaire results for media feasibility

Responden	Hasil	Kategori
Siswa Kelas Ujicoba terbatas	3.53	Sangat layak
Guru KelasUji coba terbatas	3.60	Sangat layak
Siswa kelas eksperimen	3.48	Sangat layak
Guru kelas eksperimen	3.53	Sangat layak

Based on expert validation and student and teacher questionnaire responses, the media were judged feasible for use in learning.

The posttest results after three meetings in the experimental and control classes were analyzed using an independent t-test. A prerequisite test before conducting the t-test was the data normality test. The Shapiro-Wilk test gave Sig. = 0.357 for the experimental class and Sig. = 0.744 for the control class. The posttest data of both classes were therefore normally distributed. The homogeneity test yielded Sig. = 0.316 (0.316 > 0.05). Therefore, the learning outcome data were considered homogeneous. The independent t-test was analyzed using SPSS Statistics version 27 with a significance level (α) of 0.05. In the SPSS Statistics version 27 t-test output (Table 3), Levene's test gave Sig. = 0.316 > 0.05, so the variances were equal and the Equal variances assumed row was used. The two-tailed test gave Sig. = 0.001 (0.001 < 0.05). The one-tailed Sig. is the Sig. (2 tailed) value divided by 2, giving Sig. (1 tailed) = 0.0005. Because Sig. (1-tailed) 0.0005 < 0.05, Ha is accepted: the mean posttest score of the experimental class was higher than that of the control class. The independent t-test results are presented in Table 3.

Table 3. Independent t-test results

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Hasil Belajar Siswa	Equal variances assumed	1.038	.316	3.776	33	.001	4.257	1.127	1.963	6.550
	Equal variances not assumed			3.884	32.290	.000	4.257	1.096	2.025	6.488

Scientific literacy data were obtained from observations by the teacher and the researchers in three consecutive learning meetings. Normality was tested first, in SPSS Statistics version 27, with a significance level of 0.05. The Shapiro-Wilk test gave Sig. (2-tailed) = 0.536; because 0.536 > 0.05, the scientific literacy data were normally distributed. The relationship between scientific literacy and learning outcomes was analyzed using product moment correlation. The product-moment analysis (Table 4) gave Sig. (2-tailed) < 0.05, so scientific literacy and learning outcomes were significantly related. The correlation was 0.797, which is in the strong category. The results of the product moment correlation test are presented in Table 4.

Table 4. Relationship between scientific literacy and learning outcomes

		Literasi_Sains	Hasil_Belajar
Literasi_Sains	Pearson Correlation	1	.797**
	Sig. (2-tailed)		.000
	N	16	16
Hasil_Belajar	Pearson Correlation	.797**	1
	Sig. (2-tailed)	.000	
	N	16	16

*Note. ** Correlation is significant at the 0.01 level (2-tailed).*

DISCUSSION

This discussion considers the feasibility of the BESTIE media, the differences in science learning outcomes after using BESTIE, and the relationship between science literacy and students' science learning outcomes.

The media expert assessed 14 indicators. Of these 14, 4 items received a score of 3 and 10 items a score of 4, for a validation score of 52 out of a maximum of 56 (mean 3.70, very feasible), or 92.86%. The BESTIE media validation assessment covered technical, instructional, and display aspects. The media expert advised using the researchers' own images and citing the source of any images taken from others. The material expert focused on whether the concepts matched the scope of the material. The language expert rated the media very feasible; this assessment covered suitability to the characteristics of elementary school students, clarity of information (communicative), language rules, and readability on smartphones.

These ratings are in line with other SAC development studies in Indonesian elementary schools, which reported expert feasibility of 91.67% for Pancasila education media (Anggraeni et al., 2025) and validity scores of 3.79 to 3.93 out of 4 for IPAS media (Sya'adah et al., 2025). The lowest rating in this study came from material expert 1 (2.82, feasible), whose review focused on whether the concepts matched the scope of the material. Content accuracy and alignment with the learning outcomes therefore deserve the most attention in further revisions, more than the technical and display aspects that the media expert rated highly.

The learning outcomes in this study were the results of the fifth-grade science post-test on the topic "Harmony in Ecosystems." The posttest was conducted after three meetings using BESTIE media in the

experimental class. Both classes had the same learning materials and time allocation, and students' initial abilities were reported to be comparable. The experimental class learned with BESTIE media and the control class with conventional media. The posttest was given outside class hours after the three science sessions. The results of the t-test (independent t-test) showed that the posttest score of the experimental class was higher than that of the control class. Table 3 reports a mean difference of 4.257 points between the classes (t = 3.776, df = 33). Classical mastery of the posttest of the experimental and control classes is presented in Figure 1.

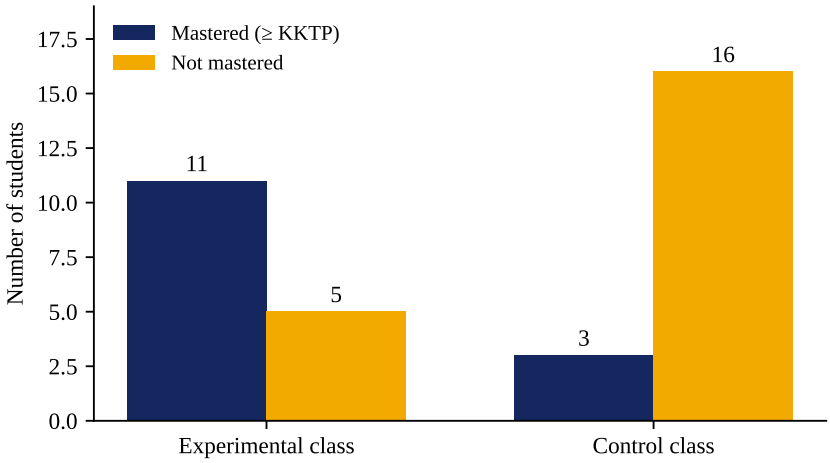

Figure 1. Classical mastery of the posttest in the experimental and control classes

Figure 1 shows classical mastery of the KKTP (75-point average score) for the 16 students in the experimental class and the 19 students in the control class. Of the 16 students in the experimental class, 11 completed the KKTP (75-point average score) and 5 students did not. In the control class, 3 students completed the KKTP (75-point average score) and 16 did not. The experimental class therefore had a higher classical mastery rate and a higher mean posttest score than the control class. This finding is consistent with the study by Pasaribu et al. (2025), in which the developed media were rated feasible by experts and highly practical by teachers and students and produced a moderate improvement in learning outcomes.

Students who learned with BESTIE therefore obtained higher posttest scores than the control class, which is consistent with the expectation that BESTIE supports learning outcomes.

A plausible explanation is that BESTIE presents ecosystem relationships through images, video, animation and simulations rather than through textbook text alone. The cognitive theory of multimedia learning holds that people learn more deeply from words and pictures than from words alone (Mayer, 2014), and food chains and interactions between organisms are processes that are easier to see than to read about. The direction of the result agrees with meta-analytic evidence on interactive multimedia in Indonesia (Khaeruman et al., 2023) and on mobile devices in teaching (Sung et al., 2016), and with an SAC study that reported a higher N-gain in the experimental class than in the control class (Anggraeni et al., 2025). The size of the effect in this study cannot be compared with those studies, however. The design compared intact classes from different schools with a posttest only, so differences in prior achievement, teachers or school conditions may account for part of the gap (Shadish et al., 2002). For teachers, the practical point is that SAC lets them build media for a specific topic and local context without programming, which is feasible in elementary schools where students already have access to Android devices.

In this study, effectiveness was judged from a quantitative aspect (learning outcomes) and a qualitative aspect (scientific literacy). Students' scientific literacy was observed during the three meetings, using four PISA scientific literacy indicators: 1) explaining phenomena scientifically, including: a) Students can connect lesson material with real life, b) students can explain scientific facts orally or in writing; 2) Evaluating and designing scientific investigations, including: c) students actively ask questions about natural phenomena/daily life, d) students can formulate problems based on observations/discussions; 3) interpreting scientific data and evidence, including: e)

students can provide opinions supported by facts, f) students can draw logical conclusions; 4) Environmental science competencies (scientific attitudes towards the environment in a sustainable manner), including: g) students show a high level of curiosity (enthusiastic) during learning, h) students respect their peers' opinions. The relationship between scientific literacy and learning outcomes can be seen in Table 4.

Scientific literacy and learning outcomes are likely to be linked because the science learning activities were designed around the PISA 2025 scientific literacy indicators. The product-moment analysis (Table 4) gave Sig. (2-tailed) <0.05, indicating a significant relationship, and the correlation of 0.797 is in the strong category. Because scientific literacy was observed only in the experimental class, this correlation does not by itself show that BESTIE improved scientific literacy.

Studies that measured scientific literacy before and after an intervention offer a useful comparison. STEAM-based science worksheets developed with ADDIE produced a significant pretest-posttest improvement in fifth graders' scientific literacy (Afrijal et al., 2023), and Articulate Storyline media produced a medium N-gain of 0.69 in elementary students' science literacy (Ramadhani & Asrul, 2024). This study did not measure scientific literacy before the intervention or in the control class, so it cannot show that BESTIE raised literacy. What the strong correlation does show is that, among students who used BESTIE, those who displayed more literacy behaviours during the lessons (explaining phenomena, asking questions, drawing conclusions from evidence) also scored higher on the posttest. Teachers can use the eight observation indicators as a checklist when planning inquiry-oriented activities, an approach that has also been studied as a route to higher-order thinking in Indonesian elementary schools (Narimo et al., 2025).

The study has several limitations. The samples were small (six students in the limited trial, 16 in the experimental class and 19 in the control class), and the three classes came from different schools. The effectiveness test used a posttest-only comparison, so the initial equivalence of the groups was not shown. Table 3 reports a mean difference of 4.257 points, but the class means and standard deviations are not reported in a table, so an effect size could not be calculated. Scientific literacy was observed in the experimental class only, and no validity or reliability evidence is reported for the observation sheet. The intervention lasted three meetings, which leaves open a novelty effect. Future studies should use a pretest-posttest control-group design with a scientific literacy test built on the PISA 2025 framework (OECD, 2023b), report N-gain and effect sizes, and follow students over a longer unit.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The following conclusions can be drawn:

The BESTIE media received feasibility scores of 3.70 from the media expert (very feasible), feasible from material expert 1, very feasible from material expert 2, and 3.55 from the language expert (very feasible). 2) In the limited trial class, the student and teacher response questionnaires gave 3.53 and 3.60 (both very feasible). In the experimental class, they gave 3.48 and 3.53 (both very feasible). 3) The posttest results of the experimental and control classes, analyzed using an independent t-test, yielded a sig (1-tailed) of 0.0005 <0.05, indicating that the average posttest score for the experimental class was higher than that of the control class. 4) The product-moment correlation between scientific literacy and learning outcomes was significant (Sig. (2-tailed) = 0.000 < 0.05) and strong (0.797). Fifth-grade students taught with BESTIE had higher posttest learning outcomes than the control class, and higher scientific literacy was associated with better outcomes; the effect of BESTIE on scientific literacy itself was not tested against a control group.

Recommendations

The researchers offer the following recommendations:

1. Students should actively participate in classroom learning activities to ensure a two-way, meaningful learning environment. In the digital era, students can use a variety of learning resources instead of relying

only on the teacher. Students are also expected to participate more actively and relate the material being studied to real-world situations in their surroundings, enabling contextual learning.

2. Teachers should keep their skills up to date and draw on a variety of relevant resources, including those from the surrounding environment, books, and digital media. Teachers are also expected to minimize factors that hinder the learning process so that learning activities can be optimally aligned with learning objectives.

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REFERENCES

Abdullah, F., Rakhmawati, D., & Indiati, I. (2025). Penerapan pendekatan TaRL (Teaching at the Right Level) dalam pembelajaran IPAS terhadap kemampuan literasi sains. *Didaktika, 5*(1). https://doi.org/10.17509/didaktika.v5i1.82223

Afrijal, Yulianti, D., Rohman, F., & Sunyono. (2023). STEAM-based science student worksheets to improve elementary school students' scientific literacy. *Thinking Skills and Creativity Journal*, *6*(2), 94–105. https://doi.org/10.23887/tscj.v6i2.67152

Afrillia, A., & Dafit, F. (2025). Tantangan guru mengimplementasikan pembelajaran berbasis teknologi digital dalam Kurikulum Merdeka di UPT SDN 023 Pandau Jaya. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 10*(4), 230–242. https://doi.org/10.23969/jp.v10i04.36163

Anggraeni, A., Erita, Y., Nora, D., & Rahmi, U. (2025). Development of Smart Apps Creator-based interactive learning media to support 21st century skills in Pancasila education for elementary schools. *Jurnal Kependidikan*, *11*(2), 702–712. https://doi.org/10.33394/jk.v11i2.15136

Aprina, E. A., Fatmawati, E., & Suhardi, A. (2024). Penerapan model problem based learning untuk mengembangkan keterampilan berpikir kritis pada muatan IPA sekolah dasar. *Didaktika: Jurnal Kependidikan*, *13*(1), 981–990.

Badriyah, L., Dike, D., & Amini, M. (2025). Multimedia pembelajaran interaktif si Dhewan berbasis Android menggunakan SAC untuk meningkatkan pemahaman IPAS dan keterampilan proses sains peserta didik sekolah dasar. *16*, 47–60.

Boeskens, L., & Echazarra, A. (2025). *Using digital resources for learning: Policy insights from PISA 2022*. OECD Publishing. https://doi.org/10.1787/eb9453f3-en

Branch, R. M. (2009). *Instructional design: The ADDIE approach*. Springer. https://doi.org/10.1007/978-0-387-09506-6

Gall, M. D., Gall, J. P., & Borg, W. R. (2007). *Educational research: An introduction* (8th ed.). Pearson.

Khaeruman, K., Sudiatmika, A. R., Suma, I. K., & Suardana, I. N. (2023). Meta-analisis: Efektivitas multimedia interaktif terhadap peningkatkan hasil belajar siswa. *Bioscientist: Jurnal Ilmiah Biologi*, *11*(2), 1630–1639. https://doi.org/10.33394/bioscientist.v11i2.9497

Kurniawan, B., & Muhibbin, A. (2024). Penerapan media pembelajaran berbasis Android dengan Smart Apps Creator (SAC) untuk meningkatkan hasil belajar Pendidikan Pancasila kelas VI SD. *9*.

Latifah, A. D., & Istianah, F. (2024). Pengembangan media interaktif Smart Apps Creator (SAC) berbasis Android untuk meningkatkan hasil belajar IPA materi transformasi energi kelas IV sekolah dasar. *Jurnal Penelitian PGSD*.

Mardiyah, N., Nuvitalia, D., Purnamasari, V., & Warsiti, B. (2024). Analisis kemampuan literasi sains peserta didik dengan pendekatan TaRL pembelajaran IPAS. *Education Journal: Journal Education Research and Development*, 393–404.

Mayer, R. E. (2014). Introduction to multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (2nd ed., pp. 1–24). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369.002

Mutia, N. B., & Admawati, H. (2023). Teachers' readiness to implement the Kurikulum Merdeka in the natural and social science learning. *Al-Bidayah: Jurnal Pendidikan Dasar Islam*, *15*(2), 267–290. https://doi.org/10.14421/albidayah.v15i2.1044

Narimo, S., Sulistyanto, H., Prayitno, H. J., Wulandari, M. D., Setyabudi, D. P., Sumardjoko, B., Anif, S., & Awaludin, A. (2025). An empirical study in Indonesia: Is adaptive inquiry learning effective for improving higher-order thinking skills of elementary school students? *International Journal of Innovation and Learning*, *37*(2), 179–194. https://doi.org/10.1504/IJIL.2025.144198

OECD. (2023a). *PISA 2022 results (Volume I): The state of learning and equity in education*. OECD Publishing. https://doi.org/10.1787/53f23881-en

OECD. (2023b). *PISA 2025 science framework*. OECD Publishing.

Pasaribu, R. M. I., Tanjung, S., & Yusnadi. (2025). Developing interactive SAC-based media to enhance elementary IPAS learning. *Inovasi Kurikulum*, *22*(4), 2115–2132.

Ramadhani, I. A., & Asrul, A. (2024). Development of interactive learning media based on Articulate Storyline to improve student' science literacy. *Lectura: Jurnal Pendidikan*, *15*(2), 533–545. https://doi.org/10.31849/lectura.v15i2.20974

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Houghton Mifflin.

Simanjuntak, R. V., Hermita, N., & Putra, M. J. A. (2025). Pengaruh pembelajaran STEM terhadap literasi sains siswa sekolah dasar. *Didaktik: Jurnal Ilmiah PGSD FKIP Universitas Mandiri*, *11*(4), 444–458. https://doi.org/10.36989/didaktik.v11i04.9733

Sugiyono. (2022a). *Metode penelitian dan pengembangan (research and development/R&D)*. Alfabeta.

Sugiyono. (2022b). *Metode penelitian kuantitatif, kualitatif dan R&D*. Alfabeta.

Sung, Y.-T., Chang, K.-E., & Liu, T.-C. (2016). The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. *Computers & Education*, *94*, 252–275. https://doi.org/10.1016/j.compedu.2015.11.008

Sya'adah, A. M. M., Kharisma, A. I., & Huda, M. M. (2025). Media Smart Apps Creator: Development an validation to improve understanding of IPAS concepts in elementary school. *Jurnal Tematik, 14*(2), 104–113. https://doi.org/10.24114/jt.v14i2.68196

Wahyuni, G. T., & Fakhriyah, F. (2025). Penerapan model contextual teaching and learning dengan metode outdoor learning dalam meningkatkan minat belajar siswa di SD Negeri 02 Mijen. *4*(2), 242–252.

Yusmar, F., & Fadilah, R. E. (2023). Analisis rendahnya literasi sains peserta didik Indonesia: Hasil PISA dan faktor penyebab. *LENSA (Lentera Sains): Jurnal Pendidikan IPA*, *13*(1), 11–19.

ICISFS-UMK 2026 EDUCATIONAL TECHNOLOGY & MEDIA

Developing Canva-Based Flipbook-Assisted Learning for Fourth-Grade Physical Education

Amelita Gayuh Silindri[1*], Gunawan Setiadi[1] and Sri Utaminingsih[1]

[1]*Master of Elementary Education Program, Faculty of Teacher Training and Education, Universitas Muria Kudus, Kudus, Indonesia*

Corresponding author: 202403066@std.umk.ac.id

ABSTRACT

This study developed and evaluated a Canva-based digital flipbook designed to support the management of fourth-grade physical education learning. The study responded to the limited use of interactive media, weak student focus during outdoor learning, and difficulties in organizing instructional time, groups, demonstrations, and assessment. A research and development design adapted from Borg and Gall was implemented through needs assessment, planning, prototype development, expert validation, product revision, main field testing, operational testing, and final refinement. Three experts validated the material and media. The main field trial involved one physical education teacher and 30 students, while the operational test involved 135 respondents from six elementary-school groups and one physical-education-teacher group. Data were collected through interviews, observation, validation sheets, response questionnaires, and pretest-posttest instruments. The product obtained an overall expert-validation score of 95.33% (highly feasible). Teacher practicality reached 90%, student response reached 88.33%, and classroom implementation was rated good to very good. The operational test showed an increase in the mean composite score from 70.89 to 94.48, with an average N-gain of 0.698. Paired-samples t-tests for all groups were significant at $p < .001$. The findings indicate that the Canva-based flipbook is feasible and practical and suggest that it can help structure learning sequences, clarify movement demonstrations, increase student engagement, and support systematic evaluation in elementary physical education.

KEYWORDS Canva | digital flipbook | learning | physical education | primary school

INTRODUCTION

Physical education in elementary schools is expected to develop movement competence, physical fitness, discipline, cooperation, responsibility, and healthy habits. Its implementation, however, differs from conventional classroom instruction: many activities take place in open spaces, and the teacher must organize students, equipment, time, demonstrations, practice, safety, and assessment at the same time. Effective learning management is therefore needed to keep students focused and to ensure that physical activities proceed in an orderly and safe manner.

Movement skills are learned largely by watching and then practising. A systematic review of 18 studies found strong evidence that observational learning improves students' motor skill learning in physical education compared with no observation (Han et al., 2022). A second review of 11 studies concluded that video-based visual feedback, using expert models or students' own performances, appeared to support motor learning in primary and secondary physical education more than verbal feedback alone. The same review noted that class size, lesson time, technical equipment and teachers' digital literacy determine whether such tools can be used in ordinary lessons (Mödinger et al., 2022). These conditions are a real constraint in Indonesia, where digital learning under the Kurikulum Merdeka is still limited by uneven teacher competence and underused ICT infrastructure (Afrillia & Dafit, 2025).

Initial observations and interviews in this study showed that fourth-grade physical education lessons relied heavily on verbal explanation and direct demonstration. These approaches are important, but they become less effective when students cannot repeatedly review the movement sequence or when the teacher must manage a large group in a limited period. Students may lose attention while waiting for instructions, and much lesson time may be spent reorganizing lines and groups. Teachers therefore need a visual learning resource that can present objectives, concepts, movement examples, activity sequences, and evaluation tasks in a single structured medium.

A digital flipbook can combine text, illustrations, video links, interactive simulations, educational games, quizzes, and discussion prompts. From the perspective of multimedia learning, appropriately integrated verbal and visual representations can reduce unnecessary cognitive processing and help learners build coherent mental models (Mayer, 2014). Meta-analyses also report a mean effect size of 1.146 for interactive multimedia on learning outcomes in Indonesian experimental studies (Khaeruman et al., 2023) and a moderate effect (0.523) for teaching with mobile devices (Sung et al., 2016). In physical education, this combination is useful because students need both conceptual explanations and observable examples of how a movement is performed. Digital content also allows a teacher to pause, repeat, or revisit demonstrations without repeatedly reconstructing the same explanation.

The use of Canva as a design platform enables teachers to organize learning content into visually consistent pages and to integrate hyperlinks, images, and videos without advanced programming skills (Septiani & Setiawan, 2024). However, the educational value of a digital product depends on the relationship between content, pedagogy, and technology, not on visual appeal alone. Mishra and Koehler (2006) argue that effective educational technology is produced when technological, pedagogical, and content knowledge are integrated. The flipbook in this study was therefore designed as an instructional tool that guides the lesson from preparation to evaluation, rather than as a digital textbook only.

Development studies in Indonesian elementary schools support the feasibility of such media. Canva- and Wordwall-based art media for grade 1 were rated 90% by media experts and 95.3% by material experts, with a student practicality score of 98% (Septiani & Setiawan, 2024). A flash flipbook for fourth graders was judged highly valid and practical and produced a moderate gain in digital literacy (Syifah et al., 2025). Canva media were associated with higher learning outcomes than a control class in a quasi-experiment on grade 5 poster writing (Khudin et al., 2025), and with a rise in mean scores from 58.92 to 83.75 in a one-group trial on the human respiratory system (Aly et al., 2026). These studies concern classroom subjects such as art, language and science. Physical education has received less attention, even though its lessons take place outside the classroom and depend on observing movement models. Indonesian research on TPACK has likewise concentrated on science and mathematics (Sutimin et al., 2025).

Student engagement is a second basis for the development. Engagement includes behavioral participation, emotional involvement, and cognitive investment in learning (Fredricks et al., 2004). In elementary physical education, an attractive and clearly sequenced medium can encourage students to observe examples, participate in practice, respond to questions, collaborate with peers, and complete reflection or assessment activities. A structured flipbook is therefore expected to support both the teacher's management of the lesson and students' active participation.

This study therefore developed a Canva-based flipbook for fourth-grade physical education on locomotor and non-locomotor movement and evaluated it through a Borg and Gall research and development cycle. It asked whether the product was feasible according to experts, practical for teachers and students, and associated with higher pretest-posttest scores when used by the seven groups in the operational test. The intended contribution is a product designed as a learning-management tool for the whole lesson sequence, from preparation to evaluation, together with evidence on its use across several schools.

LITERATURE REVIEW

The conceptual framework combines learning management, multimedia learning, and technology integration. Learning management is viewed as a continuous process of planning objectives and resources, organizing students and activities, conducting instruction, and evaluating learning. The flipbook supports these functions by providing a visible sequence of activities and reusable instructional resources. The multimedia principle explains why movement concepts are presented through concise text, images, and video demonstrations. The TPACK perspective guides the alignment of digital features with physical education content and learner characteristics.

The developed product contains a landing page, user guide, learning outcomes, material on locomotor and non-locomotor movement, illustrations, demonstration videos, interactive simulation, educational games, digital

quizzes, an online discussion space, summaries, and evaluation. Each component has a specific function. The user guide and learning outcomes support preparation; the material and videos structure explanation; simulations and games organize active practice; the discussion space supports feedback; and quizzes and evaluation provide evidence for follow-up.

Research Objectives

The study aimed to: (1) analyze the need for Canva-based flipbook-assisted learning in fourth-grade physical education; (2) develop a digital flipbook that corresponds to the characteristics of elementary learners and the requirements of physical education; (3) determine the feasibility and practicality of the developed product; and (4) examine its effectiveness in improving the quality and organization of learning, as indicated by pretest-posttest scores.

RESEARCH METHOD

Research Design

The study used a research and development design adapted from the Borg and Gall model (Gall et al., 2007), which has also been used to develop interactive multimedia for elementary schools (Rochman et al., 2024). For practical implementation, the procedure was organized into eight stages: needs assessment and information gathering; development planning; initial prototype construction; expert validation; first product revision; main field testing; second revision; and operational testing followed by final refinement. This sequence allowed the product to be reviewed and improved several times before its effectiveness was evaluated.

The needs-assessment stage used interviews and classroom observation to identify problems in planning, explaining, organizing, and evaluating physical education learning. The design stage translated those needs into a product map and page structure. The prototype was then validated by three experts with backgrounds in physical education, educational supervision, elementary education, and learning media. Recommendations were used to improve learning objectives, content depth, instructional sequence, navigation, multimedia access, and evaluation.

Respondents of the Study

The validation stage involved three expert validators. The main field trial involved one physical education teacher, 30 fourth-grade students, and one observer. The operational test involved 135 respondents distributed across seven groups: SDN 3 Putat, a physical-education-teacher group, SDN 1 Putat, SDN 7 Kuripan, SDN 1 Karanganyar, SDN 2 Candisari, and SDN 3 Candisari. Primary data were obtained from expert assessments, teacher and student responses, observations, and pretest-posttest scores. Curriculum documents and relevant literature were used as secondary data.

The instruments included structured interview guides, classroom observation sheets, expert-validation questionnaires, teacher and student response questionnaires, lesson-implementation checklists, and pretest-posttest instruments. The validation and response instruments used a five-point scale. Qualitative data were reduced, categorized, and interpreted descriptively. Quantitative data were analyzed using percentages, descriptive statistics, Shapiro-Wilk normality tests, paired-samples t-tests, and normalized gain. N-gain was interpreted using the criteria of low ($g < 0.30$), moderate ($0.30 \leq g < 0.70$), and high ($g \geq 0.70$) improvement (Hake, 1998).

RESULTS

Needs Analysis

The needs analysis identified a gap between the demands of fourth-grade physical education and the media available to teachers. Although teachers had prepared learning modules, objectives, and assessment, the instructional process continued to depend on oral explanation, printed materials, and direct demonstration. Digital media were rarely used to connect theory and practice. Students required more concrete movement examples and opportunities to review instructions, whereas teachers required a resource that could reduce repeated explanations and improve time and group management.

Table 1. Summary of the needs assessment

Aspect	Initial condition	Development need
Planning	Objectives and modules were available, but media support was limited.	A digital resource aligned with objectives and lesson stages.
Implementation	Theory was delivered mainly through oral explanation and direct demonstration.	Integrated text, images, videos, and guided activities.
Student engagement	Attention and participation varied, especially while students waited for instructions.	Interactive features, games, and short response tasks.
Class	Teachers spent considerable time organizing groups, sequences, and repeated demonstrations.	A visible and reusable activity sequence.
Evaluation	Assessment was not fully integrated with the learning medium.	Digital quizzes, reflection, and follow-up feedback.

Product Design

The prototype was developed as a digital learning package entitled Petualangan Gerak Dasar Kelas IV. The content focused on locomotor and non-locomotor movement. Its structure included a cover, teacher profile, user guide, learning outcomes, material map, teaching materials, movement illustrations, video demonstrations, interactive simulation, educational games, digital quizzes, discussion space, summary, and evaluation. The structure was linear enough to guide the lesson but flexible enough for the teacher to revisit any component as classroom needs required (Figure 1).

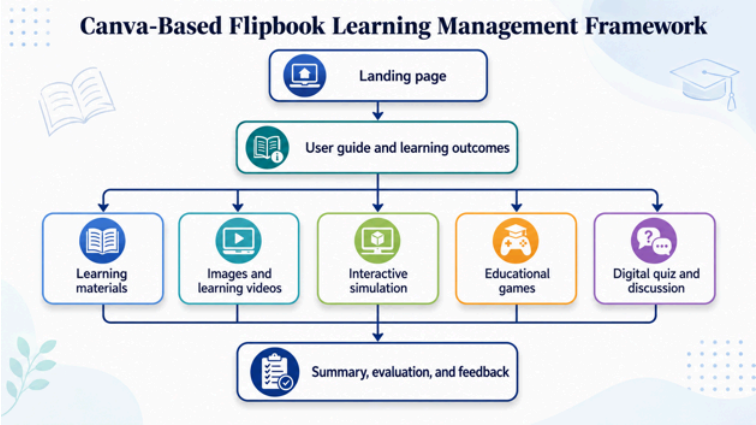

Figure 1. Learning-management structure of the Canva-based flipbook

The design reflects multimedia learning principles by placing visual examples close to concise explanations and by avoiding unnecessary duplication. It also reflects technological-pedagogical-content integration, because every feature was linked to a learning function rather than added for visual appeal. Videos provide observable movement models, simulations support conceptual discrimination, games sustain participation, and digital quizzes help the teacher monitor understanding.

Expert Validation

Expert validation rated the prototype highly feasible: material validation reached 94.67%, media validation 96.00%, and the overall score 95.33%. The experts considered the content consistent with learning objectives and learner development, while the visual design, readability, navigation, and multimedia integration were appropriate for elementary students. Revisions made the learning objectives more explicit, added more concrete movement examples, improved the sequence from concept to practice and evaluation, clarified navigation, and improved the accessibility of video and quiz links.

Table 2. Expert-validation results

Validation component	Obtained score	Maximum score	Percentage	Category
Material	71	75	94.67%	Highly feasible
Media	72	75	96.00%	Highly feasible
Overall	143	150	95.33%	Highly feasible

Practicality and Main Field Implementation

The main field trial showed that the product was practical for teachers and students: the teacher practicality score was 90% and the student response 88.33%. Observation showed that the lesson stages were implemented well: the teacher used the flipbook to introduce objectives, explain concepts, display movement videos, guide practice, provide activities, and conduct evaluation. Conceptual understanding also appeared to improve: indicators for defining and distinguishing locomotor and non-locomotor movement rose from approximately 60–63% before use to 84–86% after use.

Table 3. Main field-trial results

Evaluation aspect	Result	Category	Interpretation
Teacher practicality	90.00%	Highly practical	Easy to use and supportive of learning organization.
Student response	88.33%	Very good	Interesting, understandable, and supportive of participation.
Lesson implementation	Good to very good	Effective implementation	Activities followed the planned sequence.
Concept understanding	60–63% to 84–86%	Improved	Students more clearly understood movement concepts.

These results suggest that the product reduced dependence on repeated verbal explanation. Students could observe movement examples and follow instructions from the same medium, while the teacher could use the page sequence as a lesson-management guide. The product was revised again after the field trial by adding step-by-step instructions, simplifying some sentences, clarifying simulation and game directions, improving video links, and making digital-quiz access more visible.

Operational Effectiveness

The operational test showed improvement in all respondent groups. The combined mean increased from 70.89 in the pretest to 94.48 in the posttest, a mean difference of 23.59. The combined N-gain was 0.698, categorized as moderate and close to the high threshold. Five groups obtained high N-gain values and two groups obtained moderate values. Shapiro-Wilk analysis showed that the difference scores were normally distributed, and paired-samples t-tests were significant for every group ($p < .001$). The average item rating also increased from 3.38 (sufficient) to 4.50 (very high).

Table 4. Operational-test results by group

Group	N	Pretest mean	Posttest mean	N-gain
SDN 3 Putat	22	71.73	95.73	0.722
PE teacher group	20	73.10	96.85	0.748
SDN 1 Putat	20	66.10	88.50	0.586
SDN 7 Kuripan	16	70.31	93.62	0.674
SDN 1 Karanganyar	20	72.60	95.85	0.716
SDN 2 Candisari	16	72.06	96.00	0.731
SDN 3 Candisari	21	70.38	94.81	0.706
Combined	135	70.89	94.48	0.698

DISCUSSION

The results suggest that the flipbook served two functions: it was a learning medium and a learning-management scaffold. Its sequence enabled the teacher to communicate objectives, organize the flow of explanation and practice, and connect assessment to the material. This function matters in physical education, where instruction must coordinate conceptual understanding, observable movement, active practice, safety, equipment, and time.

This function responds directly to the needs analysis, in which teachers reported spending considerable time organizing groups, sequences and repeated demonstrations, and students' attention varied while they waited for instructions (Table 1). A visible page sequence lets the teacher move from objectives to explanation, demonstration, practice and evaluation without rebuilding each step orally, and students can see what comes next. The study did not, however, measure lesson time or time on task. The claim that the flipbook saves management time therefore rests on teachers' and observers' impressions. A time-sampling observation of management time versus activity time, before and after adoption, would test it directly.

The high expert-validation scores suggest that content, pedagogy, and technology were well aligned. This alignment is consistent with the TPACK framework, which emphasizes that technology becomes instructionally meaningful only when it supports content representation and pedagogical decisions (Koehler & Mishra, 2009; Mishra & Koehler, 2006; Tan et al., 2025). The product's videos and illustrations represented movement concepts that students would later perform, and games and quizzes provided structured transitions between observation, practice, and evaluation.

The validation scores (94.67% for material and 96.00% for media; Table 2) are similar to those reported for other Canva-based and flipbook media in Indonesian elementary schools (Septiani & Setiawan, 2024; Syifah et al., 2025). High expert ratings are common in development studies, however, and they show that the product meets the experts' criteria rather than that it improves learning. Their main value here lies in the revisions they prompted: clearer learning objectives, more concrete movement examples, a better sequence from concept to practice, and easier access to video and quiz links.

The positive teacher and student responses can also be explained through multimedia and engagement perspectives. Visual examples made oral instructions more concrete and allowed repetition, supporting the multimedia learning principle (Mayer, 2014). Interactive features invited behavioral participation and made the lesson more attractive, which is consistent with the multidimensional view of school engagement proposed by Fredricks et al. (2004). The increase in conceptual-understanding indicators suggests that the media may have helped students distinguish movement categories before performing them.

The rise in conceptual-understanding indicators (from about 60–63% to 84–86%; Table 3) is consistent with reviews showing that observing models supports motor skill learning in physical education (Han et al., 2022) and that video-based feedback may add to verbal feedback (Mödinger et al., 2022). This study, however, measured understanding of movement categories, not movement performance. The flipbook may help students know what a locomotor or non-locomotor movement should look like; whether they then perform it better was not assessed. For teachers, the practical implication is to use the video pages as models before practice and to keep live demonstration and direct feedback during practice.

In the operational test, scores rose in all seven groups: the combined mean increased from 70.89 to 94.48 (N-gain = 0.698), group N-gains ranged from 0.586 to 0.748, and the paired-samples t-tests were significant for every group ($p < .001$; Table 4). Single-group gains of similar size have been reported for an interactive flipbook e-module in junior high school science (N-gain = 0.70; Kharomah et al., 2024) and for interactive Canva media in grade 5 science (Aly et al., 2026). For schools, these results suggest that one teacher-made Canva product can be shared across schools with similar fourth-grade content, provided that the schools have display devices and internet access for the video and quiz links.

The operational results indicate that the product functioned consistently across user groups. The significant pretest-posttest differences and moderate-to-high N-gain values in all groups suggest that the improvement was

not limited to a single school. Nevertheless, the findings should be interpreted within the study design. The evaluation focused on product feasibility, user response, learning-management quality, and composite pretest-posttest scores, without a comparison group.

Several further limitations apply. Without a comparison group, the gains cannot be attributed to the flipbook rather than to the lessons themselves, repeated testing or the novelty of the medium (Shadish et al., 2002). The N-gain formula and the maximum score are not stated. Computed from the group means in Table 4 with a maximum of 100, the gains would be higher than those reported (about 0.81 for the combined group), so the reported values are presumably means of individual gains, and this should be stated. One of the seven operational groups consisted of physical education teachers who took the same test as the pupils, which makes the combined score hard to interpret. The paired t statistics, degrees of freedom and effect sizes are not reported, nor are the validity and reliability of the pretest-posttest instrument. Future research should compare the flipbook with alternative media in a controlled design, report pupils and teachers separately, assess movement performance as well as conceptual understanding, and examine retention and teachers' independent use over a longer period.

CONCLUSION AND RECOMMENDATIONS

The study produced a Canva-based flipbook that integrates learning objectives, material, images, movement videos, interactive simulation, educational games, digital quizzes, discussion, summary, and evaluation. The product was designed to support the complete cycle of fourth-grade physical education, including preparation, organization, implementation, and evaluation.

The product was highly feasible based on expert validation, highly practical based on teacher and student responses, and associated with pretest-posttest gains in operational testing. The overall validation score reached 95.33%, teacher practicality reached 90%, student response reached 88.33%, and the combined score increased from 70.89 to 94.48 with an N-gain of 0.698. These results suggest that the flipbook can help teachers structure learning, clarify movement instructions, manage lesson time, increase student participation, and conduct evaluation more systematically.

Teachers are advised to use the flipbook as a flexible support rather than a replacement for movement demonstration and direct feedback. Schools should provide internet access, suitable display devices, and professional development for teachers who wish to develop similar digital resources. Further studies should examine the product in other physical education topics, use experimental comparison groups, and assess psychomotor performance and long-term learning outcomes.

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REFERENCES

Afrillia, A., & Dafit, F. (2025). Tantangan guru mengimplementasikan pembelajaran berbasis teknologi digital dalam Kurikulum Merdeka di UPT SDN 023 Pandau Jaya. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 10*(4), 230–242. https://doi.org/10.23969/jp.v10i04.36163

Aly, Z. M., Wardana, Y. S., & Moh Aniq KHB. (2026). Keefektifan media pembelajaran Canva interaktif terhadap hasil belajar siswa pada materi pernapasan manusia di kelas V sekolah dasar. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 11*(2), 249–257. https://doi.org/10.23969/jp.v11i02.49721

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59–109. https://doi.org/10.3102/00346543074001059

Gall, M. D., Gall, J. P., & Borg, W. R. (2007). *Educational research: An introduction* (8th ed.). Pearson.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics, 66*(1), 64–74. https://doi.org/10.1119/1.18809

Han, Y., Syed Ali, S. K. B., & Ji, L. (2022). Use of observational learning to promote motor skill learning in physical education: A systematic review. *International Journal of Environmental Research and Public Health*, *19*(16), Article 10109. https://doi.org/10.3390/ijerph191610109

Khaeruman, K., Sudiatmika, A. R., Suma, I. K., & Suardana, I. N. (2023). Meta-analisis: Efektivitas multimedia interaktif terhadap peningkatkan hasil belajar siswa. *Bioscientist: Jurnal Ilmiah Biologi*, *11*(2), 1630–1639. https://doi.org/10.33394/bioscientist.v11i2.9497

Kharomah, S., Mulyati, Y., Marsuki, M. F., Fardhani, I., Hamimi, E., Ichsan, M. H. H., Hasan, S., & Sugiyanto, S. (2024). Enhancing students' science outcomes through problem-based interactive flipbook e-module. *Research and Development in Education*, *4*(2), 788–803. https://doi.org/10.22219/raden.v4i2.34572

Khudin, M. I. M., Dewi, A. L. S., & Erdiana, L. (2025). Pengaruh media Canva terhadap hasil belajar siswa pada pembelajaran Bahasa Indonesia kelas V SD. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 10*(3), 285–302. https://doi.org/10.23969/jp.v10i03.32641

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Education*, *9*(1), 60–70.

Mayer, R. E. (2014). Introduction to multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (2nd ed., pp. 1–24). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369.002

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, *108*(6), 1017–1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x

Mödinger, M., Woll, A., & Wagner, I. (2022). Video-based visual feedback to enhance motor learning in physical education: A systematic review. *German Journal of Exercise and Sport Research*, *52*, 447–460. https://doi.org/10.1007/s12662-021-00782-y

Rochman, F., Hunaifi, A. A., & Santi, N. N. (2024). Development of interactive multimedia in improving students' digital literacy skills. *Jurnal Eduscience*, *11*(1), 102–112. https://doi.org/10.36987/jes.v11i1.5359

Septiani, A. A., & Setiawan, D. (2024). Developing Canva-based Sitekol on collage topic for first-grade public elementary school students. *Journal of Integrated Elementary Education*, *4*(2). https://doi.org/10.21580/jieed.v4i2.21977

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Houghton Mifflin.

Sung, Y.-T., Chang, K.-E., & Liu, T.-C. (2016). The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. *Computers & Education*, *94*, 252–275. https://doi.org/10.1016/j.compedu.2015.11.008

Sutimin, L. A., Sariyatun, S., Musadad, A. A., Yuniyanto, T., & Abidin, N. F. (2025). TPACK research trends in Indonesia: Contributions to enhancing the equivalency education history teacher community. *Journal of Nonformal Education*, *11*(1), 19–33. https://doi.org/10.15294/jone.v11i1.20625

Syifah, A. J., Suratmi, S., & Hartono, H. (2025). Developing flash flipbook as a learning resource to improve students' digital literacy in elementary school. *Research and Development in Education*, *5*(1), 159–170. https://doi.org/10.22219/raden.v5i1.37606

Tan, X., Cheng, G., & Ling, M. H. (2025). Investigating the mediating role of TPACK on teachers' AI competency and their teaching performance in higher education. *Computers and Education: Artificial Intelligence*, *9*, Article 100461. https://doi.org/10.1016/j.caeai.2025.100461

ICISFS-UMK 2026 CURRICULUM, CULTURE & CHARACTER

Utilization of Si Pinter Media Based on Kudus Local Wisdom to Increase Learning Motivation

Dewi Srijayanri[1*], Nur Fajrie[1] and Gunawan[1]

[1]*Universitas Muria Kudus, Indonesia*

ABSTRACT

This study describes the use of Si Pinter media oriented to Kudus local wisdom in cultural diversity material to increase the learning motivation of grade IV elementary school students. The study was prompted by students' low learning motivation in this material, which was attributed to conventional and less contextual learning media. This research used Classroom Action Research in 2 cycles. The subjects were 25 grade IV students at an elementary school in Kudus Regency. Data were collected through observation, learning motivation questionnaires, interviews, and documentation. The data were analysed with descriptive quantitative and qualitative techniques. The conceptual framework of this study refers to Keller's ARCS Motivation Theory and Local Wisdom-Based Learning Theory. The results showed that Si Pinter media containing Kudus local wisdom elements, such as Menara Kudus, Djarum, Jenang Kudus, and traditional clothing, increased students' learning motivation. The average percentage of learning motivation increased from 62% in the pre-cycle to 75% in cycle I and 89% in cycle II. Students became more enthusiastic, more active in learning, and proud of their local culture. These results indicate that Si Pinter media oriented to Kudus local wisdom can increase students' learning motivation in cultural diversity material. Teachers are encouraged to develop learning media based on local wisdom to make learning more meaningful and contextual, and schools should provide facilities for such media. The findings may inform elementary school learning in the era of Society 5.0.

KEYWORDS Si Pinter media | Kudus local wisdom | cultural diversity | learning motivation | grade IV

INTRODUCTION

Cultural diversity material in grade IV asks students to recognise and value the customs, foods, crafts and traditions of the communities around them. In Indonesia this material supports the aims of civic and multicultural education, which treat respect for diversity as part of national identity (Nanggala, 2020; Ningsih et al., 2022). In many classrooms, however, grade IV students find the material boring because the media used are monotonous and distant from their daily lives. Learning media strongly shape students' interest in learning (Magdalena et al., 2021), and Indonesian authors have urged teachers to vary their methods and media rather than rely on the textbook alone (Dani et al., 2023). Teachers' and students' perceptions of the media used in class also affect how lessons are received (Anggraini et al., 2024).

Kudus Regency offers a close source of context for this material. Known as a city of santri and culture, Kudus has landmarks, foods, industries and customs that students meet every day, such as Menara Kudus, jenang Kudus, Djarum and traditional clothing. Its Gusjigang tradition (bagus, ngaji, dagang) has been proposed as a value framework that teachers can bring into instructional materials and methods (Abid, 2018). A survey of 15 principals and 85 teachers in Kudus public elementary schools found that the religious dimension of Gusjigang was strongly embedded in school leadership and character education, while its literacy and entrepreneurship dimensions were only moderately implemented (Kamal et al., 2025). In four madrasah ibtidaiyah in Kudus, religious character was strengthened through pesantren-based literacy, religious traditions and role modelling (Zuhri et al., 2025). These studies treat Kudus culture mainly as a source of character values.

Research on local wisdom-based learning in Indonesia has grown quickly. A PRISMA review of 47 Indonesian studies published from 2021 to 2026 identified five ways of implementing it, including integration into teaching materials and media, and reported gains in conceptual understanding, literacy, critical thinking and character; most of that evidence, however, came from development studies and short-term descriptive designs (Jovanda et al., 2026). At elementary level, local wisdom-based learning has been used to strengthen character

(Maharani & Muhtar, 2022), to bring local traditions into history learning (Januardi et al., 2024) and to shape the madrasah ibtidaiyah curriculum (Miskiyyah et al., 2025). Media built on local culture include the traditional game egrang as a medium for character learning (Ramdani et al., 2025), an audio-visual comic for Pancasila education oriented to local wisdom (Ardiawan, 2024) and cardboard wayang, which increased second graders' participation and concrete understanding in Surakarta (Sabrina et al., 2026). Teachers and schools are also seen as keepers of local cultural values in an era of globalisation (Sabila et al., 2025; Yusria, 2021).

Learning motivation is the outcome this study targets. Keller's ARCS model holds that learners are motivated when instruction gains their attention, is relevant to them, builds their confidence and leads to satisfaction (Keller, 2010). In a quasi-experiment with 56 fifth graders, ARCS-based instruction produced higher literacy scores than conventional teaching (Romli et al., 2024). Interactive media can also support learning: a meta-analysis of 15 Indonesian experimental studies reported a mean effect size of 1.146 for interactive multimedia on learning outcomes, with the largest estimate at elementary level (Khaeruman et al., 2023). In a one-group study with 30 third graders, learning motivation rose from 55.3 to 78.6 after a classroom quiz tool was introduced (Saputri et al., 2025). Digital media and other learning innovations are therefore widely proposed as ways to raise motivation (Anam et al., 2021; Saragih et al., 2025).

Few of these studies link local wisdom media explicitly to a motivation framework, and we found none that built an interactive medium on Kudus local wisdom for grade IV cultural diversity material. Kudus schools already use Gusjigang values for character education, but classroom media that present Kudus landmarks, foods and customs as learning content, and that are designed around the four ARCS conditions, have not been reported. Si Pinter, an interactive module on cultural diversity built on Kudus examples, was developed to fill this gap.

This classroom action research therefore asks how Si Pinter media oriented to Kudus local wisdom can be used to increase grade IV elementary school students' learning motivation in cultural diversity material. It describes how the media were implemented, follows the class's learning motivation over two cycles and reports students' responses. The study offers a locally grounded example that teachers in Kudus and similar regions can adapt.

LITERATURE REVIEW

This research is based on:

1. ARCS Motivation Theory by Keller (2010): Learning must address Attention, Relevance, Confidence, and Satisfaction. Si Pinter media were designed to address these four aspects.
2. Local Wisdom-Based Learning Theory: Connecting material with local culture makes learning more meaningful for students.

Together, the two theories link Si Pinter media, Kudus local wisdom and learning motivation: local content makes the material relevant and familiar, and the ARCS conditions guide how the media present it.

Research Objectives

1. To describe the use of Si Pinter media oriented to Kudus local wisdom in cultural diversity material.
2. To determine the increase in learning motivation of grade IV students after using Si Pinter media.
3. To identify supporting and inhibiting factors in the use of Si Pinter media.

RESEARCH METHOD

- **Research Design:** Classroom Action Research, 2 cycles (Kemmis et al., 2014)
- **Research Location:** Elementary School, Kudus Regency, Central Java
- **Research Subjects:** 25 grade IV students
- **Data Collection Techniques:** Observation, learning motivation questionnaire, interview, documentation (Ardiansyah et al., 2023)

- **Data Analysis Technique:** Descriptive quantitative analysis for questionnaire data (Martias, 2020); descriptive qualitative analysis for observation and interview data (Qomaruddin & Sa'diyah, 2024)
- **Success Indicator:** ≥80% of students have high learning motivation

RESULTS

Implementation of Si Pinter Media

Si Pinter media were presented as interactive modules on cultural diversity, with examples of Kudus local wisdom.

Table 1. Results of students' learning motivation

Cycle	Average score	Percentage	Category
Pre-cycle	62	62%	Medium
Cycle I	75	75%	High
Cycle II	89	89%	Very High

Student Responses

Students showed enthusiasm and pride when learning about their own regional culture through Si Pinter media.

DISCUSSION

The first finding is that the class average for learning motivation rose from 62% in the pre-cycle (medium) to 75% in cycle I (high) and 89% in cycle II (very high), a gain of 27 percentage points (Table 1). The cycle II average is above the 80% level named in the success indicator. The indicator, however, refers to the share of students with high motivation, and the paper reports only class averages. Whether at least 80% of the 25 students individually reached the high category therefore cannot be confirmed from these data.

One plausible explanation lies in the ARCS conditions (Keller, 2010). Si Pinter presents Menara Kudus, jenang Kudus, Djarum and traditional clothing, which students already know from their daily lives. Familiar images can capture attention, and examples from students' own town make the material relevant. Because students can recognise and talk about these examples, they may also feel more confident when answering tasks. The questionnaire scores were not reported by ARCS component, so this explanation is an interpretation rather than a tested result. In classroom action research each cycle is also revised after reflection (Kemmis et al., 2014), so part of the rise from cycle I to cycle II may reflect the teacher's growing familiarity with the media and not only the media themselves.

The direction of the change agrees with other Indonesian classroom studies. Saputri et al. (2025) reported that motivation rose from 55.3 to 78.6 among 30 third graders after a quiz tool was introduced, also without a control group. Romli et al. (2024), who did use a control group, found that ARCS-based instruction outperformed conventional teaching for fifth graders. The present study differs from both in where the motivating content comes from: local culture rather than game features or a general lesson design. The result is also consistent with the review by Jovanda et al. (2026), in which local wisdom media were associated with gains in understanding and character. That review notes that most such evidence comes from short descriptive designs, and this study shares that weakness. Unlike the studies of interactive multimedia summarised by Khaeruman et al. (2023), this study did not measure learning outcomes, so it says nothing yet about achievement.

The second finding concerns students' responses. Observation and interviews showed that students were enthusiastic and proud when they learned about their own regional culture through Si Pinter. This fits studies in which media drawn from local culture increased participation, such as cardboard wayang with second graders in Surakarta (Sabrina et al., 2026) and the egrang game used for character learning (Ramdani et al., 2025). Pride in local culture also connects the media with the character aims that Kudus schools already pursue through Gusjigang values (Abid, 2018; Kamal et al., 2025) and with the wider goal of preserving cultural values through

schooling (Sabila et al., 2025; Yusria, 2021). Such pride may feed the satisfaction component of ARCS, which could help explain why motivation stayed high in cycle II. The responses are reported descriptively, however, without the number of students who expressed them.

For teachers in Kudus, the results suggest that cultural diversity lessons can start from what students already see around them. Teachers can collect photographs and short texts about local landmarks, foods and crafts and arrange them in an interactive module, which requires modest resources. Doing so answers earlier calls to vary media in elementary classrooms (Dani et al., 2023; Magdalena et al., 2021). For principals, the findings support giving teachers devices and time to build such media and making local wisdom part of the school curriculum, as madrasah in Kudus and elsewhere already do (Miskiyyah et al., 2025; Zuhri et al., 2025). Teachers could also ask students to bring photographs or short stories about local places from home, which links the lesson with families and the wider community. Before use, such media should be checked for factual accuracy and suitability for children. At district level, the education office could collect teacher-made local media so that other schools in Kudus can reuse and improve them.

This study has several limitations. It was a two-cycle classroom action study in one class of 25 students, with no comparison group and no inferential test, so the gain cannot be attributed to Si Pinter alone; novelty, teacher enthusiasm and repeated measurement may also have raised the scores. Motivation was measured with a self-report questionnaire whose scale, maximum score and category cut-offs are not reported, and Table 1 gives only class averages. The paper does not report results for the third objective, the supporting and inhibiting factors, or the share of students in each motivation category. Future studies should report these data, compare a class using Si Pinter with a class using conventional media, analyse the four ARCS components separately and test whether higher motivation is followed by better learning outcomes.

CONCLUSION AND RECOMMENDATIONS

The use of Si Pinter media oriented to Kudus local wisdom increased the learning motivation of grade IV elementary school students in cultural diversity material. Learning motivation increased from 62% in the pre-cycle to 89% in cycle II.

Recommendations

1. Teachers should develop more learning media based on local wisdom.
2. Schools should facilitate the provision of contextual learning media.
3. Further research is recommended to examine the impact of Si Pinter media on student learning outcomes.

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REFERENCES

Abid, N. (2018). Integrating soft skill and Gusjigang local value in the learning process. Elementary: Islamic Teacher Journal, 5(1), 169–190. https://doi.org/10.21043/elementary.v5i1.2986

Anam, K., Mulasi, S., & Rohana, S. (2021). Efektivitas penggunaan media digital dalam proses pembelajaran. *Genderang Asa: Journal of Primary Education*, 2(2), 76–87.

Anggraini, S., Amalia, E. N., Eka, R., Afifa, R., & Natasya, L. N. (2024). Persepsi guru dan siswa tentang penggunaan media. *Jurnal Ilmu Pendidikan dan Kearifan Lokal*, 11–21.

Ardiansyah, Risnita, & Jailani, M. S. (2023). Teknik pengumpulan data dan instrumen penelitian ilmiah. *Jurnal Pendidikan Islam*.

Ardiawan, I. K. N. (2024). Pengembangan komik audio visual pendidikan Pancasila berorientasi kearifan lokal. Cetta: Jurnal Ilmu Pendidikan, 7(4), 181–194. https://doi.org/10.37329/cetta.v7i4.3652

Dani, D. E. R., Shaleh, & Nurlaeli. (2023). Variasi metode dan media pembelajaran. *Jurnal Ilmiah Pendidikan Madrasah Ibtidaiyah*, 7(1), 372–379.

Januardi, A., Superman, & Nur, S. (2024). Integrasi nilai-nilai tradisi masyarakat Sambas dalam pembelajaran sejarah. *Jurnal Pendidikan dan Pembelajaran Indonesia*, 4, 794–805.

Jovanda, R., Paais, R. L., Manafe, M. P., Sundari, L., Dewi, A. R., Ohodo, M. M. R., Chasanah, I. A. W., Pratama, A. H., & Waluyo, H. (2026). Local wisdom-based learning approaches for strengthening students' conceptual understanding and character in Indonesia: A systematic literature review [Version 1; peer review: 1 approved with reservations]. F1000Research, 15, Article 1384. https://doi.org/10.12688/f1000research.188148.1

Kamal, J., In'am, A., & Khozin, K. (2025). Culturally-rooted school leadership: The role of Gusjigang values in enhancing character education at the primary level. Elmidad, 17(2). https://doi.org/10.20414/elmidad.v17i2.14134

Keller, J. M. (2010). Motivational design for learning and performance: The ARCS model approach. Springer. https://doi.org/10.1007/978-1-4419-1250-3

Kemmis, S., McTaggart, R., & Nixon, R. (2014). The action research planner: Doing critical participatory action research. Springer. https://doi.org/10.1007/978-981-4560-67-2

Khaeruman, K., Sudiatmika, A. R., Suma, I. K., & Suardana, I. N. (2023). Meta-analisis: Efektivitas multimedia interaktif terhadap peningkatkan hasil belajar siswa. Bioscientist: Jurnal Ilmiah Biologi, 11(2), 1630–1639. https://doi.org/10.33394/bioscientist.v11i2.9497

Magdalena, I., Shodikoh, A. F., Pebrianti, A. R., & Susilawati, L. (2021). Pentingnya media pembelajaran untuk meningkatkan minat belajar siswa. *Ejournal STITPN*, 3, 312–325.

Maharani, S. T., & Muhtar, T. (2022). Implementasi pembelajaran berbasis kearifan lokal untuk meningkatkan karakter siswa. *Jurnal Basicedu*, 6(4), 5961–5968.

Martias, L. D. (2020). Statistika deskriptif sebagai kumpulan informasi. Fihris: Jurnal Ilmu Perpustakaan dan Informasi, 16(1), 40–59.

Miskiyyah, S. Z., Puspita, P. I. I., Dewi, T. B., Mu'izzah, R., Febriyanti, A. A., & Suttrisno. (2025). Kearifan lokal dalam kurikulum madrasah ibtidaiyah. *Jurnal Manajemen Pendidikan*, 10(2), 618–632.

Nanggala, A. (2020). Pendidikan kewarganegaraan sebagai pendidikan multikultural. *Jurnal Soshum Insentif*, 197–210.

Ningsih, I. W., Mayasari, A., & Ruswandi, U. (2022). Konsep pendidikan multikultural di Indonesia. *EDUMASPUL: Jurnal Pendidikan*, 6(1), 1083–1091.

Qomaruddin, & Sa'diyah, H. (2024). Kajian teoritis tentang teknik analisis data dalam penelitian kualitatif. *Journal of Management, Accounting and Administration*, 1(2), 77–84.

Ramdani, A., Adawiah, S. U., & Solihin, M. W. (2025). Makna simbolik dan nilai karakter dalam permainan tradisional egrang sebagai media pembelajaran karakter siswa sekolah dasar. JUDIKDAS: Jurnal Ilmu Pendidikan Dasar Indonesia, 4(4), 201–212. https://doi.org/10.51574/judikdas.v4i4.3778

Romli, M., Sudiana, I. N., & Putrayasa, I. B. (2024). The implementation of the ARCS model in Indonesian language learning to enhance literacy skills of fifth-grade students at elementary school. Jurnal Studi Guru dan Pembelajaran, 7(3). https://doi.org/10.30605/jsgp.7.3.2024.5101

Sabila, N., Safitri, D., & Sujarwo. (2025). Pelestarian nilai budaya melalui pendidikan di tengah arus globalisasi. *JIIC: Jurnal Intelek Insan Cendikia*, 2(4), 7641–7651.

Sabrina, S., Prihastari, E. B., & Mustofa, M. (2026). Analisis pemanfaatan media pembelajaran wayang kardus terhadap kreativitas peserta didik pada materi pewayangan kelas 2 SDN Kleco 1 Surakarta. Pendas: Jurnal Ilmiah Pendidikan Dasar, 11(1), 20–29. https://doi.org/10.23969/jp.v11i01.43053

Saputri, P., Nazurty, N., & Sulistiyo, U. (2025). Improving learning quality through Quizizz Paper Mode: A quantitative study of elementary school students. Lembaran Ilmu Kependidikan, 54(1), 123–133. https://doi.org/10.15294/lik.v54i1.22230

Saragih, C. A., Sianturi, F. A., Sita, S. A., Desyasrilyani, Nainggolan, L., Sinaga, G. O., & Samosir, D. (2025). Peningkatan motivasi belajar siswa melalui inovasi. *Ikraith-Humaniora*, 9(2), 1006–1013.

Yusria, I. (2021). Upaya guru dalam melestarikan nilai kebudayaan lokal. *Journal of Social Studies*, 2(2), 175–192.

Zuhri, A., Mas'ud, A., & Syukur, F. (2025). Strengthening religious character in madrasah: Integrating pesantren values as an educational strategy. Al-Tarbawi Al-Haditsah: Jurnal Pendidikan Islam, 10(1), 71–92. https://doi.org/10.24235/tarbawi.v10i1.19819

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

The Influence of Principal Partnerships and Coaching Leadership on the Quality of Learning in Public Elementary Schools within the Cempaka Cluster, Wedarijaksa District, Pati Regency

Agus Hartono[1*], Yuni Ratnasari[1] and Gunawan Setiadi[1]

[1]*Universitas Muria Kudus, Kudus, Indonesia*

Corresponding author: 202403059@std.umk.ac.id

ABSTRACT

The implementation of the Independent Curriculum requires school principals to strengthen collaborative partnerships and adopt coaching leadership practices to improve the quality of learning. However, elementary schools in the Cempaka Cluster, Wedarijaksa District, Pati Regency, continue to face challenges in implementing differentiated instruction, authentic assessment, and project-based learning. This study examines the influence of principal partnership and coaching leadership on learning quality in public elementary schools within the Cempaka Cluster. The study used a quantitative approach with Covariance-Based Structural Equation Modeling (CB-SEM) in IBM AMOS version 26. The population consisted of 171 classroom teachers from 23 public elementary schools in Wedarijaksa District. The research instrument measured three constructs: principal partnership, coaching leadership, and learning quality. The measurement model evaluation showed that all constructs met the required reliability and convergent validity criteria. Cronbach's Alpha, rho_A, and Composite Reliability values exceeded the recommended threshold of 0.70, and the Average Variance Extracted (AVE) values were above 0.50. The instrument therefore met the usual criteria for reliability and convergent validity. These results indicate that the measurement model is suitable for the structural model analysis that will test the relationships among the research variables. The study may inform educational leadership practice in elementary schools, particularly collaborative partnerships and coaching leadership.

KEYWORDS principal partnership | coaching leadership | learning quality | elementary school | structural equation modeling

INTRODUCTION

Basic education is the foundation for character building and competency development among the nation's youth as they face the challenges of the disruption era and the Industrial Revolution 4.0. The Emancipated Learning policy and the Emancipated Curriculum respond to these challenges by positioning schools as autonomous, contextual, and learner-centered centers of learning innovation (Kemendikbudristek, 2022). However, there is a wide gap between policy expectations (das Sollen) and the reality on the ground (das Sein). Preliminary data and documents obtained from the Pati Regency Education and Culture Office in 2024, together with observations at public elementary schools in the Cempaka Cluster, Wedarijaksa District, indicate that the implementation of the Independent Curriculum still faces several challenges. At the micro level, teachers face difficulties in implementing differentiated instruction and authentic assessment, as well as in contextually integrating P5 projects (Inayati, 2022; Muhsin et al., 2023).

These difficulties are not unique to Pati. First-grade teachers in another Indonesian study struggled with new Kurikulum Merdeka terms such as learning outcomes, teaching modules and the P5 project, and coped through Ministry resources, webinars and peer discussion (Asmahasanah et al., 2023). In a survey at one elementary school, teachers' own capacity for change was rated low while school leadership and collaborative culture were rated high, which suggests that adaptation to the curriculum depended largely on support around the teacher (Nuravifah et al., 2026). The picture is not uniform: IPAS teachers in Langsa rated their preparation as adequate and their implementation and assessment as good (Mutia & Admawati, 2023), so the level of difficulty appears to vary between regions and schools. Much of that support is organised by the principal.

Research on school leadership helps explain why. Four decades of empirical studies indicate that principals affect learning mainly indirectly, by shaping school conditions, teacher capacity and the context of teaching (Hallinger, 2011). An updated review reaffirmed that leadership influences student learning largely through teachers' motivation, capacity and working conditions (Leithwood et al., 2020). In a meta-analysis of 27 studies, the leadership dimension with the largest effect on student outcomes was promoting and participating in teacher learning and development (Robinson et al., 2008). Indonesian surveys point in the same direction. Principals' leadership was related to innovative work behaviour among 1,200 teachers (Hidayat & Patras, 2022), to teachers' professional development in Jakarta (Amzat et al., 2022) and to teacher performance in Pati Regency high schools, partly through work motivation (Ardliana et al., 2021).

Two forms of leadership are relevant to the Cempaka Cluster. Principal partnership mobilises resources and legitimacy from outside the school, for example through the school committee, whose role in school-based management has been examined in Indonesian schools (Ekawati et al., 2024). Coaching leadership works inside the school by helping teachers reflect on and improve their own practice (Whitmore, 2017). Coaching has strong causal evidence: a meta-analysis of 60 studies found pooled effects of 0.49 standard deviations on instruction and 0.18 on student achievement, although effects were smaller in larger programmes (Kraft et al., 2018). In Indonesia, principals' coaching leadership has been studied mostly for its link with teachers' digital competence (Tohir et al., 2025), and academic supervision has been linked with learning quality (Muhsin et al., 2023). Not every form of leadership shows an effect: in Batam elementary schools, principals' distributed leadership alone had no significant effect on education quality, whereas teacher leadership did (Yasrizal et al., 2022).

The theoretical gap addressed by this research is the absence of an empirically tested educational leadership model that integrates two complementary leadership approaches: principal partnership (an external-relational approach) and coaching leadership (an internal developmental approach). Previous research has examined these approaches separately. Studies on partnerships are largely qualitative, emphasizing administrative aspects or symbolic participation (Ekawati et al., 2024), whereas studies on coaching leadership predominantly examine its impact on specific teacher competencies, such as digital competence (Tohir et al., 2025). This study therefore examines the influence of principal partnership and coaching leadership on the quality of learning in the Cempaka Cluster of public elementary schools. This paper reports the first stage of that analysis, the validation of the measurement model for the three constructs; the structural tests are still to be completed. The findings are expected to offer an integrative leadership model for elementary schools and practical implications for principals, teachers, and policymakers in Pati Regency who seek to achieve high-quality learning within the framework of the Independent Curriculum.

LITERATURE REVIEW

The theoretical review synthesizes recent theoretical developments (2016–2026) and places them in the setting of Indonesian primary education under the Independent Curriculum. This approach supports an argument that is theoretically sound and applicable in practice (Creswell & Creswell, 2018). The concept of learning quality has changed considerably over the last decade. In the Indonesian context, this change is visible in the implementation of the Emancipated Curriculum, which is recognized for accommodating personalization through differentiated instruction and context-based projects (Kemendikbudristek, 2022; Inayati, 2022). Effective partnerships depend less on "having many connections" than on the ability to activate those networks to support learning goals [citation needed]. This capability requires reflective and strategic leadership, which links partnership to the second variable, coaching leadership.

There is a tension between the philosophy of coaching and the organizational culture of Indonesian schools. Coaching leadership is rooted in a non-directive and egalitarian philosophy (Whitmore, 2017). It therefore meets resistance in Indonesian educational organizations, which remain strongly hierarchical and in which staff are reluctant to cause discomfort or overstep boundaries. Coaching leadership is therefore a practice that must be adapted to the local culture rather than simply imported. Its success depends largely on the principal's ability to act

as a cultural broker, translating coaching principles into language and approaches that are accepted in the local socio-cultural context.

Research Objectives

The objectives of this study are (a) to analyze the influence of principal partnership on the quality of learning in public elementary schools in the Cempaka Cluster, Wedarijaksa District, Pati Regency; (b) to analyze the influence of coaching leadership on the quality of learning in these schools; and (c) to analyze the simultaneous influence of principal partnership and coaching leadership on the quality of learning in these schools.

RESEARCH METHOD

Research Design

The data were analysed with covariance-based Structural Equation Modeling (SEM) in IBM AMOS (Analysis of Moment Structures) version 26. SEM was chosen over multiple linear regression because it can estimate measurement and structural relationships simultaneously in models with several latent variables.

Respondents of the Study

The population of this study consisted of all active classroom teachers at State Elementary Schools (SDN) in Wedarijaksa District, Pati Regency. Based on data from the Pati Regency Education and Culture Office as of February 2026, there are 23 State Elementary Schools in Wedarijaksa District, with a total of 171 classroom teachers distributed across these schools.

The research instrument had a demographic section (respondents' names, ages, teaching experience, and schools of origin) and three questionnaire sections: principal partnership, coaching leadership, and learning quality. A sample of respondents is shown below.

Table 1. Sample of respondents

Name	School Name	Teaching Experience
Pangestia Novi Tri	SD Tluwuk	5-10 years
Ravita Deasy Rahmawati	SD Panggungroyom	5-10 years
Erna Fitriana Rohmawati	SD Panggungroyom	5-10 years
Ismiatul Faidah	SD Jetak	5-10 years
Siti Irsani	SD Panggungroyom	5-10 years
Rintan Kumala Dewi	SD Panggungroyom	11-15 years
Frida Asih Sulistiyani	SD Panggungroyom	>15 years
Lusiana	SD Swaduk 02	>15 years
Sigit Humartanto	SD Panggungroyom	>15 years
Budi Sayekti	SD Kepoh	>15 years
Dewi Prasetiyowati	SD Wedarijaksa 03	>15 years

RESULTS

Table 2 reports the convergent validity results of the measurement model for the three constructs.

All research constructs (X1, X2, and Y) met the reliability and validity criteria. Cronbach's Alpha values range from 0.955 to 0.959, and Composite Reliability values range from 0.960 to 0.962. All exceed the minimum threshold of 0.70, which indicates high internal consistency. The rho_A values fall within the 0.958–0.960 range. Average Variance Extracted (AVE) values are 0.578 for principal partnership, 0.950 for coaching leadership and 0.962 for quality of learning (Table 2), all above the 0.50 threshold, which satisfies the criterion for convergent validity.

Table 2. AVE results from convergent validity testing

	Average variance extracted (AVE)	Information
Principal partnership	0.578	Valid
Coaching leadership	0.950	Valid
Quality of learning	0.962	Valid

All variables in the research model therefore meet the criteria for reliability and convergent validity: Cronbach's Alpha, rho_A, and Composite Reliability values exceed the recommended minimum thresholds, and Average Variance Extracted (AVE) values exceed the 0.50 benchmark. Each construct is measured consistently by its indicators and shows adequate convergent validity. The measurement model (outer model) is therefore suitable as the basis for the next stage of analysis, testing the structural model (inner model) to examine the relationships between the research variables.

Based on the prior studies reviewed above, a conceptual framework was constructed that explains the relationships between the variables and the mechanisms that may link them. Three propositions follow from the research objectives: principal partnership is positively related to learning quality; coaching leadership is positively related to learning quality; and the two together are related to learning quality.

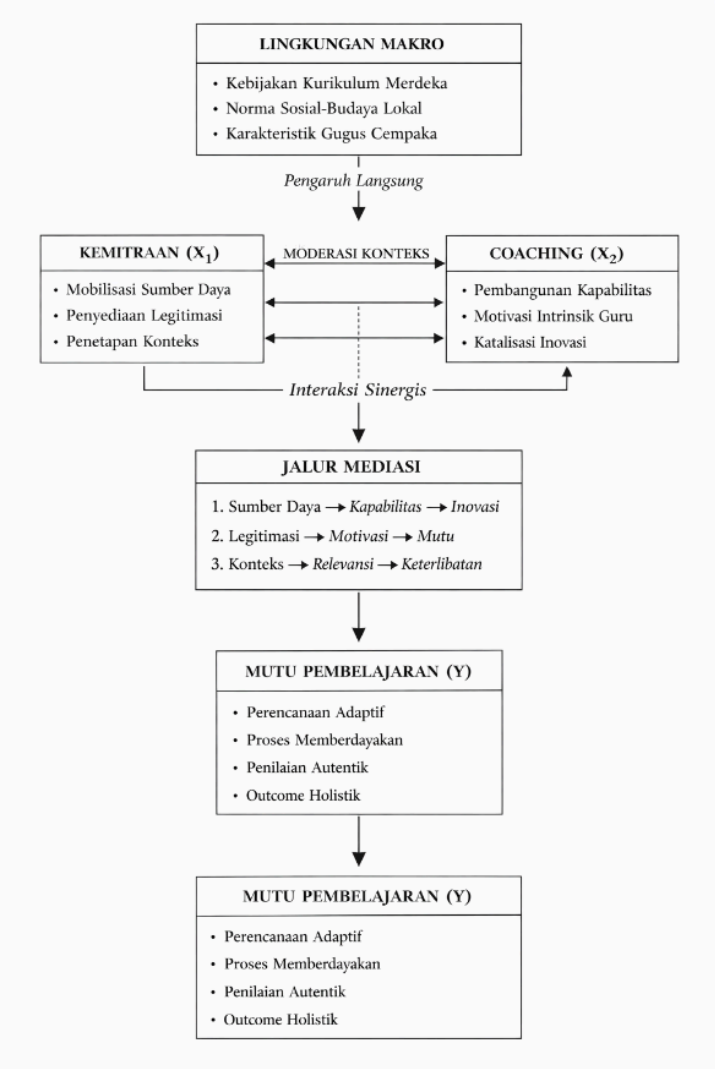

Figure 1. Conceptual framework of the study

The figure above shows the relationships of X1 and X2 with Y, both direct and through their interaction, and allows for possible intervening or moderating variables. The model also includes contextual variables (such as

school culture and cluster policy support) that may influence the strength of these relationships, and mediating mechanisms (such as enhanced teacher capacity).

DISCUSSION

The first finding is that the three scales showed high internal consistency. Cronbach's Alpha ranged from 0.955 to 0.959 and Composite Reliability from 0.960 to 0.962, well above the 0.70 threshold, and every AVE value in Table 2 exceeded the 0.50 criterion for convergent validity (Fornell & Larcker, 1981). Teachers therefore answered the items of each scale consistently, and each construct accounted for more than half of the variance in its indicators.

These values need careful reading. Reliability coefficients above 0.95 can indicate that several items repeat the same idea in slightly different words, which raises reliability without adding information. The AVE values of 0.950 and 0.962 for coaching leadership and quality of learning are unusually high and close to the reliability values reported in the text, so they should be checked against the software output. The paper also does not report discriminant validity. Because the same teachers rated principal partnership, coaching leadership and learning quality, the constructs may overlap. The Fornell-Larcker criterion or, preferably, the heterotrait-monotrait ratio should be reported before the structural model is estimated (Henseler et al., 2015).

A further point concerns the method. Indices such as rho_A and the terms outer and inner model belong to PLS-SEM, whereas the study reports covariance-based SEM in AMOS. The two approaches rest on different assumptions and reporting standards (Hair et al., 2019). The final paper should state which one was used and report the matching evidence: standardized loadings and model fit for CB-SEM, or loadings, HTMT, R^2 and bootstrapped paths for PLS-SEM (Hair et al., 2022).

The structural relationships have not yet been tested, so the study cannot yet say whether partnership or coaching leadership is related to learning quality in the Cempaka Cluster. Prior research gives reasons to expect positive relationships. Leadership tends to affect learning through teachers (Hallinger, 2011; Leithwood et al., 2020), and support for teacher learning is the leadership practice most strongly linked with student outcomes (Robinson et al., 2008). Coaching is a direct form of such support, with causal evidence of better instruction (Kraft et al., 2018). Indonesian studies have found that principal leadership relates to teacher performance in elementary and high schools (Ardliana et al., 2021; Starlinsky et al., 2022), and an AMOS model of 24 elementary schools found that principals' digital leadership affected teacher performance and student competence (Timan et al., 2022). The evidence for partnership is thinner (Ekawati et al., 2024), and the Batam study shows that some leadership forms have no effect on quality once other factors are considered (Yasrizal et al., 2022). The structural test may therefore show different strengths for the two forms of leadership.

The conceptual framework in Figure 1 proposes that partnership and coaching interact and that their effects run through mechanisms such as teacher capability, motivation and the relevance of learning. These mechanisms fit the indirect pathways described in leadership research (Leithwood et al., 2020). The questionnaire did not measure them, however, so the current data cannot test them. A later model could add teacher capacity or work motivation as a mediator, as Ardliana et al. (2021) did for teacher performance in Pati Regency.

For principals in the Cempaka Cluster, the validated scales offer a practical tool. Principals and cluster supervisors can use the partnership and coaching scales to learn how teachers perceive their leadership and to plan coaching conversations and partnership activities. Given the difficulties with differentiated instruction, authentic assessment and P5 projects described above, coaching could focus on these practices and use the peer discussion and shared resources that teachers already find helpful (Asmahasanah et al., 2023). Once discriminant validity has been confirmed, the Pati Regency Education and Culture Office could also use the instrument for cluster-level monitoring of curriculum implementation.

The study has clear limitations. Most important, the structural model that would answer the three research objectives has not been reported, so no conclusions about influence can be drawn. The sample size, sampling method and response rate are not stated; for a population of 171 teachers, the table of Krejcie and Morgan (1970)

can justify the minimum sample, and covariance-based SEM generally needs larger samples than PLS-SEM (Hair et al., 2019). All data are teacher self-reports from one questionnaire at one time, which can inflate relationships through common method variance (Podsakoff et al., 2003). The design is cross-sectional, so even a significant structural path would show association, not causation. Future work should report the full structural model with fit indices and path estimates, test discriminant validity and common method bias, and add observed measures of learning quality such as classroom observation or student outcomes. Finally, Table 1 lists respondents' full names and schools; for ethical reporting, respondents should be identified by codes, and informed consent should be stated.

CONCLUSION AND RECOMMENDATIONS

This study found that all research constructs met the required reliability and convergent validity criteria. The values of Cronbach's Alpha, rho_A, Composite Reliability, and AVE exceeded the recommended thresholds, so the instrument can be regarded as reliable and as having convergent validity. The measurement model is therefore appropriate for the structural model analysis. Because the structural model has not yet been tested, the study cannot yet draw conclusions about the influence of principal partnership and coaching leadership on learning quality.

School principals are encouraged to strengthen partnerships with stakeholders and to apply coaching leadership consistently. Teachers should actively participate in professional development activities, while future research is recommended to complete the structural model analysis and explore additional variables that may influence learning quality.

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REFERENCES

Amzat, I. H., Yanti, P. G., & Suswandari, S. (2022). Estimating the effect of principal instructional and distributed leadership on professional development of teachers in Jakarta, Indonesia. SAGE Open, 12. https://doi.org/10.1177/21582440221109585

Ardliana, B., Rusdarti, R., & Suminar, T. (2021). Effect of principal leadership, school culture and pedagogic competence through work motivation on teachers performance. Educational Management, 10(2), 273–283.

Asmahasanah, S., Chairunnissa, I. C., & Hakim, N. (2023). Navigating Merdeka curriculum in first grade: Teacher challenges and strategies. Journal of Integrated Elementary Education, 3(2), 137–149. https://doi.org/10.21580/jieed.v3i2.17592

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). Sage Publications.

Ekawati, H., Haryati, T., & Wuryandini, E. (2024). Peran komite sekolah dalam implementasi manajemen berbasis sekolah. MANAJERIAL: *Jurnal* Inovasi *Manajemen* dan Supervisi *Pendidikan*, 4(4), 278–289. https://doi.org/10.51878/manajerial.v4i4.4179

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research, 18(1), 39–50. https://doi.org/10.1177/002224378101800104

Hair, J. F., Jr., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2022). A primer on partial least squares structural equation modeling (PLS-SEM) (3rd ed.). Sage.

Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. European Business Review, 31(1), 2–24. https://doi.org/10.1108/EBR-11-2018-0203

Hallinger, P. (2011). Leadership for learning: Lessons from 40 years of empirical research. Journal of Educational Administration, 49(2), 125–142. https://doi.org/10.1108/09578231111116699

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. Journal of the Academy of Marketing Science, 43(1), 115–135. https://doi.org/10.1007/s11747-014-0403-8

Hidayat, R., & Patras, Y. E. (2022). The effect of principals' leadership and learning organization on teachers' innovative work behavior during the COVID-19 pandemic. Tadris: Jurnal Keguruan dan Ilmu Tarbiyah, 7(1), 161–175. https://doi.org/10.24042/tadris.v7i1.11355

Inayati, U. (2022). Konsep dan implementasi kurikulum merdeka pada pembelajaran abad-21 di SD/MI. 2nd ICIE: International Conference on Islamic Education, 2, 293–304.

Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi. (2022). *Kebijakan Merdeka Belajar*.

Kraft, M. A., Blazar, D., & Hogan, D. (2018). The effect of teacher coaching on instruction and achievement: A meta-analysis of the causal evidence. Review of Educational Research, 88(4), 547–588. https://doi.org/10.3102/0034654318759268

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. Educational and Psychological Measurement, 30, 607–610.

Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven strong claims about successful school leadership revisited. School Leadership & Management, 40(1), 5–22. https://doi.org/10.1080/13632434.2019.1596077

Muhsin, M., Sudadi, S., Mahmud, M. E., & Muadin, A. (2023). Supervisi akademik untuk meningkatkan mutu pembelajaran dan pengembangan budaya mutu. Journal of Education Research, 4(4), 2393–2398. https://doi.org/10.37985/jer.v4i4.569

Mutia, N. B., & Admawati, H. (2023). Teachers' readiness to implement the Kurikulum Merdeka in the natural and social science learning. Al-Bidayah: Jurnal Pendidikan Dasar Islam, 15(2), 267–290. https://doi.org/10.14421/albidayah.v15i2.1044

Nuravifah, S., Amelia, L., Zakiyah, N. S., & Pujiasti, D. A. (2026). Tingkat adaptasi guru terhadap Kurikulum Merdeka. Pendas: Jurnal Ilmiah Pendidikan Dasar, 11(2), 263–271. https://doi.org/10.23969/jp.v11i02.47141

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal of Applied Psychology, 88(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Robinson, V. M. J., Lloyd, C. A., & Rowe, K. J. (2008). The impact of leadership on student outcomes: An analysis of the differential effects of leadership types. Educational Administration Quarterly, 44(5), 635–674. https://doi.org/10.1177/0013161X08321509

Starlinsky, L., Belawati, T., & Rosita, T. (2022). Korelasi antara kepemimpinan kepala sekolah dan supervisi akademik terhadap kinerja guru sekolah dasar di Kecamatan Lebakgedong Kabupaten Lebak. Indonesian Journal of Educational Counseling, 6(1), 26–33. https://doi.org/10.30653/001.202261.190

Timan, A., Mustiningsih, M., & Imron, A. (2022). Digital leadership kepala sekolah hubungannya dengan kinerja guru dan kompetensi siswa era abad 21. Jurnal Administrasi dan Manajemen Pendidikan, 5(4).

Tohir, T., Hartinah, S., & Habibi, B. (2025). Pengaruh kepemimpinan transformasional, coaching leadership, dan digital leadership kepala sekolah terhadap kompetensi digital guru SMP Negeri di Kabupaten Pemalang. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 10*(2), 743–753. https://doi.org/10.23969/jp.v10i2.24759

Whitmore, J. (2017). *Coaching for performance: The principles and practice of coaching and leadership* (5th ed.). Nicholas Brealey Publishing.

Yasrizal, Y., Dahlan, J. A., & Chandrawati, T. (2022). Pengaruh kepemimpinan distribusi kepala sekolah dan kepemimpinan guru terhadap mutu pendidikan sekolah dasar. Lentera: Jurnal Ilmiah Kependidikan, 15(1), 23–38.

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

Principal's Strategies in Academic Supervision and School Management to Improve School Quality

Sukaryono[1*], Wawan Shokib Rondli[1] and Santoso[1]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: 202403149@std.umk.ac.id

ABSTRACT

Principals influence educational quality through academic supervision and school management. However, many schools still implement academic supervision primarily as an administrative activity rather than as a continuous professional development process for teachers. This study analyzes the principal's strategies in implementing academic supervision and school management, identifies the supporting and inhibiting factors, and examine their contribution to improving educational quality at SMP Negeri 1 Jakenan, Pati Regency, Indonesia.

This research used a qualitative descriptive case study design. The study was conducted at SMP Negeri 1 Jakenan, with the principal and teachers serving as the primary participants. Data were collected through in-depth interviews, observations, and document analysis. Data validity was ensured through source triangulation, technique triangulation, prolonged engagement, and member checking. Data were analyzed with the interactive model of Miles, Huberman, and Saldaña, which consists of data condensation, data display, and conclusion drawing.

The findings indicate that the principal implements academic supervision and school management through integrated planning, organizing, implementation, and evaluation. Academic supervision is conducted systematically through supervision planning, classroom observation, constructive feedback, and continuous follow-up. School management supports supervision implementation by integrating supervision findings into school planning, teacher professional development, and quality improvement programs. Implementation is supported by the principal's leadership, teacher commitment, a collaborative school culture, and adequate administrative systems. Limited time, teachers' workload, and administrative demands are the main challenges. Participants perceived the integration of academic supervision and school management as contributing to teacher professionalism, instructional quality, and school improvement.

The study suggests that integrating academic supervision with school management can serve as an instructional leadership model for improving educational quality in this school. The findings offer practical recommendations for school leaders who wish to strengthen teacher performance through integrated supervision and management.

KEYWORDS academic supervision | principal strategy | school management | school quality

INTRODUCTION

Educational quality depends on teachers' competence and students' achievement, and also on how well school leaders manage people, programmes and resources (Sallis, 2021). Leadership is a process in which one person influences a group toward common goals (Northouse, 2021), and in schools this responsibility falls mainly on the principal. Principals are expected to act as instructional leaders who support teachers' professional growth and create organizational conditions for high-quality learning (Hallinger, 2011; Mulyasa, 2022). Recent disruptions, including the COVID-19 pandemic, have added to these demands (Harris & Jones, 2020), and curriculum reform requires principals who can lead a culture of change (Fullan, 2021).

Academic supervision has shifted from inspection toward a developmental process that emphasizes professional assistance, collaboration, reflection, and continuous improvement (Glickman et al., 2022). Rather than focusing solely on administrative compliance, effective supervision encourages teachers to improve instructional planning, classroom practices, assessment strategies, and professional competence. Academic supervision should therefore be part of school management rather than an isolated administrative task.

Research on school leadership supports this developmental view. A meta-analysis of 27 studies found that the average effect of instructional leadership on student outcomes was three to four times that of transformational leadership, and that promoting and participating in teacher learning and development had the largest effect of the

five leadership dimensions (Robinson et al., 2008). Coaching, which resembles the follow-up stage of supervision, improved instruction by 0.49 standard deviations and student achievement by 0.18 in a meta-analysis of 60 causal studies (Kraft et al., 2018). Reviews also conclude that leadership affects learning mainly indirectly, through teachers' motivation, capacity and working conditions (Hallinger, 2011; Leithwood et al., 2020). Reviews of leadership models describe several approaches, including instructional and distributed leadership, that principals combine in practice (Bush, 2020; Bush & Glover, 2014).

School management also affects whether supervision programs succeed. Classical management theory describes four functions, planning, organizing, actuating and controlling (Terry, 1977), which are still used to describe how organizations and schools are run (Robbins & Coulter, 2021; Usman, 2023). In strategic management terms, a strategy is the set of decisions that links an organization's goals with its resources and actions (David & David, 2023; Wheelen et al., 2021). A principal's strategy therefore concerns how supervision findings feed into the school's plans, staffing and budget. Well-managed schools translate supervision results into professional development, resource allocation and quality improvement.

Indonesian studies report that principal leadership and academic supervision are associated with teacher performance. Among 64 elementary school teachers in Lebak Regency, principal leadership and academic supervision each related positively to teacher performance (Starlinsky et al., 2022). In Pati Regency high schools, principal leadership affected teacher performance directly and through work motivation (Ardliana et al., 2021). Academic supervision has been described as a means of improving learning quality and building a quality culture (Muhsin et al., 2023), and in Aceh Besar junior high schools, management practices affected teacher performance but not teacher motivation (Sariakin et al., 2025). However, many studies have examined academic supervision and school management as separate variables, so little is known about how the two functions interact in principals' leadership practice.

Another limitation in previous research concerns methodological approaches. Most of the studies above used surveys that test relationships between leadership variables and teacher outcomes (Ardliana et al., 2021; Sariakin et al., 2025; Starlinsky et al., 2022). The qualitative studies that exist concern mainly elementary schools and madrasah, such as principals' instructional leadership in three elementary schools in Jombang (Hanik et al., 2025) and a madrasah head's use of mentoring and modelling to build teacher discipline in Lampung (Dermawan et al., 2026). There is therefore limited evidence on how principals of public junior high schools formulate strategies, implement supervision, overcome barriers and use supervision findings in everyday managerial decisions.

SMP Negeri 1 Jakenan, Pati Regency, was chosen because it implements academic supervision and school management in an integrated way. Earlier work on principal leadership in Pati Regency has focused on high schools and used surveys (Ardliana et al., 2021). Examining the principal's strategies in this school may clarify which instructional leadership practices support quality improvement.

This study therefore analyzes the principal's strategies in implementing academic supervision and school management, identifies supporting and inhibiting factors, and examines how these strategies contribute to educational quality. Its contribution is to examine academic supervision and school management within a single instructional leadership framework, using a qualitative case study of an Indonesian public junior high school.

LITERATURE REVIEW

The conceptual framework of this study is grounded in instructional leadership theory (Hallinger, 2011), which emphasizes the principal's responsibility for improving teaching quality through systematic academic supervision and effective school management. Academic supervision is viewed as a continuous professional development process rather than an administrative inspection. School management provides the organizational mechanism through which supervision findings become decisions that improve educational quality.

This study adopts George R. Terry's management theory (Terry, 1977), which conceptualizes management through four interrelated functions: planning, organizing, actuating, and controlling (POAC). These functions are

integrated with instructional leadership principles to explain how principals plan supervision programs, organize resources, implement supervision, and evaluate its effectiveness.

Academic supervision in this research includes supervision planning, classroom observation, professional dialogue, constructive feedback, evaluation, and follow-up actions. School management covers strategic planning, human resource management, organizational coordination, program implementation, resource use, monitoring, and institutional evaluation. Integrating the two is assumed to help principals build a quality assurance system that improves teachers' professional competence and instructional effectiveness.

The implementation of these strategies is influenced by several supporting and inhibiting factors. Supporting factors include visionary principal leadership, teachers' commitment to professional development, collaborative school culture, adequate educational resources, effective communication, and stakeholder participation. Conversely, implementation is constrained by teachers' administrative workload, limited supervision time, scheduling conflicts, and increasing managerial responsibilities assigned to school leaders.

The integration of academic supervision and school management is expected to improve teacher professionalism, instructional quality, and school performance. In this framework, the principal's strategy links supervision practices with school improvement.

Research Objectives

This study aims to analyze the principal's strategy in implementing academic supervision and school management at SMP Negeri 1 Jakenan, Pati Regency, Indonesia. Specifically, the objectives are: 1) To analyze the principal's strategies for planning and implementing academic supervision. 2) To examine the principal's strategies in managing school administration through planning, organizing, implementation, and evaluation. 3) To identify supporting and inhibiting factors affecting the implementation of academic supervision and school management. 4) To examine the contribution of integrated academic supervision and school management strategies to improving teacher professionalism, instructional quality, and overall school effectiveness.

RESEARCH METHOD

Research Design

This study employed a qualitative approach using a descriptive case study design (Yin, 2018). A qualitative case study was chosen because it allows an in-depth examination of the principal's leadership practices in their real context. Instead of testing relationships statistically, it explores the processes, interactions, and managerial decisions that shape the implementation of academic supervision and school management.

The research was conducted at SMP Negeri 1 Jakenan, Pati Regency, Central Java, Indonesia. The school was selected purposively because it implements systematic academic supervision integrated with school management.

Participants

Participants were selected using purposive sampling based on their direct involvement in supervision and school management activities. They were: 1) the principal as the primary informant; 2) vice principals; 3) teachers from different subject areas; and 4) school documents, which served as supporting data.

These participants could provide information on supervision planning and implementation, management practices, and school improvement initiatives.

Data Collection

Data were collected through three complementary techniques: 1) In-depth interviews were conducted with the principal and teachers to explore leadership strategies, supervision implementation, managerial practices, and challenges encountered during implementation; 2) Participant observations focused on classroom supervision, teachers' instructional practices, school management activities, professional meetings, and follow-up discussions after supervision; 3) Document analysis included annual work plans, supervision programs, supervision reports, school development plans, meeting minutes, teacher performance documents, and other official administrative records relevant to academic supervision and school management.

Combining these techniques allowed methodological triangulation.

Data Analysis

Data were analyzed with the interactive model proposed by Miles et al. (2014), which consists of data condensation, data display, and conclusion drawing with continuous verification throughout the research process. Data condensation involved selecting and categorizing information according to the research objectives. The organized data were subsequently presented in narrative descriptions and thematic matrices before final interpretations were formulated.

The analysis focused on identifying patterns describing how the principal integrates academic supervision into school management and how these integrated strategies contribute to continuous educational quality improvement.

Trustworthiness

The credibility of the findings was strengthened through source triangulation, technique triangulation, prolonged engagement, member checking, and continuous verification throughout the research process. These procedures were intended to support the credibility, dependability, confirmability, and transferability of the findings, following Lincoln and Guba (1985), so that the conclusions reflect participants' experiences and the actual implementation of academic supervision and school management at SMP Negeri 1 Jakenan.

RESULTS

Principal's Strategy in Implementing Academic Supervision

The findings show that the principal at SMP Negeri 1 Jakenan implements academic supervision through a systematic cycle consisting of planning, implementation, evaluation, and follow-up. Academic supervision is designed as a continuous professional development process that helps teachers improve instructional quality, not only as an administrative requirement.

During the planning stage, the principal prepares an annual supervision program based on the school's work plan, teachers' professional needs, and curriculum implementation priorities. Supervision schedules are communicated at the beginning of the academic year to ensure teachers understand the objectives and procedures of supervision.

Implementation consists of lesson plan review, classroom observation of teaching practice, and post-observation conferences. During classroom visits, the principal evaluates instructional strategies, classroom management, use of learning media, student engagement, and assessment practices. Feedback is then given in reflective discussions that focus on professional improvement rather than fault-finding.

The supervision process concludes with evaluation and follow-up activities. Teachers who face instructional difficulties receive individual coaching, peer discussion, participation in the Subject Teacher Forum (MGMP), In-House Training (IHT), and mentoring. Supervision findings are documented and become references for subsequent professional development programs.

Table 1. Principal's strategy in academic supervision

Supervision Stage	Empirical Findings	Contribution
Planning	Annual supervision program, supervision schedule, preparation of supervision instruments	Clear supervision direction and teacher readiness
Implementation	Classroom observation, lesson plan review, instructional observation, professional dialogue	Improvement of instructional practices
Evaluation	National Reflection meetings, performance assessment, supervision documentation	Identification of teachers' strengths and weaknesses
Follow-up	Coaching, MGMP participation, In-House Training, mentoring	Continuous professional development

This suggests that academic supervision works as an instructional leadership strategy focused on teacher capacity building rather than administrative compliance. The finding is consistent with Glickman et al. (2022), who argue that supervision should support professional learning through collaborative reflection and continuous improvement.

Principal's Strategy in School Management

The study also found that the principal integrates academic supervision into broader school management practices. School management follows George R. Terry's four management functions: planning, organizing, actuating, and controlling (POAC). This allows supervision results to become part of strategic decision-making.

Planning involves developing the School Work Plan (RKS), Annual Work Plan (RKT), School Activity and Budget Plan (RKAS), supervision programs, and teacher development initiatives aligned with the school's vision and mission.

Organizing is reflected in the distribution of responsibilities among vice principals, department coordinators, teachers, and administrative staff. Clear organizational structures facilitate coordination and help ensure that supervision recommendations are implemented collectively.

Implementation includes coordination meetings, professional learning communities, teacher workshops, curriculum development, and continuous monitoring of instructional activities. The principal encourages collaborative decision-making and open communication to strengthen organizational commitment.

Controlling is conducted through routine monitoring, evaluation meetings, supervision reports, teacher performance reviews, and school program evaluation. Supervision findings become evidence for improving policies, allocating resources, and determining future development priorities.

Table 2. Integration of school management and academic supervision

Management Function	Empirical Findings	Contribution
Planning	School strategic planning integrated with supervision programs	Alignment between supervision and school goals
Organizing	Distribution of managerial responsibilities	Effective organizational coordination
Actuating	Teacher development, meetings, collaborative activities	Strong implementation of educational programs
Controlling	Monitoring, evaluation, performance review	Sustainable quality improvement

These findings indicate that academic supervision and school management are implemented as mutually reinforcing components rather than separate functions. This integration allows instructional improvement to inform school development policies.

Supporting and Inhibiting Factors

The implementation of integrated academic supervision and school management is influenced by several supporting and inhibiting factors.

Supporting factors include the principal's visionary leadership, teachers' commitment to professional growth, collaborative organizational culture, effective communication, availability of school administrative documents,

adequate learning facilities, and stakeholder participation. These factors encourage teachers to accept supervision as an opportunity for professional learning.

Several constraints remain. Teachers' administrative workload often reduces preparation time for instructional improvement. The principal also has limited time because of many managerial responsibilities, which makes supervision difficult to schedule. Differences in teachers' competence and in their readiness to adopt new instructional practices also affect supervision.

Table 3. Supporting and inhibiting factors

Supporting Factors	Inhibiting Factors
Visionary principal leadership	Limited supervision time
Teacher commitment	Heavy administrative workload
Collaborative school culture	Multiple managerial responsibilities
Effective communication	Differences in teachers' competencies
Adequate facilities	Scheduling constraints
Stakeholder participation	Limited opportunities for intensive coaching

These findings are consistent with the implementation theory of Edwards III (1980), which identifies communication, resources, disposition, and bureaucratic structure as determinants of policy implementation.

DISCUSSION

This study found that the principal of SMP Negeri 1 Jakenan practises instructional leadership by linking academic supervision with school management in one quality improvement cycle. According to the principal and teachers, supervision is not a separate activity; it is a main source of information for managerial decisions and programme improvement (Tables 1 and 2). Because the data consist of interviews, observations and documents from one school, the findings describe how this principal works and how participants perceive it, not measured effects on quality.

The supervision cycle in Table 1 (planning, classroom observation, reflective feedback, evaluation and follow-up through coaching, MGMP and In-House Training) reflects the developmental supervision model of Glickman et al. (2022), which emphasizes professional dialogue, collaborative reflection and continuing assistance. The mechanism is plausible: when teachers know the schedule and instruments in advance and receive feedback aimed at improvement, supervision is less likely to be felt as inspection and more likely to lead to changes in practice. The follow-up stage matters most here. Coaching has the strongest causal evidence among teacher development activities, with clear effects on instruction (Kraft et al., 2018), and promoting teacher learning is the leadership practice most strongly linked with student outcomes (Robinson et al., 2008). The pattern agrees with Hanik et al. (2025), who found that supervision, continuing professional development and a collaborative culture distinguished effective instructional leadership in three Jombang elementary schools, and with Muhsin et al. (2023), who described supervision as a route to learning quality. It differs from those studies in setting: a public junior high school, where subject specialisation makes it harder for one principal to give content-specific feedback, which may explain the reliance on MGMP and peer discussion.

The second finding is that supervision results enter school management through the four functions of Terry (1977), as shown in Table 2. Supervision findings inform the School Work Plan, Annual Work Plan and budget (planning), the division of tasks among vice principals and coordinators (organizing), workshops and professional learning communities (actuating), and performance reviews and programme evaluation (controlling). In this way, managerial decisions appear more responsive to instructional needs, in line with the continuous improvement logic of quality management in education (Sallis, 2021). The finding adds a practical detail to the survey by Sariakin et al. (2025), in which management practices affected teacher performance but not motivation: in this school, management seems to support teachers mainly by turning supervision findings into concrete development programmes and resources.

The third finding concerns supporting and inhibiting factors (Table 3). Visionary leadership, teacher commitment, a collaborative culture, communication, facilities and stakeholder participation supported

implementation, while limited time, administrative workload, multiple managerial duties and differences in teacher competence constrained it. These factors map onto the communication, resources, disposition and bureaucratic structure of Edwards III (1980). They also echo the view that leadership works through teachers' motivation, capacity and working conditions (Leithwood et al., 2020): workload and time are working conditions, and they limit how far supervision can reach. Similar supports were reported where a madrasah head improved teacher discipline through mentoring and personal modelling (Dermawan et al., 2026).

These challenges suggest that instructional leadership requires institutional support beyond the principal's own capacity. Within the school, the principal could share supervision with vice principals and senior teachers, a distributed approach described in reviews of leadership models (Bush & Glover, 2014), and use MGMP meetings for peer observation. The Pati Regency education office and other authorities could reduce unnecessary administrative reporting and provide training in coaching and feedback for principals and supervisors. Such measures are consistent with the demands that recent disruptions have placed on school leaders (Harris & Jones, 2020).

Taken together, the case suggests an integrated model in which academic supervision and school management are complementary: supervision identifies teachers' needs, and management turns them into plans, resources and follow-up. For other principals, the practical lesson is to plan supervision and management in the same cycle: schedule supervision when the annual plan is drafted, record findings in a form that can be used in budgeting, and review follow-up at evaluation meetings. The model is a proposal drawn from one school and should be tested elsewhere.

The study has several limitations. It is a single case of one public junior high school chosen because it already integrates supervision and management, so the findings may not transfer to schools without this practice. The paper does not state how many vice principals and teachers took part, and it reports no interview quotations, participant codes or document excerpts, which makes the strength of the evidence hard to judge. The claims about contributions to teacher professionalism and instructional quality rest on participants' perceptions rather than outcome data such as supervision scores, teacher appraisal results or student achievement. Future research should compare several schools with different supervision practices, report direct evidence from interviews and documents, and combine qualitative data with measures of teaching quality in a mixed-methods design.

CONCLUSION

This study examined the principal's strategy in implementing academic supervision and school management at SMP Negeri 1 Jakenan, Pati Regency, Indonesia. The findings show that academic supervision and school management are implemented as integrated components of instructional leadership rather than as separate administrative functions.

Academic supervision is systematically conducted through planning, classroom observation, reflective feedback, evaluation, and continuous follow-up. According to the principal and teachers, these activities support teachers' professional development by encouraging reflective teaching and improving instructional competence.

The study also shows that the principal integrates supervision outcomes into school management through planning, organizing, implementation, and evaluation processes. Supervision findings become the basis for teacher professional development programs, school policy formulation, resource allocation, and continuous quality improvement. This integration enables school management to respond directly to instructional needs identified during supervision.

The implementation of these strategies is supported by visionary leadership, collaborative school culture, teacher commitment, effective communication, stakeholder participation, and adequate educational resources. Nevertheless, several challenges remain, particularly limited supervision time, teachers' administrative workload, multiple managerial responsibilities, and differences in teachers' professional readiness.

Theoretically, this study proposes a framework that connects academic supervision with school management through Terry's management functions (planning, organizing, actuating, and controlling). Whereas previous

studies often examined supervision and school management separately, this case suggests that school improvement may be supported when supervision outcomes inform managerial decisions.

Practically, principals and educational authorities can strengthen instructional leadership by linking supervision to teacher professional development and school planning. Future studies could examine this model in other schools through comparative case studies or mixed-methods designs.

REFERENCES

Ardliana, B., Rusdarti, R., & Suminar, T. (2021). Effect of principal leadership, school culture and pedagogic competence through work motivation on teachers performance. Educational Management, 10(2), 273–283.

Bush, T. (2020). Theories of educational leadership and management (5th ed.). Sage.

Bush, T., & Glover, D. (2014). School leadership models: What do we know? School Leadership & Management, 34(5), 553–571. https://doi.org/10.1080/13632434.2014.928680

David, F. R., & David, F. R. (2023). Strategic management: Concepts and cases (17th ed.). Pearson.

Dermawan, O., Yusnita, E., & Putri, A. (2026). The role of school leadership in enhancing teacher work discipline. Tadris: Jurnal Keguruan dan Ilmu Tarbiyah, 11(1), 319–327. https://doi.org/10.24042/tadris.v11i1.28890

Edwards III, G. C. (1980). Implementing public policy. Congressional Quarterly Press.

Fullan, M. (2021). Leading in a culture of change (2nd ed.). Jossey-Bass.

Glickman, C. D., Gordon, S. P., & Ross-Gordon, J. M. (2022). SuperVision and instructional leadership: A developmental approach (11th ed.). Pearson.

Hallinger, P. (2011). Leadership for learning: Lessons from 40 years of empirical research. Journal of Educational Administration, 49(2), 125–142. https://doi.org/10.1108/09578231111116699

Hanik, H., Nuphanudin, N., Khamidi, A., Roesminingsih, E., Kristanto, A., Trihantoyo, S., & Haq, M. S. (2025). Kepala sekolah sebagai instructional leader: Penguatan kompetensi pedagogik guru untuk pembelajaran mendalam di sekolah dasar. Didaktika, 5(3). https://doi.org/10.17509/didaktika.v5i3.93269

Harris, A., & Jones, M. (2020). COVID 19 – school leadership in disruptive times. School Leadership & Management, 40(4), 243–247. https://doi.org/10.1080/13632434.2020.1811479

Kraft, M. A., Blazar, D., & Hogan, D. (2018). The effect of teacher coaching on instruction and achievement: A meta-analysis of the causal evidence. Review of Educational Research, 88(4), 547–588. https://doi.org/10.3102/0034654318759268

Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven strong claims about successful school leadership revisited. School Leadership & Management, 40(1), 5–22. https://doi.org/10.1080/13632434.2019.1596077

Lincoln, Y. S., & Guba, E. G. (1985). Naturalistic inquiry. Sage.

Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). Qualitative data analysis: A methods sourcebook (3rd ed.). Sage.

Muhsin, M., Sudadi, S., Mahmud, M. E., & Muadin, A. (2023). Supervisi akademik untuk meningkatkan mutu pembelajaran dan pengembangan budaya mutu. Journal of Education Research, 4(4), 2393–2398. https://doi.org/10.37985/jer.v4i4.569

Mulyasa, E. (2022). Menjadi kepala sekolah profesional. Remaja Rosdakarya.

Northouse, P. G. (2021). Leadership: Theory and practice (9th ed.). Sage.

Robbins, S. P., & Coulter, M. (2021). Management (15th ed.). Pearson.

Robinson, V. M. J., Lloyd, C. A., & Rowe, K. J. (2008). The impact of leadership on student outcomes: An analysis of the differential effects of leadership types. Educational Administration Quarterly, 44(5), 635–674. https://doi.org/10.1177/0013161X08321509

Sallis, E. (2021). Total quality management in education (4th ed.). Routledge.

Sariakin, S., Yeni, M., Usman, M. B., Mare, A. S., Munzir, M., & Saleh, M. (2025). Fostering a productive educational environment: The roles of leadership, management practices, and teacher motivation. Frontiers in Education, 10, Article 1499064. https://doi.org/10.3389/feduc.2025.1499064

Starlinsky, L., Belawati, T., & Rosita, T. (2022). Korelasi antara kepemimpinan kepala sekolah dan supervisi akademik terhadap kinerja guru sekolah dasar di Kecamatan Lebakgedong Kabupaten Lebak. Indonesian Journal of Educational Counseling, 6(1), 26–33. https://doi.org/10.30653/001.202261.190

Terry, G. R. (1977). Principles of management. Richard D. Irwin.

Usman, H. (2023). Manajemen pendidikan. Bumi Aksara.

Wheelen, T. L., Hunger, J. D., Hoffman, A. N., & Bamford, C. E. (2021). Strategic management and business policy (16th ed.). Pearson.

Yin, R. K. (2018). Case study research and applications: Design and methods (6th ed.). Sage.

ICISFS-UMK 2026 EARLY CHILDHOOD & INCLUSIVE EDUCATION

Collaborative Batik Finger Painting to Enhance Early Childhood Social Skills through Self-Expression

Anna Wahyu Ruhani[1*], Nur Fajrie[1] and Moch. Widjanarko[1]

[1]*Elementary Education Study Program, Faculty of Education, Universitas Muria Kudus, Indonesia*

ABSTRACT

Social skills help young children interact, communicate, cooperate, and adjust to their social surroundings. However, observations in several early childhood education settings in Andong District, Boyolali Regency, showed that children had few opportunities for collaborative learning, and their cooperation, sharing, communication, empathy, and respect for peers were limited. This research evaluated the implementation of collaborative batik art activities using finger painting, assessed children's participation through self-expression, and examined the effect on early childhood social skills. The research used a Sequential Explanatory Mixed Methods approach: a quantitative quasi-experimental stage followed by qualitative observations, interviews, and documentation. The participants consisted of children between the ages of 5 and 6 years from early childhood education centers in Boyolali Regency. Quantitative data were analysed with descriptive statistics, regression analysis, the Mann–Whitney U test, and the Wilcoxon Signed Rank test. Qualitative data were analysed through data reduction, data display, and conclusion drawing. The results showed that collaborative batik finger painting improved children's social skills. In the regression analysis, the model explained 72.2% of the variance in social skills ($R = 0.850$; $R^2 = 0.722$; $p = 0.010$). The Mann–Whitney U test showed significant differences between the experimental and control groups, and the Wilcoxon Signed Rank test showed significant gains after the intervention. Qualitative results also showed improved cooperation, communication, sharing, empathy, emotional regulation, and self-expression during collaborative activities. These results suggest that collaborative batik finger painting is a culturally relevant, age-appropriate approach that can improve young children's social skills while introducing local cultural traditions.

KEYWORDS batik art | collaborative learning | early childhood education | finger painting | self-expression | social skills

INTRODUCTION

Social skills allow young children to interact with others, build positive relationships, and adjust to their social surroundings. They include cooperation, communication, sharing, empathy, respect for others, and emotional regulation (Gresham & Elliott, 2008). Prosocial behaviours such as helping, sharing and comforting others develop considerably during the early childhood years (Eisenberg et al., 2015). In early childhood, social skills develop quickly through meaningful interactions with peers, teachers, and the environment. Early childhood education should therefore offer learning opportunities that promote active involvement and cooperation, not only academic achievement.

Indonesian early childhood education policy increasingly emphasizes holistic child development through play-based and learner-centered approaches. International evidence supports play in which adults guide rather than direct: in a meta-analysis of 17 studies with children aged one to eight, guided play produced better results than direct instruction for several early learning outcomes (Skene et al., 2022). In practice, however, classrooms often remain teacher-centered, which limits children's opportunities to cooperate, talk, and share their ideas. Art activities are often given as individual tasks that focus on the product rather than the process. Children therefore have few opportunities to develop cooperation, sharing, empathy, and communication through real social interaction.

Preliminary observations in several early childhood education centers in Andong District, Boyolali Regency, showed similar conditions. Children usually completed tasks on their own and rarely cooperated with peers. They had few opportunities to exchange ideas, share materials, solve problems together, or consider other views.

Teachers tended to prioritize completing learning objectives over collaborative activities. These conditions point to a need for learning approaches that promote creativity, cooperation, and social engagement together.

Cooperative learning is widely used to develop children's social skills because it offers opportunities for active engagement, mutual support, and shared accountability (Gillies, 2016; Laal & Ghodsi, 2012). Vygotsky's social constructivist theory (Vygotsky, 1978) holds that children's cognitive and social development occurs through interaction with more capable peers and adults. Johnson et al. (2014) emphasized that cooperative learning builds positive interdependence, social interaction, and individual responsibility. Piaget (1952) argued that children construct knowledge through direct experience, which makes hands-on art activities suitable for early childhood education.

Finger painting is a developmentally suitable art activity because it lets children explore colors, textures, and shapes while expressing their ideas and feelings. Combined with collaborative learning, it gives children opportunities to talk, negotiate, cooperate, and solve problems together. Incorporating batik, part of Indonesia's cultural heritage, into finger painting also introduces children to local cultural values.

Earlier research has reported that finger painting supports children's fine motor skills (Anggraini et al., 2018) and creativity (Hasibuan & Ningrum, 2016). In a study of 15 kindergarten children, more children showed originality, imagination and confidence with colours and shapes after finger painting (Bungge et al., 2025), and in classroom action research with seven children, finger painting improved artistic ability, although progress varied between children (Haya et al., 2025). Finger painting has also been examined as art learning (Chantika et al., 2024) and as a way to support social-emotional development, through a needs analysis (Loita et al., 2023) and through teacher-parent collaboration (Henawati et al., 2025). Group activities improve children's social interaction: collaborative learning with recycled materials was used to increase creativity (Jafar, 2018), and the traditional game engklek improved collaboration, communication, empathy and turn-taking among kindergarten children in Sukabumi (Hurri et al., 2026). Other work has introduced batik to young children through kindergarten programmes and batik-making activities (Aninditto et al., 2023; Damayanti, 2018; Fauzia & Umayah, 2025), and has used local culture in early childhood art learning (Dyahningtyas, 2022; Kusumastuti, 2014). However, these studies have usually examined each element separately, and most used descriptive designs with small groups. Few studies have combined artistic expression, local cultural heritage and collaborative learning in one instructional framework for improving young children's social skills, so there is little evidence on how the three together affect social competence.

The novelty of this research is an instructional framework that combines collaborative learning, batik-inspired finger painting, and children's self-expression in one teaching strategy. Unlike earlier studies that examined these elements separately, this study tests their combined effect on children's social skills in early childhood education.

This study aims to describe the implementation of collaborative batik art activities using finger painting, assess children's involvement through self-expression, and examine the effect of these activities on early childhood social skills in Boyolali Regency.

LITERATURE REVIEW

Social skills in early childhood develop through meaningful interactions that require children to communicate, cooperate, share, show respect, and manage their emotions. The social constructivist theory of Vygotsky (1978) holds that children's learning and development take place through interaction with adults and peers. In collaborative settings, children build knowledge by exchanging ideas and solving problems together. Collaborative learning therefore offers a basis for developing children's social skills.

Piaget's theory of cognitive development (Piaget, 1952, 1962) holds that young children learn best through hands-on exploration of their surroundings. Experiential tasks let children build understanding through concrete experience rather than passive instruction. Finger painting allows children to explore colors, textures, and patterns while expressing their thoughts and feelings.

Johnson et al. (2014) describe collaborative learning as defined by positive interdependence, personal responsibility, effective communication, and group engagement. These features give children opportunities to develop cooperation, communication, empathy, and responsibility. In her observations of preschool social play, Parten (1932) found that cooperative play organized around shared goals becomes more common as children grow older. Joint art activities are therefore suitable for developing children's social relationships.

Incorporating batik into finger painting combines creative expression with regional cultural values. Batik designs let children appreciate Indonesia's cultural heritage while creating art together. During the activity, children interact, negotiate, share ideas, and share materials, which gives them real opportunities to practise social skills.

Based on these theories, this research proposes that collaborative batik finger painting is a learning model that encourages self-expression and, through it, improves social skills in early childhood. Figure 1 depicts the connection between the research variables.

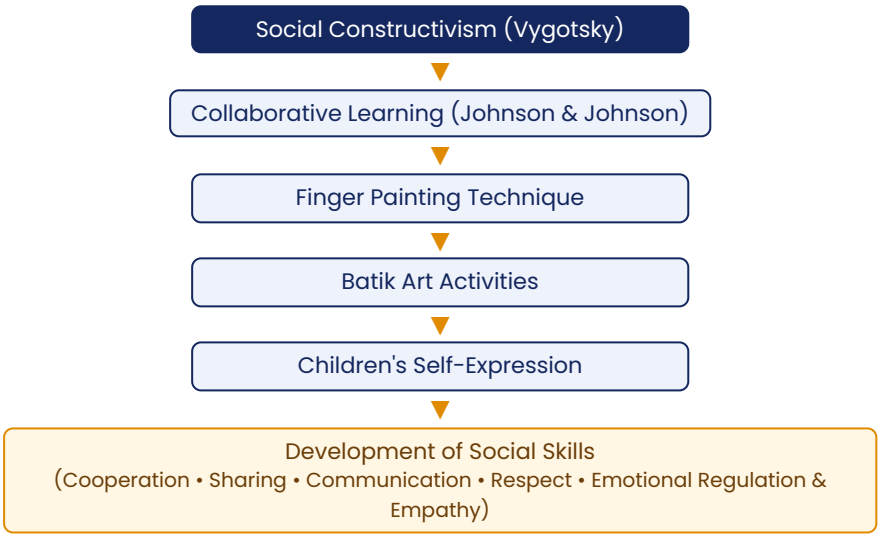

Figure 1. Conceptual framework illustrating the integration of collaborative batik finger painting to enhance early childhood social skills

The conceptual framework guided both the quantitative and qualitative phases of this sequential explanatory mixed-methods study. The quantitative phase tested the effect of collaborative batik finger painting on children's social skills, and the qualitative phase examined how collaborative interaction and self-expression developed during the activities. Combining the two phases shows both whether the intervention worked and how it affected children's social development.

RESEARCH METHOD

Research Design

This research used a Sequential Explanatory Mixed Methods design (Creswell & Plano Clark, 2018) that combined quantitative and qualitative strategies to examine the implementation and effect of collaborative batik finger painting on children's social skills. A quantitative quasi-experimental phase was followed by a qualitative phase (classroom observations, interviews, and documentation) that explained the quantitative results (Creswell & Creswell, 2018).

The quantitative phase employed a non-equivalent control group design (Campbell & Stanley, 1963), with an experimental group that took part in collaborative batik finger painting and a control group that followed regular learning activities. The qualitative phase examined children's learning experiences, collaboration, and self-expression during the activities.

Participants

The participants were children aged 5 to 6 years enrolled in early childhood education centers located in the Andong District of Boyolali Regency, Central Java, Indonesia. The research included 187 children, comprising 121 children in the experimental group and 66 children in the control group. Participants were selected by purposive sampling, based on the schools' willingness to take part and on whether their learning activities matched the research aims.

Research Instruments

Data were collected with observation forms, interview protocols, and documentation. Children's social skills were assessed with an observation instrument with five indicators: cooperation, sharing, communication, respect for others, and emotional regulation and empathy.

The instrument was validated by experts, and its reliability was satisfactory (Cronbach's Alpha above 0.70), which indicates that it is suitable for assessing children's social skills.

Data Collection

Quantitative data were collected by observing children's social skills in a pretest before and a posttest after the intervention. Qualitative data were then collected through classroom observations, semi-structured interviews with teachers, and documentation of learning activities. The qualitative results were used to explain the quantitative findings.

Data Analysis

Quantitative data were analysed with descriptive statistics, homogeneity tests, regression analysis, the Mann–Whitney U test, and the Wilcoxon Signed Rank test. Qualitative data were examined according to the interactive framework suggested by Miles, Huberman, and Saldaña (2014), which encompasses data reduction, data display, and drawing conclusions. The results of both phases were then integrated to explain how collaborative batik finger painting affects children's social skills.

RESULTS

Implementation of Collaborative Batik Finger Painting Activities

Collaborative batik finger painting was implemented in three phases: planning, implementation, and assessment. In the planning phase, teachers prepared lesson plans, learning resources, batik designs, finger painting materials, and group arrangements. The tasks were designed to promote active involvement, interaction, and collaboration among children.

In the implementation phase, children worked in small groups to produce batik art with finger painting. They were encouraged to exchange ideas, choose colors, share materials, and help each other finish the artwork. Teachers acted as facilitators: they offered support, encouraged participation, and gave children opportunities to express their thoughts and feelings.

Assessment was based on ongoing classroom observation of children's cooperation and social interaction. Teachers recorded children's involvement using indicators of cooperation, sharing, communication, respect for peers, and emotional regulation.

These observations suggest that collaborative batik finger painting shifted art activities from a focus on the product to a focus on the process. Children took an active part in social interaction during learning, which is consistent with the view of Vygotsky (1978) that meaningful learning takes place through collaborative social experience.

Children's Engagement through Self-Expression

Observation and interview results showed that children took an active part in collaborative batik finger painting. Being free to choose colors, design batik patterns, and share artistic ideas allowed children to express their ideas, feelings, and creativity.

Children were eager to collaborate, willingly shared materials, interacted with classmates, and respected different views during group tasks. Teachers also reported that working together on art projects increased children's confidence in sharing ideas and their willingness to collaborate with peers.

These results are consistent with the theory of Piaget (1952) that young children learn best through hands-on exploration. Finger painting offered concrete experiences that encouraged creativity, and collaborative learning created meaningful social interactions through which children practised communication, empathy, and responsibility.

Effect of Collaborative Batik Finger Painting on Children's Social Skills

The quantitative results show that the experimental group's mean social skills score rose more from pretest to posttest than the control group's (Table 1).

Table 1. Mean scores of children's social skills

Group	Pre-test	Post-test
Experimental	12.66	17.69
Control	11.55	12.11

DISCUSSION

The main quantitative result is that the experimental group's mean social skills score rose from 12.66 at pretest to 17.69 at posttest, while the control group's mean changed little, from 11.55 to 12.11 (Table 1). The abstract also reports a regression model that explained 72.2% of the variance in social skills and significant Mann–Whitney U and Wilcoxon results. These test statistics are not shown in the Results, so the size and certainty of the group difference cannot yet be judged from the paper itself. The experimental group also started slightly higher than the control group, which matters in a non-equivalent control group design (Shadish et al., 2002).

A plausible mechanism lies in the structure of the activity. Children shared one piece of work, one set of colours and one batik design, so they had to talk, take turns and agree on choices. This is the positive interdependence that Johnson et al. (2014) place at the centre of cooperative learning. It also provides the peer interaction through which, according to Vygotsky (1978), social and cognitive skills develop. Teachers acted as facilitators, which resembles guided play: children lead the activity while adults support it. A meta-analysis found that guided play outperformed direct instruction on several early learning outcomes, though not on all of them (Skene et al., 2022). The age of the children also fits the activity, since cooperative play becomes more common towards the end of the preschool years (Parten, 1932).

The results agree with Indonesian studies of finger painting and collaborative play. Finger painting has been linked with creativity (Bungge et al., 2025; Hasibuan & Ningrum, 2016) and fine motor skills (Anggraini et al., 2018), and it has been combined with teacher-parent collaboration to stimulate social-emotional development (Henawati et al., 2025). In a Sukabumi kindergarten, the traditional game engklek improved collaboration, communication, empathy and turn-taking (Hurri et al., 2026), which are close to the indicators measured here. This study differs in two ways. It measured social skills rather than creativity or motor skills, and it compared 187 children in experimental and control groups, whereas most earlier finger painting studies were descriptive or action research with small groups, such as seven children in Haya et al. (2025) and 15 in Bungge et al. (2025).

The qualitative findings help explain the gain. Children chose colours, designed batik patterns and shared ideas, and teachers reported that children became more confident in sharing ideas and more willing to collaborate. Self-expression may act as a bridge: when each child has something of their own to contribute, there is a reason to talk with peers and negotiate. Batik added a cultural layer, as in studies that introduced batik in kindergartens

(Aninditto et al., 2023; Fauzia & Umayah, 2025) or used local culture in early childhood art learning (Dyahningtyas, 2022; Kusumastuti, 2014). A review of local wisdom-based learning in Indonesia reported benefits for character but noted that most of the evidence comes from short descriptive studies (Jovanda et al., 2026). The qualitative data in this study share that weakness, because no quotations, informant numbers or coding examples are reported.

For early childhood teachers in Boyolali and similar districts, the activity is inexpensive and easy to adopt. Teachers can replace some individual art tasks with small-group work on one shared batik piece, give children simple roles such as choosing colours or leading a pattern, and observe the five social skills indicators during the activity. Principals of early childhood centres can provide materials and time for group art, and local education offices can include collaborative, culture-based art in teacher training on play-based learning. Because the activity uses batik, it can also be linked to curriculum themes on local culture, and parents can be invited to share batik motifs from their own families, which connects the classroom with children's homes. Teachers should keep the focus on the shared process rather than on a finished product, since the social benefits observed here came from interaction during the work.

Several limitations apply. The groups were formed by purposive sampling, were unequal in size (121 and 66) and differed at pretest, so selection effects cannot be ruled out (Shadish et al., 2002). Social skills were rated by observation, and the paper does not report the number of items, the actual reliability coefficient or agreement between raters. If the teachers who delivered the activity also rated the children, their expectations may have influenced the scores. The Results lack the group standard deviations, test statistics and effect sizes needed to judge the difference (Lakens, 2013), and the variables in the regression model are not described. The length of the intervention is not stated, and there was no follow-up. Future studies should report full statistics, analyse gains while adjusting for pretest scores, use independent raters and follow children over time to see whether the gains last.

CONCLUSION AND RECOMMENDATIONS

Conclusions

This research indicates that collaborative batik finger painting can improve early childhood social skills by providing artistic and cooperative experiences. The activities motivated children to take an active part in learning, interact with peers, share materials, work together on group tasks, and express their thoughts and feelings with confidence.

The quantitative results indicated larger gains in social skills in the experimental group than in the control group, which followed regular learning. The qualitative findings showed that joint art activities encouraged cooperation, communication, empathy, emotional regulation, and respect for others. The main contribution of this study is a developmentally suitable learning model that combines local cultural heritage, finger painting, and collaborative learning.

Collaborative batik finger painting supported children's creative expression and their social skills through real collaborative learning experiences.

Collaborative batik finger painting can therefore be a teaching option that supports holistic child development and helps preserve Indonesia's local cultural heritage.

Recommendations

Early childhood teachers are advised to include collaborative art-based learning in their practice to support children's social development and introduce local cultural values. Institutions could also consider adding collaborative batik finger painting to their early childhood programs.

Future studies should examine the long-term effects of collaborative batik finger painting on children's social-emotional development, creativity, and communication, and test it in other educational and cultural settings.

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REFERENCES

Anggraini, S., Jaya, M. T. B. S., & Sofia, A. (2018). Penerapan kegiatan finger painting dalam mengembangkan motorik halus anak usia dini. Jurnal Educhild: Jurnal Ilmiah Pendidikan Pendidik Anak Usia Dini, 7(1), 1–9.

Aninditto, A., Widdiyanti, W., Yulimarni, Y., Akbar, T., & Sundari, S. (2023). Pengenalan dan edukasi batik bagi anak usia dini di Taman Kanak-kanak Pembina Padangpanjang. Jurnal Abdidas, 4(3), 257–264.

Bungge, S. M., Durrotunnisa, Setianingsih, H. P., & Zuama, S. N. (2025). Finger painting activities and their effects on creativity in early childhood. Indonesian Journal of Early Childhood Educational Research, 4(2). https://doi.org/10.31958/ijecer.v4i2.15964

Campbell, D. T., & Stanley, J. C. (1963). Experimental and quasi-experimental designs for research. Houghton Mifflin.

Chantika, B., Andika, W. D., & Pagarwati, L. D. A. (2024). Analisis pembelajaran seni anak usia dini melalui kegiatan finger painting. PAUD Lectura, 7(2), 79–91.

Creswell, J. W., & Creswell, J. D. (2018). Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.). Sage.

Creswell, J. W., & Plano Clark, V. L. (2018). Designing and conducting mixed methods research (3rd ed.). Sage.

Damayanti, A. (2018, July). Peningkatan kreativitas seni melalui kegiatan membatik (pendidikan pusaka membangun karakter anak usia dini). In Prosiding Seminar Nasional Pendidikan (Vol. 1, No. 1).

Dyahningtyas, A. A. S. (2022). Identifikasi kebudayaan Kemataraman dalam pembelajaran seni di TK Pangudi Luhur Boro. Jurnal Anak Usia Dini Holistik Integratif (AUDHI), 5(1), 32–41.

Eisenberg, N., Spinrad, T. L., & Knafo, A. (2015). Prosocial development. In R. M. Lerner & M. E. Lamb (Eds.), Handbook of child psychology and developmental science: Socioemotional processes (7th ed., Vol. 3, pp. 610–658). John Wiley & Sons. https://doi.org/10.1002/9781118963418.childpsy315

Fauzia, W. F. W., & Umayah, U. (2025). Pendampingan kegiatan membatik untuk mengenalkan batik Banten Indonesia dan batik Malaysia di Tadika UPSI. Joong-Ki: Jurnal Pengabdian Masyarakat, 4(3), 794–803.

Gillies, R. M. (2016). Cooperative learning: Review of research and practice. Australian Journal of Teacher Education, 41(3), 39–54.

Gresham, F. M., & Elliott, S. N. (2008). Social skills improvement system rating scales manual. NCS Pearson.

Hasibuan, R., & Ningrum, M. A. (2016). Pengaruh bermain outdoor dan kegiatan finger painting terhadap kreativitas anak usia dini. JP (Jurnal Pendidikan): Teori dan Praktik, 1(1), 73–81.

Haya, A. F., Ahmad, A., Purnamasari, D. P., Aliya, L., & Musfidah, U. L. (2025). Fostering early childhood creativity through finger painting activities: A case study. Nak-Kanak: Journal of Child Research, 2(3), 89–97. https://doi.org/10.21107/njcr.v2i3.140

Henawati, E., Fitri, S. R. A., & Milah, S. (2025). Stimulasi perkembangan sosial emosional anak usia dini melalui kegiatan finger painting berbasis kolaborasi guru dan orang tua. Arunika Widya: Jurnal Pendidikan Dasar dan Menengah, 1(2), 1–13.

Hurri, I., Maulana, R. A., Elnawati, E., & Maspupah, I. M. (2026). Mengembangkan keterampilan sosial anak melalui permainan tradisional di TK ABA 1 Kota Sukabumi. Jurnal PIPSI (Jurnal Pendidikan IPS Indonesia), 11(1), 88–99. https://doi.org/10.26737/jpipsi.v11i1.8211

Jafar, K. (2018). Peningkatan kreativitas anak melalui pembelajaran kolaboratif dengan media bahan bekas. AL-ATHFAL: Jurnal Pembelajaran dan Pendidikan Anak Usia Dini, 1(1).

Johnson, D. W., Johnson, R. T., & Smith, K. A. (2014). Cooperative learning: Improving university instruction by basing practice on validated theory. Journal on Excellence in University Teaching, 25(3–4), 85–118.

Jovanda, R., Paais, R. L., Manafe, M. P., Sundari, L., Dewi, A. R., Ohodo, M. M. R., Chasanah, I. A. W., Pratama, A. H., & Waluyo, H. (2026). Local wisdom-based learning approaches for strengthening students' conceptual understanding and character in Indonesia: A systematic literature review [Version 1; peer review: 1 approved with reservations]. F1000Research, 15, Article 1384. https://doi.org/10.12688/f1000research.188148.1

Kusumastuti, E. (2014). Penerapan pembelajaran seni berbasis budaya untuk karakter bangsa. Jurnal Imajinasi: Jurnal Seni, 8(1), 1–10.

Laal, M., & Ghodsi, S. M. (2012). Benefits of collaborative learning. Procedia - Social and Behavioral Sciences, 31, 486–490.

Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for t-tests and ANOVAs. Frontiers in Psychology, 4, Article 863. https://doi.org/10.3389/fpsyg.2013.00863

Loita, A., Sumardi, S., & Afifah, N. (2023). Analisis kebutuhan pengembangan aktivitas finger painting untuk memfasilitasi perkembangan sosial emosional anak usia dini. Jurnal PAUD Agapedia, 7(1), 1–8.

Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). Qualitative data analysis: A methods sourcebook (3rd ed.). Sage.

Parten, M. B. (1932). Social participation among preschool children. Journal of Abnormal and Social Psychology, 27(3), 243–269.

Piaget, J. (1952). The origins of intelligence in children. International Universities Press.

Piaget, J. (1962). Play, dreams and imitation in childhood. Norton.

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). Experimental and quasi-experimental designs for generalized causal inference. Houghton Mifflin.

Skene, K., O'Farrelly, C. M., Byrne, E. M., Kirby, N., Stevens, E. C., & Ramchandani, P. G. (2022). Can guidance during play enhance children's learning and development in educational contexts? A systematic review and meta-analysis. Child Development, 93(4), 1162–1180. https://doi.org/10.1111/cdev.13730

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Harvard University Press.

ICISFS-UMK 2026 EDUCATIONAL TECHNOLOGY & MEDIA

Developing a Scratch-Based GEMBILI Game to Improve Primary Students' Mathematical Cognitive Learning

Ika Isna Umiyati[1*], Sumaji[1] and Erik Aditia Ismaya[1]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: Isnaika392@gmail.com

ABSTRACT

Primary education builds fundamental mathematical abilities, yet fourth-grade students often struggle to master number multiples and pictogram data representations when instruction is abstract and conventional. This study aimed to analyze student and teacher needs, to design and develop the Scratch-based GEMBILI (Game Edukasi Matematika Kelipatan Bilangan) educational game, to evaluate its validity, and to assess its effectiveness in improving cognitive learning outcomes. Using a Research and Development (R&D) design, data were collected from 59 fourth-grade students in three classes (IV A, IV B, and IV C) at SDN Growong Kidul 02, Pati Regency. Initial observations showed that only 33.9% of students (20 out of 59) had reached basic mastery. Expert validation produced scores of 90.5% for material accuracy, 88.0% for media design, and 92.0% for language appropriateness. Practicality ratings from teachers and students were 89.7% and 90.20%, respectively, both in the highly practical category. The experimental group reached a posttest mean of 88.25 and an N-gain of 0.7174 (high category), compared with a mean of 74.50 and an N-gain of 0.4214 (medium category) in the control group. An independent-samples t-test on posttest scores gave a significance value of 0.001, indicating a statistically significant difference between the groups. These findings suggest that Scratch game-based learning can link abstract mathematical concepts to concrete visual representations, reduce learning barriers, and improve the mathematical achievement of primary school students.

KEYWORDS cognitive learning outcomes | game-based learning | multiples of numbers | pictograms | Scratch

INTRODUCTION

Primary education lays the foundation for essential cognitive capabilities, and mathematics develops logical reasoning, critical thinking, and structured problem-solving skills (Yunitasari et al., 2023). In the fourth-grade curriculum, basic concepts such as number multiples are a prerequisite for later mathematical learning. However, many primary students struggle with factors and multiples because the material is presented abstractly (Anggraini et al., 2024; Pakpahan et al., 2025). These conceptual difficulties lead to low achievement and can also trigger helplessness, math anxiety, and declining motivation among young learners (Harefa, 2023; Lubis et al., 2022).

These learning difficulties often stem from conventional instructional practices. Mathematics teaching in primary classrooms is still dominated by teacher-centered lectures, drill-and-practice routines, and monotonous media (Puteri et al., 2024). Conventional approaches often fail to involve students actively, which points to the need for interactive digital learning media at the primary level (Ramadhani et al., 2023). As a result, learning objectives are often not met and student achievement remains low. Addressing this problem requires educational innovation, particularly as Society 5.0 calls for digital technology to be integrated into learning (Pane et al., 2024). Digital game-based learning (GBL) addresses these shortcomings by offering interactive, challenging, and enjoyable learning experiences that increase student engagement and interest (Afrianti & Maryatun, 2025; Debrenti, 2024; Hidayat et al., 2024; Rosydiana et al., 2023).

Evidence on digital game-based learning in primary school is now substantial. A meta-analysis of 41 studies found that game-based learning raised science achievement compared with traditional instruction ($g = 0.705$), with larger effects among primary school students (Lei et al., 2022). A meta-analysis of 18 studies in primary schools likewise reported positive effects of digital games on learning outcomes, especially in mathematics, with effects that depended on game type, platform, and duration (Behnamnia et al., 2024). Scratch, a free block-based programming environment, lets developers combine animation, sound, and feedback in one game, and Indonesian

studies have linked Scratch-based games to better learning outcomes in geometric transformations (Fitrianingsih et al., 2024), fractions (Rokhmaniyah, 2025), the area of plane figures (Sunarto, 2025), and fourth-grade science and social studies (Amalia & Sukasih, 2025).

Learning models such as Problem-Based Learning (PBL) have also been shown to improve students' academic achievement when combined with multimedia software (Sumaji et al., 2023). When integrated into interactive web platforms, PBL provides a meaningful context that improves students' mathematical learning outcomes (Franoto et al., 2025).

The studies above leave two gaps that matter here. First, the Scratch games we reviewed address geometry, fractions, area, or science topics; none treats number multiples and pictograms together, although reading a pictogram depends on multiplying the number of icons by a fixed key. Second, several development studies judge effectiveness from the pretest and posttest of a single group (e.g., Amalia & Sukasih, 2025), which cannot separate the effect of the medium from that of ordinary teaching. Because the effects of digital games vary with their design and duration (Behnamnia et al., 2024), each new game needs its own evidence against a comparison class.

Preliminary data from SDN Growong Kidul 02 in Pati Regency show the same problem. Among 59 fourth-grade students in three classes (IV A, IV B, and IV C), the baseline mastery rate for number multiples was only 33.9% (Table 1).

Table 1. Initial baseline assessment of fourth-grade mathematics learning mastery

No	Class	Total Students	Mastered (≥ KKTP)	Unmastered (< KKTP)	Mastery Percentage (%)
1	IV A	20	8	12	40.0%
2	IV B	20	6	14	30.0%
3	IV C	19	6	13	31.5%
Total / Average		**59**	**20**	**39**	**33.9%**

Source: Initial assessment scores for grade IV, 2026.

Interviews with fourth-grade students were consistent with these findings. Students expressed a strong preference for interactive and enjoyable learning media. When shown possible digital platforms (Wordwall, Canva, and Scratch), all students chose Scratch because of its animations, audio feedback, and game mechanics. Factors contributing to low achievement included conventional teaching habits, a lack of automated feedback, and the absence of practice adapted to students' ability levels. The GEMBILI (Game Edukasi Matematika Kelipatan Bilangan) media was designed to address these barriers. GEMBILI includes pictogram material because pictograms depend on number multiples (one icon represents a fixed number of units). In Scratch, animated number lines and symbols added step by step provide visual scaffolding that supports the transition from concrete to abstract thinking.

This study therefore developed GEMBILI and tested it in the school where the problem was observed. It followed the Borg and Gall development stages, asked material, media, and language experts to judge the product, and compared the learning outcomes of a class that used GEMBILI with those of a class taught with the usual method. Its contribution is a validated Scratch game for one specific fourth-grade topic, multiples and pictograms, together with pretest and posttest data from an experimental and a control class.

LITERATURE REVIEW

The framework of this study combines Piaget's cognitive development theory, Bruner's stages of representation, and Game-Based Learning principles. According to Piaget, children aged 7–11 are in the concrete operational stage and need visual and physical representations to grasp mathematical abstractions (Piaget & Inhelder, 1969). Bruner asserts that learning progresses through enactive, iconic, and symbolic stages (Hatip & Setiawan, 2021). GEMBILI links iconic visual representations (pictograms and leap animations on digital number lines) to symbolic mathematical operations.

The Scratch platform is well suited to building interactive media that promote computational thinking and 4C skills (Fagerlund et al., 2021; Ulya et al., 2022). Interactive digital media, immediate automated feedback, and

structured levels can reduce cognitive load and math anxiety and thus support the attainment of mathematical concepts (Agustriana et al., 2025; Gui et al., 2023; Juhaeni et al., 2023). Figure 1 shows the conceptual framework and how the GEMBILI development model addresses each barrier.

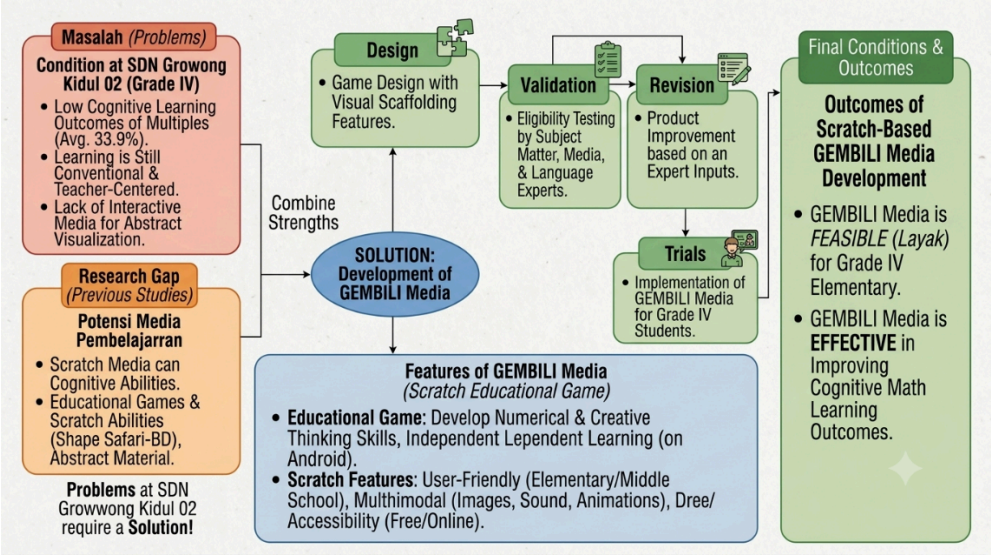

Figure 1. Conceptual framework and barrier resolution diagram

Research Objectives

The objectives of this study are as follows:

1. To analyze teacher and student needs regarding game-based mathematical learning media for number multiples and pictograms in fourth grade.
2. To describe the instructional design and development process of the Scratch-based GEMBILI media.
3. To evaluate the product validity and feasibility of GEMBILI based on expert appraisals in material, media, and language.
4. To assess the effectiveness of GEMBILI in improving fourth-grade students' cognitive learning outcomes in elementary mathematics.

RESEARCH METHOD

Research Design

This study adopted a Research and Development (R&D) design based on the Borg & Gall development model, which comprises research and information collection, planning, development of the preliminary product, expert validation, first product revision, small-group field testing, second product revision, field testing, final product revision, and dissemination and implementation (Sugiyono, 2022). The R&D design allows educational software to be created, validated, and evaluated systematically.

Respondents of the Study

The population comprised 59 fourth-grade students enrolled across three classes (IV A = 20, IV B = 20, IV C = 19) at SDN Growong Kidul 02, Pati Regency, Central Java, during the 2025/2026 academic year. Purposive sampling was used to select the classes for the pre-test and post-test field trials.

Data collection instruments included structured teacher/student interview guides, expert validation evaluation sheets (5-point Likert scale), and cognitive learning tests (pre-test and post-test assessing Bloom's taxonomy levels C1 to C4). GEMBILI was developed in Scratch 3.0. Its specifications include online and offline access, a widescreen 16:9 display, compatibility with school Chromebooks with at least 2GB RAM, and five main menus: Instructions, Developer Profile, Multiples & Pictogram Concepts, Interactive Catch-Game, and Pictogram Data Quizzes.

RESULTS

GEMBILI was developed through the Borg & Gall stages. The needs analysis showed that 100% of students preferred technology-based games to conventional methods. The media design emphasized visual clarity, progressive leveling, and immediate audio feedback ("ye benar" / "ups salah").

Product Feasibility and Expert Validation

Subject-matter, media, and language experts rated GEMBILI as very highly valid and feasible for classroom use (Table 2).

Table 2. Expert validation results for the GEMBILI educational game

No	Validation Category	Score (%)	Qualitative Description
1	Material Expert Validation	90.5%	Very Highly Valid / Feasible
2	Media Expert Validation	88.0%	Very Highly Valid / Feasible
3	Language Expert Validation	92.0%	Very Highly Valid / Feasible
Average Feasibility Score		**90.2%**	**Very Highly Valid / Feasible**

Source: GEMBILI Media Validation Data, 2026.

Cognitive Achievement and Effectiveness Analysis

The use of GEMBILI was associated with higher cognitive learning outcomes. The experimental class obtained a mean N-Gain of 0.7174, a high gain in the categories of Hake (1998), whereas the control class obtained a mean N-Gain of 0.4214, a medium gain. The gain was therefore larger in the class that used GEMBILI than in the control class.

The descriptive statistics of the pretest and posttest results for both groups are summarized in Table 3.

Table 3. Descriptive statistical comparison of learning outcomes

Group	Test Type	Minimum Score	Maximum Score	Mean Score
Experimental Class (IV A)	Pretest	40.00	80.00	62.50
	Posttest	70.00	100.00	88.25
Control Class (IV B)	Pretest	35.00	75.00	54.75
	Posttest	60.00	90.00	74.50

Source: Pretest and Posttest Results of Experimental Class and Control Class, 2026.

The data show that the experimental class, which used the Scratch-based game, gained more in conceptual mastery than the control group. An independent-samples t-test on the posttest scores gave a significance value of $0.001 < 0.05$, indicating that the experimental group scored significantly higher than the control group.

DISCUSSION

GEMBILI met the validity criteria set for the development stage. The three experts gave mean scores of 90.5% for material, 88.0% for media, and 92.0% for language, an average of 90.2% (Table 2). The material score indicates that the content and items match the fourth-grade objectives for multiples and pictograms, while the slightly lower media score suggests that the visual and navigation design had more room for revision than the content. High expert ratings are typical of primary school media developed through R&D in Indonesia; a Scratch game for fourth-grade science and social studies, for example, was also judged practical (86.5%) before its classroom test (Amalia & Sukasih, 2025). Expert percentages show that the product is acceptable to its reviewers. They do not show that it improves learning, a question that only the classroom comparison can answer.

The classroom trial favoured GEMBILI. The experimental class (IV A) moved from a pretest mean of 62.50 to a posttest mean of 88.25, and the control class (IV B) from 54.75 to 74.50 (Table 3). The mean N-gain was 0.7174 in the experimental class, a high gain in the categories of Hake (1998), against 0.4214, a medium gain, in the control class, and the posttest difference was significant ($p = 0.001$). Both classes improved, but the

experimental class closed a larger share of the distance to the maximum score, which is consistent with an added contribution of the game beyond regular teaching. This pattern agrees with meta-analytic evidence that game-based learning outperforms traditional instruction and works well with primary pupils (Behnamnia et al., 2024; Lei et al., 2022). It also matches Indonesian Scratch studies on geometric transformations, fractions, and area (Fitrianingsih et al., 2024; Rokhmaniyah, 2025; Sunarto, 2025). Similar gains have been reported when digital or local media were combined with problem-solving models, such as an ethnomathematics-based e-module within PBL (Sumaji et al., 2025) and a mobile application within Creative Problem Solving, which had a positive effect on numeracy (Shahira et al., 2024).

Two features of the game may explain the larger gain. First, GEMBILI shows multiples as jumps along an animated number line and as rows of pictogram icons before students write the corresponding numbers. This sequence follows Bruner's movement from iconic to symbolic representation (Hatip & Setiawan, 2021) and suits children in Piaget's concrete operational stage, who reason more easily about quantities they can see (Piaget & Inhelder, 1969). Because one pictogram icon stands for a fixed number of units, practising multiples and reading pictograms in the same game lets each skill support the other. Second, the game gives immediate audio feedback ("ye benar" / "ups salah") and moves students through levels, so errors can be corrected as they occur. A meta-analysis of digital educational games in STEM found that their effects varied with game design (Gui et al., 2023), which supports attention to these design features. This study did not measure anxiety, motivation, or engagement, so the suggestion that GEMBILI also works through these routes, as studies of Scratch media and motivation propose (Puteri et al., 2024), remains a hypothesis for this sample.

For teachers at SDN Growong Kidul 02 and similar schools, the results suggest that a Scratch game can be added to regular lessons on multiples and pictograms without new hardware, since GEMBILI runs offline on the school's Chromebooks. The game is a practice tool, not a replacement for teaching: the control class also improved, which shows that the teacher's explanation still carries much of the learning. Teachers could use GEMBILI after introducing the concept, assign levels according to students' pretest results, and use the game's feedback to identify students who need further help. Principals and the district education office could support this by maintaining devices and by giving teachers time to adapt or build Scratch games for other topics.

The findings have several limitations. The trial used two intact classes in one school, and the part played by the third class (IV C) is not reported, so the results may not generalise to other schools. The classes were not equivalent at the start, since the experimental class had the higher pretest mean (62.50 vs 54.75; Table 3). A t-test on posttest scores alone does not adjust for this difference; an analysis of covariance with the pretest as covariate, or a test on individual N-gain scores, would give a fairer comparison (Shadish et al., 2002). The paper also does not report the t statistic, degrees of freedom, or an effect size, and the practicality ratings from teachers and students are given only as summary percentages. The test was written by the researchers, the length of the intervention is not reported, and no delayed posttest was given, so retention and novelty effects cannot be ruled out. Future studies should involve more schools, assign classes at random where possible, report effect sizes, measure retention, and test directly whether the game reduces mathematics anxiety.

CONCLUSION AND RECOMMENDATIONS

This study developed and validated the Scratch-based GEMBILI educational game for fourth-grade primary mathematics. GEMBILI received a mean validation rating of 90.2% from material, media, and language experts. In classroom implementation, the mean score of the experimental class rose from 62.50 to 88.25, with an N-gain of 0.7174 (high category), compared with a rise from 54.75 to 74.50 in the control class. Students who used GEMBILI gained more in their understanding of number multiples and pictogram data representations than students in the control class.

Primary school teachers are encouraged to integrate Scratch-based learning games into mathematics instruction to create interactive, student-centered lessons. School administrators should support digital media infrastructure, such as utilizing school Chromebooks for interactive learning. Future research could extend GEMBILI to more advanced mathematical topics and other grade levels.

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REFERENCES

Afrianti, R., & Maryatun, I. B. (2025). Utilization of educational games as learning media: Recognize the concept of numbers. *Jurnal Eduscience*, *12*(2), 592–604. https://doi.org/10.36987/jes.v12i2.6833

Agustriana, M., Purwasi, L. A., & Nugroho, K. U. Z. (2025). Systematic literature review: Penggunaan game edukasi berbasis Scratch dalam pembelajaran matematika. *Seminar Nasional Silamparilist*, *1*. https://ojs.unpari.ac.id/sclost/article/view/337/104

Amalia, M. N., & Sukasih, S. (2025). Development of Scratch-based educational games media to enhance Natural Sciences and Social Sciences (IPAS) learning outcomes in elementary school. *Jurnal Paedagogy, 12*(3), 615–625. https://doi.org/10.33394/jp.v12i3.15872

Anggraini, D., Nadhifah, A., Candrawati, N. A. N., & Rahmawati, L. (2024). Analisis kesulitan pemahaman matematika materi kelipatan dan faktorisasi bilangan di kelas 5 Sekolah Dasar 1 Loram Kulon. *Tarunateach: Journal of Elementary School, 2*(1), 13–24. https://doi.org/10.54298/tarunateach.v2i1.166

Behnamnia, N., Kamsin, A., & Hayati, S. (2024). Impact of digital game-based learning on STEM education in primary schools: A meta-analysis of learning approaches. *Innoeduca. International Journal of Technology and Educational Innovation, 10*(2). https://doi.org/10.24310/ijtei.102.2024.19694

Debrenti, E. (2024). Game-based learning experiences in primary mathematics education. *Frontiers in Education*, 9, Article 1331312. https://doi.org/10.3389/feduc.2024.1331312

Fagerlund, J., Häkkinen, P., Vesisenaho, M., & Viiri, J. (2021). Computational thinking in programming with Scratch in primary schools: A systematic review. *Computer Applications in Engineering Education, 29*(1), 12–28. https://doi.org/10.1002/cae.22255

Fitrianingsih, A. N. A., Rosjanuardi, R., & Sudihartinih, E. (2024). Super Geo-Bros game: A Scratch-based mathematics game for learning geometric transformations to improve learning outcomes. *Jurnal Pendidikan MIPA, 25*(2), 792–802. https://doi.org/10.23960/jpmipa/v25i2.pp792-802

Franoto, O. A., Sumaji, & Bintoro, H. S. (2025). Media games interaktif berbasis web dengan problem based learning (PBL) untuk meningkatkan hasil belajar matematika. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *14*(3), 945–957. https://doi.org/10.24127/ajpm.v14i3.11819

Gui, Y., Cai, Z., Yang, Y., Kong, L., Fan, X., & Tai, R. H. (2023). Effectiveness of digital educational game and game design in STEM learning: A meta-analytic review. *International Journal of STEM Education, 10*(1). https://doi.org/10.1186/s40594-023-00424-9

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, *66*(1), 64–74. https://doi.org/10.1119/1.18809

Harefa, D. (2023). The relationship between students' interest in learning and mathematics learning outcomes. AFORE: Jurnal *Pendidikan Matematika*, *2*(2), 112–122. https://doi.org/10.57094/afore.v2i2.1054

Hatip, A., & Setiawan, W. (2021). Teori kognitif Bruner dalam pembelajaran matematika. PHI: *Jurnal Pendidikan Matematika*, 5(2), 87–97. https://doi.org/10.33087/phi.v5i2.141

Hidayat, R., Qi, T. Y., Ariffin, P. N. B. T., Hadzri, M. H. B. M., Chin, L. M., Ning, J. L. X., & Nasir, N. (2024). Online game-based learning in mathematics education among Generation Z: A systematic review. *International Electronic Journal of Mathematics Education*, *19*(1), 1–8. https://doi.org/10.29333/iejme/14024

Juhaeni, J., Cahyani, E. I., Utami, F. A. M., & Safaruddin, S. (2023). Pengembangan media game edukasi dalam meningkatkan hasil belajar matematika kelas III siswa madrasah ibtidaiyah. *Journal of Instructional and Development Researches*, *3*(2), 58–66. https://doi.org/10.53621/jider.v3i2.225

Lei, H., Chiu, M. M., Wang, D., Wang, C., & Xie, T. (2022). Effects of game-based learning on students' achievement in science: A meta-analysis. *Journal of Educational Computing Research, 60*(6), 1373–1398. https://doi.org/10.1177/07356331211064543

Lubis, A. H., Dasopang, M. D., Ramadhini, F., & Dalimunthe, E. M. (2022). Augmented reality pictorial storybook: How does it influence on elementary school mathematics anxiety? Premiere Educandum: Jurnal *Pendidikan Dasar Dan Pembelajaran*, *12*(1), 41. https://doi.org/10.25273/pe.v12i1.12393

Pakpahan, G. P., Sastrawati, E., & Pamela, I. S. (2025). Analisis hambatan belajar peserta didik pada pembelajaran matematika materi faktor dan kelipatan di kelas IV fase B sekolah dasar. *Jurnal Ilmiah Pendidikan Dasar*, *10*(September), 1587–1593.

https://repository.unja.ac.id/id/eprint/76167

Pane, A. R., Hutagaol, R., Rahman, A., & Lubis, J. D. A. (2024). Inovasi pembelajaran digital menggunakan media interaktif Scratch pada era Society 5.0. Transformasi Pendidikan di Era Society 5.0, 1–7. https://e-journal.upr.ac.id/index.php/PSN-FKIP/article/view/17943/6633

Piaget, J., & Inhelder, B. (1969). *The psychology of the child* (H. Weaver, Trans.). Basic Books.

Puteri, S. N., Farhurohman, O., & Arofah, S. (2024). Pemanfaatan media Scratch untuk meningkatkan motivasi belajar matematis siswa SD. JS (Jurnal Sekolah), 8(3), 480–494. https://doi.org/10.24114/js.v8i3.57912

Ramadhani, N., Ulya, W. J., Nustradamus, S. B., Fakhriyah, F., & Ismaya, E. A. (2023). Sistematic literature riview: Peran media pembelajaran interaktif dan konvensional pada proses pembelajaran di sekolah dasar. *Student Scientific Creativity Journal*, *1*(5), 99–114. https://doi.org/10.55606/sscj-amik.v1i5.1941

Rokhmaniyah, F. (2025). SCRATCH-PEMAN: Pengembangan media pembelajaran interaktif berbasis Scratch MIT untuk meningkatkan penguasaan konsep pecahan pada siswa. *Jurnal Guru Sekolah Dasar*, *2*(1), 61–71. https://doi.org/10.70277/jgsd.v2i1.6

Rosydiana, E. A., Sudjimat, D. A., & Utama, C. (2023). The effect of digital learning media using Scratch game based learning on student problem solving skills. Jurnal Penelitian Pendidikan IPA, *9*(11), 10010–10015. https://doi.org/10.29303/jppipa.v9i11.4876

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Houghton Mifflin.

Shahira, S. P., Sumaji, & Ulya, H. (2024). Efektivitas model pembelajaran creative problem solving berbantuan media Permath Apps terhadap kemampuan numerasi matematis. *Jurnal Riset HOTS Pendidikan Matematika*, *4*(September), 1287–1299. https://doi.org/10.51574/kognitif.v4i3.1720

Sugiyono. (2022). Metode penelitian kuantitatif, kualitatif, dan R&D. Alfabeta.

Sumaji, S., Widianingrum, E., Wanabuliandari, S., & Premprayoon, K. (2025). The effectiveness of problem-based learning assisted with the ethnomathematics-based Geocube e-module on problem-solving skills. *JRAMathEdu (Journal of Research and Advances in Mathematics Education)*, *10*(3), 135–145. https://doi.org/10.23917/jramathedu.v10i3.3228

Sumaji, Wanabuliandari, S., & Rahaju. (2023). Efektifitas model pembelajaran problem based learning berbasis Adobe Flash untuk meningkatkan prestasi belajar. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *12*(1), 1484–1491. https://doi.org/10.24127/ajpm.v12i1.7167

Sunarto. (2025). Pengembangan MEDALUS-BD (MEDia pembelajaran Aplikatif LUaS Bangun Datar) berbasis Scratch MIT untuk meningkatkan hasil belajar siswa kelas 5 SD. *1*(6), 41–53. https://doi.org/10.70277/jgsd.v1i6.5

Ulya, A., Utaminingsih, S., & Aditia, E. (2022). The effectiveness of Tynker and Scratch application to improve 4C skills in ecosystem themes in Klumpit Public Elementary School. *ANP Journal of Social Sciences and Humanities*, *2*(3), 1–6. https://doi.org/10.53797/anp.jssh.v3sp2.1.2022

Yunitasari, F., Sintawati, M., & Mastul, A.-R. H. (2023). The application of contextual teaching and learning for increasing learning outcomes and reducing anxiety in elementary school mathematics. *International Journal of Learning Reformation in Elementary Education*, *2*(02), 77–85. https://doi.org/10.56741/ijlree.v2i02.283

ICISFS-UMK 2026 EDUCATIONAL TECHNOLOGY & MEDIA

Development of LKPD Based on Liveworksheets to Improve Critical Thinking Skills on Biodiversity Topics of Elementary School Students

Nurul Suryandari[1*], Fina Fakhriyah[1] and Khamdun[1]

[1]*Muria Kudus University, Indonesia*

ABSTRACT

This study aimed (1) to examine the feasibility of *Liveworksheets*-based student worksheets (LKPD) on the biodiversity topic in IPAS (Integrated Science) for improving elementary school students' critical thinking skills, (2) to examine their practicality, and (3) to examine their effectiveness in improving these skills. It used the research and development (R&D) method with the ten steps outlined by Sugiyono (2017): (1) problem identification, (2) data collection, (3) product design, (4) design validation, (5) design revision, (6) product testing, (7) product revision, (8) product validation, (9) evaluation and final revision, and (10) dissemination. The data collection techniques in this study included observation, interviews, questionnaires, documentation, and tests. Effectiveness was analyzed with a normality test of learning outcomes, a homogeneity test of the variances of the experimental and control classes, a t-test comparing pretest and posttest learning outcomes, and an N-Gain test describing the improvement in learning mastery. The data sources were teachers and students at SDN Kembangan and SDN Sukodono 1, Bonang District, Demak Regency. The media expert gave the LKPD a validation score of 97 and the material expert a score of 76, both without a need for revision, and students rated its practicality at 93%. The experimental class reached a higher mean posttest score than the control class (85 vs 45).

KEYWORDS learning media | LKPD | Liveworksheets | critical thinking skills | biodiversity

INTRODUCTION

Natural Science and Social Studies (IPAS) is an integrated subject aimed at shaping students into intelligent, honest, and responsible individuals who understand the natural environment and the society around them. Students are expected to think critically by understanding their environment, history, and social dynamics within national life. In line with the *Merdeka Belajar* (Freedom to Learn) movement of the Ministry of Education, Culture, Research, and Technology, IPAS is a key element in strengthening the Pancasila Student Profile. Under the *Kurikulum Merdeka* (Independent Curriculum), whose learning outcomes are set by the Ministry (Kemendikbudristek, 2024), IPAS teaches theory and also develops students who are faithful, noble-minded, independent, creative, collaborative, and capable of critical reasoning through scientific inquiry. In school practice, IPAS learning involves direct observation and solving real social and environmental problems. Student success in this subject is therefore measured by how well students master science and social process skills rather than by how well they memorize the material.

Critical thinking skills allow students to evaluate information carefully and reason through situations, which is essential for making sound decisions on scientific issues. In science lessons this means using data as evidence and giving reasons for claims. Critical thinking can be taught: a meta-analysis of 341 studies found a small positive effect of instruction on critical thinking ($g = 0.30$) and the largest effect when dialogue, authentic problems, and mentoring were combined ($g = 0.57$) (Abrami et al., 2015). In elementary IPAS, a review of 20 studies found that STEAM learning consistently improved critical thinking but noted limited teacher competence and a need for critical-thinking scaffolding (Prakoso et al., 2026).

The researcher's observations at SDN Sukodono 1, Bonang District, Demak Regency, revealed problems in IPAS learning on the topic of biodiversity. *Liveworksheets* had not been used for this topic because of limited learning media. Teacher observation sheets on the topic of forces around us showed that student performance was still low. Questionnaire responses also showed that students were uninterested and unenthusiastic during lessons,

and 15 out of 22 students did not understand the material taught. The Learning Objective Completion Criteria (KKTP) score for IPAS is 70. On the biodiversity topic, 15 out of 22 students (68.18%) scored below the KKTP, while only 7 students (31.82%) scored above it. Interviews with the teacher indicated that students were still passive and lacked confidence in expressing their analysis or views during lessons. Students tended to give brief answers on worksheets because they had difficulty analyzing data and linking statements to IPAS concepts, particularly on the topic of biodiversity.

LITERATURE REVIEW

An LKPD (lembar kerja peserta didik, student worksheet) guides students through a sequence of tasks: observing, recording, analyzing, and drawing conclusions. Liveworksheets turns such worksheets into interactive online forms with images, drop-down and matching items, and automatic checking, so that students receive feedback while they work. Indonesian studies have developed Liveworksheets-based teaching materials and LKPD for elementary school in civics (Widiyani & Pramudiani, 2021) and for fifth-grade learning (Hariyati & Rachmadyanti, 2022), and have used Liveworksheets to raise learning outcomes (Prabowo, 2021). The framework of this study links these features to critical thinking. When the worksheet asks students to compare organisms, classify them, and explain why a plant or animal is useful, students practise the analysis and justification that critical thinking requires. Guided inquiry built on such tasks has improved fifth graders' critical thinking in science (Aras et al., 2024).

Liveworksheets has already been used for science worksheets in elementary school. Inanta et al. (2026) developed a guided-inquiry science e-LKPD with *Liveworksheets* on the properties of light for grade 5. Experts rated it valid (Aiken's V 0.83 to 1.00), users gave a response of 92%, and the mean N-gain in cognitive learning outcomes was 0.78 (high). Like the present study, it used *Liveworksheets* for an IPAS topic. It differs in its topic, grade, and outcome: it measured cognitive learning outcomes on light in grade 5, whereas the present study addresses critical thinking on biodiversity in grade 4.

In mathematics, Sari et al. (2023) developed a *Liveworksheets* electronic worksheet that uses a contextual, problem-based scientific approach for flat-sided solids in grade 8. Experts rated it 88.97% (very valid), and a small-group trial rated it 83.08% (very practical). Like the present study, it used *Liveworksheets* as the platform for an interactive worksheet. It differs in subject, level, and evidence: it addressed junior high school mathematics and reported validity and practicality only, without a test of learning gains.

These studies show that *Liveworksheets* worksheets can be valid and practical and can raise cognitive learning outcomes, but they leave a gap for this setting. None of them targets critical thinking on the biodiversity topic in grade 4, and several report validity and practicality without comparing an experimental class with a control class. In the schools studied, students also had no prior experience with *Liveworksheets* (Table 2). This study therefore developed a *Liveworksheets*-based LKPD on biodiversity for grade 4 IPAS through a research and development design and examined its feasibility, practicality, and effectiveness by comparing a class that used the LKPD with a class taught conventionally.

Research Objective

The purpose of this study is to test the effectiveness of the Liveworksheets-based LKPD in improving the critical thinking skills of elementary school students on biodiversity topics in the Sultan Trenggono Cluster, Bonang District, Demak Regency.

RESEARCH METHOD

Research Design

This study used a research and development (R&D) design.

Research Procedures

The research stages were media development, media feasibility testing, media practicality testing, media effectiveness testing, and mass production.

Assessment Instrument

Table 1 lists the instruments used to collect the data.

Table 1. Data collection instruments

No.	Data Collection Technique	Type	Instrument
1.	Test	Objective Test	Pretest and posttest question sheets consisting of multiple-choice questions on the *biodiversity* topic.
2.	Non-Test	Interview	Interview guideline containing questions regarding teachers' challenges, learning media, students' learning outcomes, and the conditions of teachers and students at SDN Kembangan, Bonang District, Demak Regency.
		Questionnaire	1. Teacher and student needs assessment questionnaire for the *LKPD Based on Liveworksheets* learning media. 2. Expert validation questionnaire for media and subject matter experts. 3. Teacher and student response questionnaire regarding the *LKPD Based on Liveworksheets* learning media.
		Documentation	Grade IV students' summative assessment scores. Student response questionnaire on Science (IPAS) learning. Pretest and posttest scores. Item tryout results for Science (IPAS) on the biodiversity topic for Grade IV students at kembangan. Photographs of the learning activities.
		Observation	Observation checklist (observation assessment instrument).

RESULTS

The results address the 3 research problems: the feasibility, practicality, and effectiveness of the Liveworksheets-based LKPD for improving the critical thinking skills of fourth-grade elementary school students on biodiversity topics.

Needs Analysis of the Liveworksheets-Based LKPD

The needs analysis for the Liveworksheets-based LKPD was conducted in two stages, observation and interviews, with the Grade IV teachers at SDN Kembangan and SDN Sukodono 1.

Table 2. Student needs analysis for the Liveworksheets-based LKPD

No.	Questions	Yes (%)	No (%)
1	Have you ever been taught the on biodiversity topics?	100%	0%
2	Have you ever used the LKPD Based on Liveworksheets learning media to study the human respiratory system?	0%	100%
3	Do you find the on biodiversity topics difficult to understand?	90%	10%
4	Do you often use learning media when studying Science (IPAS), especially the on biodiversity topics?	0%	100%
5	Have you ever learned Science (IPAS), particularly on biodiversity topics, using LKPD Based on Liveworksheets learning media developed by your teacher?	0%	100%
6	Have you ever learned the on biodiversity topics in Science (IPAS) using LKPD Based on Liveworksheets learning media?	0%	100%
7	Have the learning media you previously used in Science (IPAS) made you more interested in participating in the lesson?	75%	25%
8	Have you ever seen the LKPD Based on Liveworksheets learning media used for learning activities?	0%	100%
9	Have you ever learned using the LKPD Based on Liveworksheets learning media?	0%	100%
10	Have you ever heard of the LKPD Based on Liveworksheets learning media?	0%	100%

Source: Analysis of LKPD Based on Liveworksheets learning media needs questionnaire

Table 2 shows that all students had received lessons on the biodiversity topic at school: 100% of respondents answered "yes" to the first statement. However, all respondents (100%) stated that they had never used Liveworksheets-based LKPD when learning the biodiversity topic (statements 2, 5, 6, 8, 9, and 10). This shows that Liveworksheets-based LKPD had not been used in science learning in the participating schools.

Development Design of the Liveworksheets-Based LKPD

Material planning involved analyzing the learning outcomes (CP), formulating the learning objectives (TP), and collecting Grade IV material on biodiversity from the main textbook and supporting books. The next step was to write evaluation questions on biodiversity. The final step was to plan the media itself (its flow, design, image and text placement, font, and color) so that the Liveworksheets-based LKPD would look attractive.



Figure 1. Design of the Liveworksheets-based LKPD media

The two experts gave validation scores of 97 (media expert) and 76 (material expert) (Table 3), which indicates that the Liveworksheets-based LKPD met the criteria of content suitability, material presentation, and alignment with the learning objectives. The media can therefore be used in the learning process after revision based on the validators' suggestions.

Eligibility of the Liveworksheets-Based LKPD

Media and material experts assessed feasibility in a single validation stage. The Liveworksheets-based LKPD was rated suitable for use, so no revalidation was needed. The validators nevertheless suggested improvements to make the media more effective, engaging, and suited to student needs, and these were used to revise the media before classroom implementation.

Table 3. Validation values according to experts

Expert	Average Value	Category
Media Expert	97	Very good, No revision
Subject Matter Expert	76	Eligible, No revision

The expert validation placed the Liveworksheets-based LKPD in a suitable category without the need for revision. The media expert gave an average value of 97 (very suitable), indicating that the appearance, design, language, and technical aspects of the media met the criteria. The material expert gave an average value of 76

(suitable), indicating that the content, its alignment with the learning objectives, and the accuracy of the concepts were acceptable.

Practicality of the Liveworksheets-Based LKPD

Practicality was determined from teacher and student response questionnaires. Based on these questionnaires, a score of 98 was obtained, which places the Liveworksheets-based LKPD in the practical category for classroom use.

The student response questionnaire gave a total score of 744 from 20 participating students. Converted to a percentage, this equals 93%, indicating that students found the Liveworksheets-based LKPD practical and interesting. Both teachers and students responded positively to the media, which suggests that it is suitable for elementary school learning.

Effectiveness of the Liveworksheets-Based LKPD

Pretest and posttest scores were analyzed with the N-Gain test to determine the effectiveness of the Liveworksheets-based LKPD. The SPSS output gave the number of students in each N-Gain category.

Of the 38 students with N-Gain scores, 15 (39.5%) reached the high category, 4 (10.5%) the medium category, and 19 (50.0%) the low category. The values 15 and 19 are therefore numbers of students, not N-Gain scores. Because the output does not separate the experimental and control classes, it cannot show by itself which class gained more.

DISCUSSION

Eligibility of the Liveworksheets-Based LKPD

The researchers revised the Liveworksheets-based LKPD in response to the validators' feedback. The content was divided into segments matching each meeting to give a more logical flow. Spelling, punctuation, terminology, and sentence structure were corrected, and the evaluation items for each session were adjusted and extended to support understanding of the material. These revisions were intended to improve the content validity, presentation, and usability of the media.

The validation results show that the experts judged the LKPD usable but did not rate it equally. The media expert gave 97 (very good) and the material expert 76 (eligible), both without a requirement for revision (Table 3). The difference suggests that the visual design and technical functions of the worksheets were stronger than the content and its alignment with the learning objectives, which is why the revisions focused on dividing the material by meeting and on the evaluation items. Other Liveworksheets worksheets have received higher content ratings: a guided-inquiry science e-LKPD for grade 5 obtained Aiken's V values of 0.83 to 1.00 (Inanta et al., 2026), and a contextual problem-based worksheet for grade 8 mathematics was rated 88.97% valid (Sari et al., 2023). Because the material score comes from a single expert, a second content review, or an agreement index across several validators, would make the feasibility claim firmer.

Practicality of the Liveworksheets-Based LKPD

Students rated the LKPD as practical. The 20 students who completed the response questionnaire gave a total score of 744, or 93%, and the teacher and student questionnaires together gave a score of 98. These values are close to those reported for other digital worksheets and modules in elementary school: a Liveworksheets e-LKPD for science obtained a user response of 92% (Inanta et al., 2026), a contextual E-LKPD on fractions obtained student responses of 83% to 89% (Sakinah et al., 2023), and a digital science practicum module was rated 93.3% to 96% practical (Pratiwi & Jayanta, 2023). Teachers described the media as clear, simple to follow, and matched to the curriculum, and students reported that it made the material easier to understand and increased their focus. Practicality in these studies, as here, rests on short self-report questionnaires completed soon after a new medium is introduced, so part of the positive response may reflect novelty. Schools that adopt the LKPD will also need enough devices and a stable internet connection for each lesson.

Effectiveness of the Liveworksheets-Based LKPD

The effectiveness evidence is weaker than the evidence on feasibility and practicality. The experimental class reached a mean posttest score of 85, compared with 45 in the control class, a difference that favours the LKPD. The N-Gain output, however, gives only the number of students in each category across both classes: 15 high, 4 medium, and 19 low out of 38. Half of the students therefore gained little between pretest and posttest, and without class-level values the N-Gain cannot show that the experimental class gained more (Hake, 1998). If most high-gain students were in the experimental class, the pattern would agree with the high mean N-gain reported for a guided-inquiry Liveworksheets e-LKPD (Inanta et al., 2026) and with a meta-analysis of Indonesian studies in which interactive multimedia raised learning outcomes, with the largest estimate at elementary level (Khaeruman et al., 2023). A possible mechanism is that the worksheets present the levels and uses of biodiversity with pictures and ask students to complete statements and check their answers, which gives repeated practice in analysis with immediate feedback. Guided inquiry built on similar tasks has improved fifth graders' critical thinking in science (Aras et al., 2024), and instruction that combines authentic problems with dialogue has had the largest effects on critical thinking (Abrami et al., 2015); in Indonesian elementary schools, problem-based learning has shown a large mean effect on critical thinking (Setyowati & Sutikno, 2024). The pretest and posttest in this study were multiple-choice tests of biodiversity learning outcomes (Table 1), not a separate critical thinking instrument, so conclusions about critical thinking itself remain tentative.

For grade 4 teachers in the Sultan Trenggono Cluster, the results suggest that existing paper worksheets on biodiversity can be turned into interactive Liveworksheets with modest effort. To train critical thinking rather than recall, teachers could add items that ask students to compare organisms, explain why a plant or animal is useful, and give reasons for their answers, and then discuss those answers in class. Principals can support this by providing devices and connectivity and by giving teachers time to build and share worksheets within the cluster.

This study has several limitations. It drew on two schools (SDN Kembangan and SDN Sukodono 1), and the paper does not report which classes formed the experimental and control groups, how many students each had, or whether they were equivalent at pretest. The normality, homogeneity, and t-tests announced in the Abstract are not reported in the Results, and the posttest standard deviations (1.493 and 1.865) are unusually small for a classroom test. Validity rests on two experts, and practicality on self-report questionnaires. The test measured learning outcomes with multiple-choice items rather than a validated critical thinking instrument. Future studies should report N-Gain values for each class and a t-test or analysis of covariance on pretest-adjusted scores with an effect size (Shadish et al., 2002), measure critical thinking directly, and test the LKPD in more schools and over a longer period.

CONCLUSION AND RECOMMENDATIONS

The Liveworksheets-based LKPD for the biodiversity topic in science was found to be feasible and practical, and the results suggest that it is effective for elementary school learning. Feasibility is supported by expert validation scores of 97% from the media expert (very feasible) and 76% from the material expert (feasible), so the media meets the criteria for classroom use. For practicality, the student response questionnaire gave a total score of 744 from 20 participating students (93%), indicating that students found the media very practical, interesting, and easy to use. Teachers and students both responded positively to the media. For effectiveness, learning outcomes differed between the experimental class and the control class. The mean posttest score was 85 (SD = 1.493) in the experimental class and 45 (SD = 1.865) in the control class. The N-gain categories (15 students high, 4 medium, 19 low) were not reported separately for each class. The posttest difference favours the Liveworksheets-based LKPD, but class-level N-gain values and a significance test are needed before it can be called effective.

Future researchers could develop Liveworksheets-based LKPD that is more widely accessible and more attractive, and could complete all 10 development stages. Careful preparation is also needed so that the research meets its objectives.

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REFERENCES

Abrami, P. C., Bernard, R. M., Borokhovski, E., Waddington, D. I., Wade, C. A., & Persson, T. (2015). Strategies for teaching students to think critically: A meta-analysis. *Review of Educational Research*, *85*(2), 275–314. https://doi.org/10.3102/0034654314551063

Aras, N. F., Lestari, M., Pendit, S. S. D., & Sani, N. K. (2024). The critical thinking skills of students through guided inquiry models in elementary school. *Jurnal Studi Guru dan Pembelajaran, 7*(3). https://doi.org/10.30605/jsgp.7.3.2024.4703

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, *66*(1), 64–74. https://doi.org/10.1119/1.18809

Hariyati, D. P., & Rachmadyanti, P. (2022). Pengembangan bahan ajar berbasis liveworksheet untuk siswa sekolah dasar kelas V. Jurnal Penelitian Pendidikan Guru Sekolah Dasar, 10(7), 1473–1483. https://doi.org/10.26740/jppgsd.v10i07.47566

Inanta, I. D., Winarni, E. W., & Muktadir, A. (2026). Pengembangan e-LKPD IPA berbasis inkuiri terbimbing berbantuan Liveworksheets untuk meningkatkan hasil belajar kognitif siswa kelas V SD. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 11*(2), 281–300. https://doi.org/10.23969/jp.v11i02.52516

Kemendikbudristek. (2024). *Keputusan Kepala Badan Standar, Kurikulum, dan Asesmen Pendidikan Nomor 032/H/KR/2024 tentang capaian pembelajaran*. Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi.

Khaeruman, K., Sudiatmika, A. R., Suma, I. K., & Suardana, I. N. (2023). Meta-analisis: Efektivitas multimedia interaktif terhadap peningkatkan hasil belajar siswa. *Bioscientist: Jurnal Ilmiah Biologi*, *11*(2), 1630–1639. https://doi.org/10.33394/bioscientist.v11i2.9497

Prabowo, A. (2021). Penggunaan liveworksheet dengan aplikasi berbasis web untuk meningkatkan hasil belajar peserta didik. Jurnal Pendidikan dan Teknologi Indonesia, 1(10), 383–388.

Prakoso, G. B., Manafe, M. P., & Atmojo, I. R. W. (2026). Analisis keterampilan berpikir kritis siswa pada pembelajaran IPAS SD berbasis STEAM: Systematic literature review. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 11*(2), 292–308. https://doi.org/10.23969/jp.v11i02.48311

Pratiwi, N. K. A., & Jayanta, I. N. L. (2023). Elementary school science skills practical digital teaching module. *Jurnal Edutech Undiksha, 11*(2). https://doi.org/10.23887/jeu.v11i2.61524

Sakinah, S., Dewi, R. S., & Hakim, Z. R. (2023). Development of contextual-based E-LKPD to improve the ability to understand fraction concepts. *EduBasic Journal: Jurnal Pendidikan Dasar, 5*(1), 71–82. https://doi.org/10.17509/ebj.v5i1.51576

Sari, Z. R., Hutapea, N. M., & Suanto, E. (2023). Pengembangan E-LKS Liveworksheet melalui pendekatan saintifik berbasis masalah kontekstual materi bangun ruang sisi datar. *Aksioma: Jurnal Program Studi Pendidikan Matematika, 12*(1), 837–848. https://doi.org/10.24127/ajpm.v12i1.6475

Setyowati, N., & Sutikno, P. Y. (2024). Meta analisis: Model pembelajaran problem based learning (PBL) terhadap keterampilan berpikir kritis siswa sekolah dasar. *Jurnal Inovasi Pendidikan dan Pembelajaran Sekolah Dasar, 8*(2), 587–599. https://doi.org/10.24036/jippsd.v8i2.127679

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Houghton Mifflin.

Sugiyono. (2017). *Metode penelitian kuantitatif, kualitatif, dan R&D*. Alfabeta.

Widiyani, A., & Pramudiani, P. (2021). Pengembangan lembar kerja peserta didik (LKPD) berbasis software liveworksheet pada materi PPKn. Jurnal Riset Pedagogik, 5(1), 132–141.

ICISFS-UMK 2026 EARLY CHILDHOOD & INCLUSIVE EDUCATION

Exploration of Natural Materials in STEAM-Based Learning to Enhance the Cognitive Abilities of Children in Early Childhood Education in Boyolali Regency

Sri Mujahidatin[1*], Nur Fajrie[1] and Sri Utaminingsih[1]

[1]*Muria Kudus University, Indonesia*

Corresponding author: afnandut@gmail.com

ABSTRACT

This study analyzes how STEAM-based learning through natural material exploration relates to the cognitive abilities of 5–6-year-old children in Boyolali Regency. It used a sequential mixed-methods design in which qualitative data from classroom observations, teacher interviews, and documentation were followed by quantitative measurement (Creswell & Plano Clark, 2018). The sample consisted of 190 children aged 5–6 years selected using probability sampling. The research instruments included creativity indicators (fluency, flexibility, originality, elaboration, and redefinition) and symbolic thinking indicators (number recognition, use of symbols, letter recognition, and pictorial representation). Qualitative data were analyzed thematically, while quantitative data were analyzed using multiple linear regression. The qualitative results indicate that natural material exploration in STEAM learning supports children's symbolic, logical, and imaginative thinking. In the regression model, the Adjusted R Square was 0.501: STEAM learning and natural material exploration together explained 50.1% of the variance in cognitive ability, and both predictors had positive coefficients with reported significance values below 0.05. STEAM learning through natural material exploration therefore appears to be associated with higher cognitive abilities in young children and offers contextual, creative, and meaningful learning experiences.

KEYWORDS early childhood education | STEAM | natural material exploration | cognitive ability | symbolic thinking

INTRODUCTION

Early childhood education (ECE) lays the foundation for later learning. Article 1 of Law No. 20 of 2003 on the National Education System defines ECE as educational services for children from birth to six years old that support their physical, mental, and intellectual development and prepare them for further education. Children grow rapidly in physical, cognitive, social, and emotional terms during these years, so the quality of their learning experiences in kindergarten matters for later schooling.

Play-based learning is the main approach in ECE because it fits children's developmental characteristics. Guided play, in which adults prepare materials and support children's exploration, outperformed direct instruction for early mathematics ($g = 0.24$) and shape knowledge ($g = 0.63$) in a meta-analysis of 17 studies with children aged 1 to 8 (Skene et al., 2022). Between about ages 4 and 6, symbolic thinking emerges: children begin to use numbers, letters, words, and images to stand for objects and ideas (Piaget & Inhelder, 1969). According to the Indonesian Early Childhood Development Standards (Permendikbud No. 137 of 2014), children aged 5–6 years are expected to count from 1 to 10, understand number concepts, recognize numerical symbols, and identify alphabet symbols.

Cognitive development at this age includes thinking, reasoning, memory, language, creativity, and imagination. Children begin to classify objects, recognize patterns, and understand numbers, shapes, colors, and letters. STEAM (Science, Technology, Engineering, Arts, and Mathematics) supports these skills through hands-on exploration and problem solving suited to children's developmental level. A scoping review of STEM, STEAM, and makerspace experiences for children from birth to eight found that research is still emerging, that adding the arts is especially relevant for young children, and that such learning needs deliberate planning and professional learning for educators (Johnston et al., 2022). In Indonesia, a review of 15 studies proposed five steps

for implementing STEAM in ECE under the Kurikulum Merdeka (reflection, research, discovery, application, and communication), with the teacher acting as facilitator (Motimona & Maryatun, 2023).

Natural materials such as sand, stones, leaves, twigs, and seeds are inexpensive and easy to find, and they can serve as loose parts that children move, combine, and transform. In focus group discussions, Indonesian early childhood educators linked loose parts in STEAM to freedom of creation in science, mathematics, and arts, and to problem solving in engineering and technology (Rahardjo, 2019). Kindergarten teachers have used natural loose parts for sand play, leaf necklaces, and forming letters with leaves, and reported benefits for cognitive, language, art, and motor development (Rianti et al., 2022). In one rural ECE centre, outdoor exploration with natural loose parts developed fluency and flexibility in all 16 children, although elaboration developed unevenly (Rahmadanti & Sitorus, 2026). Low-cost recycled materials have likewise supported early numeracy, with mastery rising from 53.00% to 89.17% over two action research cycles with children aged 5–6 (Pujiantie et al., 2026).

However, ECE in Indonesia is often judged by children's early reading, writing, and arithmetic skills, which reduces opportunities for meaningful play. Many teachers still rely on worksheets and magazines, so learning is less engaging even though natural learning resources are abundant.

Boyolali Regency has natural resources that can support STEAM learning, including agricultural products, forests, sand, gravel, papaya leaf stalks, and other natural materials. As a major agricultural and dairy-producing region with extensive forest areas, Boyolali offers ample resources for learning activities that draw on children's local environment.

Studies of STEAM with loose parts have reported benefits for young children's critical thinking (Azizah et al., 2022), problem solving (Najamuddin et al., 2022), and cognitive development (Nursakdiah et al., 2021). Much of this work is qualitative or classroom action research in a single kindergarten, and it focuses on problem solving, logical thinking, creativity, and critical thinking. Symbolic thinking, the use of numbers, letters, and pictures to represent ideas, has received less attention, and few studies have examined natural materials and STEAM learning together across several ECE institutions. This study therefore combines teacher interviews with a regression analysis of data on 190 children aged 5–6 years in Boyolali Regency to examine how STEAM-based learning and natural material exploration relate to children's cognitive abilities, particularly symbolic thinking.

LITERATURE REVIEW

Natural media are materials available in children's surroundings. Using them gives children direct experience and encourages self-expression and exploration. This fits Piaget's description of the preoperational period, roughly ages 2 to 7, in which children increasingly use symbols, including pretend play and drawing, to represent their surroundings while still relying on concrete objects (Piaget & Inhelder, 1969).

One relevant learning approach for current educational needs is STEAM (Science, Technology, Engineering, Arts, and Mathematics). STEAM extends the STEM concept by incorporating arts into learning activities. This interdisciplinary approach develops students' knowledge in science, technology, engineering, and mathematics as well as their creativity and aesthetic awareness through artistic exploration (Najamuddin et al., 2022). According to Tritiyatma (as cited in Hakim Naba & Nirwana, 2021), STEAM is a context-based learning approach that helps students understand surrounding phenomena and connects learning to real-life experiences.

The framework of this study therefore treats STEAM-based learning (the planned integration of the five disciplines) and natural material exploration (children's hands-on use of local materials) as two related features of classroom practice. Both are expected to support cognitive abilities, particularly symbolic thinking, by giving children concrete objects to sort, arrange, and use as symbols.

Research Objectives

This study explores the implementation of STEAM-based learning using natural materials and examines its relationship with the cognitive development of early childhood learners, particularly symbolic thinking, logical reasoning, creativity, and problem-solving skills. The findings are intended to inform meaningful and contextual learning strategies that support children’s cognitive growth.

RESEARCH METHOD

This study employed a mixed-methods approach using a sequential exploratory design, in which qualitative data were collected initially through observations and interviews, followed by quantitative measurement to strengthen the findings (Creswell & Plano Clark, 2018). The research was conducted during the second semester of the 2024/2025 academic year across several Early Childhood Education (ECE) institutions in Boyolali Regency, involving 190 children aged 5–6 years as research participants. The sample was selected by probability sampling so that it would represent the target population (Sugiyono, 2022).

Data were collected through observations of children's exploration of natural materials during STEAM-based learning activities, interviews with teachers, documentation of school profiles and children's artwork, and teacher questionnaires using a four-point Likert scale (1–4). The research instruments included indicators for assessing children's creativity, namely fluency, flexibility, originality, elaboration, and redefinition, as well as indicators of symbolic cognitive thinking, including number recognition, the use of numerical symbols, letter recognition, and pictorial representation (adapted from Permendikbud No. 137 of 2014).

The qualitative data obtained from observations, interviews, and documentation were analyzed using descriptive qualitative analysis, whereas the quantitative data were analyzed using descriptive and inferential statistical techniques. Integrating the two analyses gave a fuller picture of how STEAM-based learning using natural materials relates to the cognitive abilities of young children, particularly their symbolic thinking skills (Miles et al., 2020).

RESULTS

Qualitative Data Analysis

Qualitative data were collected through semi-structured interviews conducted with seven teachers from different kindergarten institutions, all of whom had direct experience implementing natural-material-based learning in their classrooms. The interviews were conducted face-to-face using open-ended questions designed to explore the teachers' understanding of STEAM-based learning, the importance of utilizing natural materials as learning resources, the exploratory activities they had implemented, children's responses to these learning experiences, the challenges encountered during implementation, and the perceived impact of these activities on children's cognitive development, particularly in relation to symbolic thinking. The qualitative data were analyzed using a thematic analysis approach, which involved three interrelated stages: data reduction, data display, and conclusion drawing. The principal findings are presented according to the major themes that emerged from the participants' responses. Representative verbatim quotations from the participants are included to support descriptive validity and give context.

Teachers' Understanding of the STEAM Concept

Almost all respondents showed a sound understanding of the STEAM approach. They recognized STEAM as an integrated educational framework that combines science, technology, engineering, arts, and mathematics within the teaching and learning process for young children.



Figure 1. Documentation of the interview with a teacher at Arofah 1 Kindergarten, Boyolali

According to SN, “STEAM is a learning approach in which teachers integrate science, technology, engineering, arts, and mathematics into early childhood education.” (Interview, June 20, 2025). WN expressed a

similar view, explaining that “the STEAM approach aims to foster children's critical thinking, creativity, and collaborative skills from an early age.” (Interview, June 20, 2025).



Figure 2. Documentation of the interview with a teacher at PGRI Pandeyan Kindergarten

The Importance of Natural Materials in Learning

All respondents agreed that integrating natural materials into early childhood learning is very important because such materials are readily available, inexpensive, and educationally valuable. According to MAP, “The use of natural materials stimulates children's imagination, enhances their creativity, and provides meaningful learning experiences.” (Interview, June 20, 2025). Similarly, ES explained that natural materials possess diverse textures and forms, which stimulate children's senses and enrich their sensory experiences (Interview, June 20, 2025). ES also emphasized the contextual significance of natural materials, stating that “Natural materials reflect local environmental richness and help strengthen children's connection with their surrounding environment. Therefore, the use of natural materials not only supports the learning process but also fosters ecological awareness and promotes the appreciation of local wisdom.” (Interview, June 20, 2025).



Figure 3. Documentation of the interview with a teacher at Arofah Bade Kindergarten

The Relationship Between Natural Materials and Cognitive Development

The respondents believed that exploring natural materials supports the development of children's logical thinking, problem-solving abilities, and imagination. ES explained, “When children sort stones according to their size, they learn the concept of classification. Arranging leaves from the smallest to the largest also helps them develop an understanding of sequencing.” (Interview, June 20, 2025). DC expressed a similar view, stating that “when children use banana leaves to make flower pots, they begin to understand the functions of different parts of the plant and relate them to everyday life.” (Interview, June 20, 2025).



Figure 4. Documentation of the interview with a teacher at Pertiwi IV Kindergarten, Boyolali

According to SN, “The use of natural materials can also enhance children's ability to recognize letters and numbers. For example, when children arrange letters using small pebbles, they begin to understand early literacy concepts through learning experiences that are both enjoyable and concrete.” (Interview, June 20, 2025).

Overall, the interview findings indicate that the exploration of natural materials within the STEAM approach promotes learning experiences that are contextual, engaging, and meaningful for young children. The participating teachers consistently perceived a strong relationship between the use of natural materials in exploratory activities and improvements in children's logical thinking, symbolic thinking, and creativity. They also believed that these learning experiences contribute substantially to children's overall cognitive development.

Although teachers reported challenges related to preparation time, material safety, and the availability of suitable resources, these obstacles were addressed through careful planning and collaboration with parents in collecting natural materials. This points to the role of teachers as facilitators and learning designers who create meaningful exploratory experiences tailored to children's developmental needs (Motimona & Maryatun, 2023).

Quantitative Data Analysis

The quantitative analysis was conducted to estimate how strongly STEAM-based learning through the exploration of natural-material learning media predicts the cognitive abilities of children aged 5–6 years.

Table 1. Model summary analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.693[a]	.709	.501	.217

In the multiple regression analysis (Table 1), the Adjusted R Square was 0.501, indicating that about 50.1% of the variance in young children's cognitive abilities is explained by the two independent variables, natural material exploration and STEAM-based learning. The remaining 49.9% is attributable to factors not included in the model. Before adjustment for the number of predictors, the R Square of 0.709 indicates that the model explains 70.9% of the variance in children's cognitive abilities. The multiple correlation coefficient (R = 0.693) indicates a strong positive relationship between the two predictors combined and young children's cognitive abilities. The Standard Error of the Estimate (SEE), which reflects the model's prediction error, was 0.217.

Table 2. Coefficients analysis

Model	Unstandardized Coefficients (B)	Std. Error	Standardized Coefficients (Beta)	t	Sig.
(Constant)	61.004	6.679	—	9.133	0.000
STEAM Based Learning	0.044	0.191	0.620	0.228	0.002
Natural Material Exploration	0.203	0.200	0.590	1.018	0.003

In Table 2, the first independent variable, STEAM-based learning, had an unstandardized coefficient (B) of 0.044 with a significance value of 0.002, indicating a positive association with children's cognitive abilities that

Table 2 reports as statistically significant. This finding suggests that, for every one-unit increase in the quality of STEAM-based learning, children's cognitive ability is expected to increase by 0.044 points (according to the measurement scale used), assuming that the other independent variables remain constant. The second variable, natural material exploration, had an unstandardized coefficient (B) of 0.203 with a significance value of 0.003, also indicating a positive and statistically significant relationship. This result suggests that children who engage more often in exploratory activities with natural materials tend to have higher cognitive ability scores.

Although the unstandardized regression coefficient for STEAM-based learning (B = 0.044) is smaller than that of natural material exploration (B = 0.203), the standardized regression coefficients (Beta) reveal that STEAM-based learning (β = 0.620) has a slightly stronger relative association with children's cognitive abilities than natural material exploration (β = 0.590). Because standardized coefficients are expressed on the same measurement scale, they provide a more appropriate basis for comparing the relative contribution of each predictor variable within the regression model. However, the t values in Table 2 (0.228 and 1.018) are not consistent with the reported significance values, and the R Square in Table 1 (0.709) is not consistent with R (0.693) and the Adjusted R Square (0.501), so these estimates need to be checked against the original output.

DISCUSSION

The teacher interviews suggest that natural material exploration gives children concrete objects through which they practise symbolic and logical thinking. Teachers described children sorting stones by size, arranging leaves from the smallest to the largest, and forming letters with small pebbles, and the findings also describe children using leaves as money or stones as food in pretend play. These are the representational acts that Piaget placed at the centre of the preoperational period, when children begin to let one object stand for another (Piaget & Inhelder, 1969). Similar classroom uses of natural loose parts, such as forming letters with leaves, were reported by Rianti et al. (2022), and teachers in a rural ECE centre saw fluency and flexibility develop during outdoor exploration with natural materials (Rahmadanti & Sitorus, 2026). These accounts come from seven teachers who already used natural materials, however, and they describe what teachers perceived rather than measured change in children.

In the regression model, STEAM-based learning and natural material exploration together explained 50.1% of the variance in cognitive ability (Adjusted R Square = 0.501; Table 1). Both predictors had positive coefficients (B = 0.044 and 0.203), and their standardized coefficients were similar (β = 0.620 and 0.590; Table 2). This suggests that the way teachers plan integrated STEAM activities and the extent to which children handle natural materials are related to cognitive ability to a similar degree. The two predictors are likely to overlap, because natural materials are usually used within STEAM activities, so their separate contributions should be read with caution. The direction of the association agrees with Indonesian studies reporting that STEAM with loose parts supports young children's cognitive development (Nursakdiah et al., 2021), critical thinking (Azizah et al., 2022), and problem solving (Najamuddin et al., 2022), and with meta-analytic evidence that guided play supports early mathematics more than direct instruction (Skene et al., 2022). Unlike most of these studies, which observed one class, this study estimated the association across 190 children in several institutions. It did not compare children with and without STEAM learning, so it cannot show that the approach caused higher cognitive scores.

One explanation for the association is that natural material activities combine several kinds of thinking in one task. When children arrange stones into number patterns, shape objects from clay, or make symbols from leaves, they observe and compare materials (science), plan and build (engineering), make aesthetic choices (arts), and count, order, and match (mathematics). Low-cost materials have supported early numeracy in a similar way: touch counting with bottle caps improved quantity-numeral matching and numeral recognition among kindergarten children in Pati Regency (Mahmud et al., 2026), and recycled-material games raised early numeracy mastery across two action research cycles (Pujiantie et al., 2026). Teachers in this study also observed that children explained the meaning of their creations with confidence. Talking about a product in this way may help children link an object to the idea it represents, which is the core of symbolic thinking.

For ECE institutions in Boyolali Regency, where sand, gravel, leaves, papaya leaf stalks, and agricultural products are easy to obtain, natural materials offer a low-cost alternative to worksheets and magazines. Teachers can plan activities that ask children to sort, sequence, and count materials, to use them as symbols for letters and numbers, and then to explain what they made. Recording these explanations, with photographs of the products, would also give teachers simple evidence of children's symbolic thinking for assessment. The challenges teachers reported (preparation time, material safety, and the availability of suitable materials) point to practical needs: lesson plans that specify safe materials, shared collections built with parents, and protected preparation time. Principals and the district education office can support this through professional development on STEAM planning, which reviews of early childhood STEAM identify as a condition for good implementation (Johnston et al., 2022; Motimona & Maryatun, 2023).

This study has several limitations. First, the regression output is internally inconsistent: the R Square (0.709) does not match R (0.693) or the Adjusted R Square (0.501) in Table 1, and the t values in Table 2 (0.228 and 1.018) do not fit the reported significance values (0.002 and 0.003). The quantitative conclusions therefore depend on re-checking the original analysis. Second, the design is cross-sectional and correlational, so the results show association, not effect. Third, the paper does not describe how STEAM-based learning, natural material exploration, and cognitive ability were scored for each child, who rated them, or how reliable the instruments were; if teachers rated both predictors and the outcome, common method bias may have inflated the association (Podsakoff et al., 2003). Fourth, the qualitative data come from seven teachers who already used natural materials, and the creativity indicators listed in the method are not reported in the results. Future studies should report the full regression output with reliability coefficients, assess children's symbolic thinking directly, and compare classes with and without natural material STEAM activities over a school term.

CONCLUSION AND RECOMMENDATIONS

The exploration of natural materials within STEAM-based learning in Early Childhood Education (ECE) institutions across Boyolali Regency was implemented in an active, creative, and well-structured manner. The participating teachers demonstrated a sound understanding of the STEAM approach and integrated natural materials (clay, stones, leaves, and twigs) into a variety of learning activities. The children showed a high level of enthusiasm throughout the learning process and were able to produce symbolic and imaginative creations. Findings from the classroom observations and teacher interviews suggest that teachers saw the exploration of natural materials as contributing to the development of children's symbolic thinking, classification skills, imagination, and understanding of fundamental concepts, including color, shape, and quantity.

In the regression analysis, STEAM-based learning and natural-material learning media were both positive predictors of young children's cognitive abilities, with significance values that need to be confirmed by re-analysis. These findings suggest that combining an interdisciplinary instructional approach with contextual learning media may create learning experiences that are more meaningful, creative, and that connect abstract concepts with children's real-life experiences. The R Square value of 0.709 indicates that the regression model explains 70.9% of the variation in the cognitive abilities of children aged 5–6 years.

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REFERENCES

Azizah, A., Munawar, M., & Khasanah, I. (2022). Implementasi pembelajaran berbasis STEAM dalam menumbuhkan keterampilan berpikir kritis anak usia 5-6 tahun di TKIT Harapan Bunda Semarang. *Wawasan Pendidikan*, *2*(2), 593–599. https://doi.org/10.26877/wp.v2i2.10059

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). SAGE.

Hakim Naba, A., & Nirwana. (2021). Implementasi metode STEAM berbasis media audio visual dalam meningkatkan aspek kognitif pada pendidikan anak usia dini. *Algazali International Journal* of *Educational Research*, *4*(1), 78–90.

Johnston, K., Kervin, L., & Wyeth, P. (2022). STEM, STEAM and makerspaces in early childhood: A scoping review. *Sustainability, 14*(20), Article 13533. https://doi.org/10.3390/su142013533

Law of the Republic of Indonesia No. 20 of 2003 on the National Education System [Undang-Undang Republik Indonesia Nomor 20 Tahun 2003 tentang Sistem Pendidikan Nasional]. (2003).

Mahmud, S., Niswah, K., & Ruiyat, S. A. (2026). Numeracy-on-a-budget: A design-based study of low-cost embodied numeracy using recycled manipulatives in early childhood. *The International Journal of Emerging Issues in Early Childhood Education*, *8*(1), 62–76. https://doi.org/10.33830/ijeiece.v8i1.13738

Miles, M. B., Huberman, A. M., & Saldaña, J. (2020). *Qualitative data analysis: A methods sourcebook* (4th ed.). SAGE.

Motimona, P. D., & Maryatun, I. B. (2023). Implementasi metode pembelajaran STEAM pada Kurikulum Merdeka untuk PAUD. *Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini*, *7*(6), 6493–6504. https://doi.org/10.31004/obsesi.v7i6.4682

Najamuddin, N., Fitriani, R., & Puspandini, M. (2022). Pengembangan bahan ajar science, technology, engineering, art and mathematics (STEAM) berbasis loose part untuk meningkatkan kemampuan pemecahan masalah anak usia dini. *Jurnal Basicedu*, 6(1), 954–964. https://doi.org/10.31004/basicedu.v6i1.2097

Nursakdiah, Hayati, F., & Marlini, C. (2021). Meningkatkan perkembangan kognitif anak melalui pembelajaran STEAM dengan menggunakan bahan loose part pada anak usia 5-6 tahun di TKIT Syeikh Abdurrauf. *Jurnal Ilmiah Mahasiswa*, 2(1).

Permendikbud No. 137 Tahun 2014 tentang Standar Nasional Pendidikan Anak Usia Dini [Regulation of the Minister of Education and Culture No. 137 of 2014 on National Standards for Early Childhood Education]. (2014). Kementerian Pendidikan dan Kebudayaan Republik Indonesia.

Piaget, J., & Inhelder, B. (1969). *The psychology of the child* (H. Weaver, Trans.). Basic Books.

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology, 88*(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Pujiantie, T., Elnawati, E., & Maulana, R. A. (2026). Peningkatan early numeracy melalui permainan berbasis recycled materials pada anak usia 5–6 tahun. *Journal of Education Research, 7*(3), 2105–2116. https://doi.org/10.37985/jer.v7i3.4066

Rahardjo, M. M. (2019). How to use loose-parts in STEAM? Early childhood educators focus group discussion in Indonesia. *JPUD – Jurnal Pendidikan Usia Dini, 13*(2), 310–326. https://doi.org/10.21009/JPUD.132.08

Rahmadanti, L., & Sitorus, A. S. (2026). Efektivitas loose parts berbasis bahan alam dalam mengembangkan kreativitas anak usia 5–6 tahun. *Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini*, *10*(2), 1346–1352. https://doi.org/10.31004/obsesi.v10i2.8264

Rianti, R., Nurjanah, I., Latifah, D., Alifah, N., & Asyiah, A. (2022). Freedom learning on early childhood education: Implementation of STEAM method with loose parts media. *Golden Age: Jurnal Ilmiah Tumbuh Kembang Anak Usia Dini*, *7*(2), 99–108. https://doi.org/10.14421/jga.2022.72-05

Skene, K., O'Farrelly, C. M., Byrne, E. M., Kirby, N., Stevens, E. C., & Ramchandani, P. G. (2022). Can guidance during play enhance children's learning and development in educational contexts? A systematic review and meta-analysis. *Child Development, 93*(4), 1162–1180. https://doi.org/10.1111/cdev.13730

Sugiyono. (2022). *Metode penelitian kuantitatif, kualitatif, dan R&D*. Alfabeta.

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

The Effect of Transformational Leadership and Principal Supervision on Job Satisfaction and Performance of Junior High School Teachers

Anik Kusumawati[1*], Ahmad Hariyadi[1] and Erik Aditia Ismaya[1]

[1]*Master of Basic Education Study Program, Postgraduate Program, Universitas Muria Kudus, Indonesia*

Corresponding author: anik.kusumawati@std.umk.ac.id

ABSTRACT

This study analyzed the effects of transformational leadership and principal supervision on the job satisfaction and performance of teachers at State Junior High Schools (SMP Negeri) in Pati Regency, Indonesia. The study was motivated by indications of low teacher job satisfaction and discipline, reflected in modest Teacher Performance Assessment (PKG) scores and delays in instructional administration. A quantitative approach with a survey design and path analysis was employed. The population comprised teachers from ten State Junior High Schools in four districts of Pati Regency (Batangan, Juwana, Wedarijaksa, and Trangkil), from which 226 teachers were drawn as respondents using cluster random sampling, exceeding the minimum sample of 210 computed with the Slovin formula. Data were collected using a five-point Likert-scale questionnaire consisting of 20 items per variable (transformational leadership, principal supervision, job satisfaction, and teacher performance), all of which met validity (corrected item-total correlation > 0.3) and reliability (Cronbach's Alpha > 0.7) criteria. Data were analyzed using Structural Equation Modeling (SEM) in AMOS version 24, which produced an acceptable model fit (CMIN/DF = 2.354, TLI = 0.919, CFI = 0.933, RMSEA = 0.079). The results show that: (1) transformational leadership had no significant effect on job satisfaction ($p = 0.249$); (2) principal supervision had a significant positive effect on job satisfaction ($p < 0.001$); (3) job satisfaction had a significant positive effect on teacher performance ($p < 0.001$); (4) principal supervision had a significant positive direct effect on teacher performance ($p < 0.001$), while transformational leadership did not ($p = 0.345$); and (5) for job satisfaction as a mediator of principal supervision, both component paths were significant but the reported Sobel test was not ($p = 0.829$), and job satisfaction did not mediate the effect of transformational leadership ($p = 0.733$). The model explained 27.6% of the variance in job satisfaction and 40.4% of the variance in teacher performance. These findings suggest that principal supervision and job satisfaction are the strongest correlates of teacher performance in this sample, whereas transformational leadership has no significant direct effect. They point to the need to strengthen academic supervision and principal training programs.

KEYWORDS job satisfaction | principal supervision | teacher performance | transformational leadership

INTRODUCTION

Education is the foundation of national development, and schools, as formal educational institutions, are central to producing high-quality human resources. Although development in Indonesia continues, challenges related to the quality, relevance, and efficiency of the education system remain significant. Progress in education shapes human character and the quality of a society's human resources.

The success of school education depends largely on teacher performance. Teachers are the front line of the learning process, and school leaders influence student learning mainly through their effects on teachers' motivation, capacity, and working conditions (Leithwood et al., 2020). Transformational leadership refers to leaders who encourage and inspire subordinates to achieve outcomes beyond expectations through a process of transformation (Robbins & Judge, 2017). Bass and Riggio (2006) add that transformational leadership influences subordinates so that they feel trust, pride, loyalty, and respect toward the leader and become motivated to exceed set expectations.

Teacher performance is influenced by internal factors, such as commitment and job satisfaction, and external factors, such as principal leadership, the school environment, working conditions, and school culture (Ardliana et al., 2021). Effective principal leadership can create a conducive working climate, build collective morale, and

encourage teachers' continuous professional development. Transformational leadership is regarded as particularly relevant because it can inspire, motivate, and empower teachers. Principal supervision is equally important: supervision conducted in a constructive, participatory, and sustained manner can improve teachers' job satisfaction, refine instructional practice, and support the achievement of professional competency standards. Job satisfaction may act as an intervening variable: reviews of transformational school leadership describe its effects as largely indirect, operating through school culture, teacher commitment, and job satisfaction (Leithwood & Jantzi, 2005).

Preliminary observations in the State Junior High Schools of Juwana District, Pati Regency, revealed several concerns. Based on 2023/2024 Teacher Performance Assessment (PKG) and e-kinerja data, the average teacher performance score was 74.2 (categorized as adequate), yet 38% of teachers scored below the minimum standard, 66% had not consistently implemented digital-based learning, and only 71% completed instructional administration on time. Regarding discipline, average attendance was 88%, but 26% of teachers were late more than ten times per semester and 34% frequently left school before the end of their duty hours. An internal survey by the Council of School Principals (MKKS) involving 132 teachers further indicated low-to-moderate job satisfaction: 54% of teachers reported dissatisfaction with their principal's leadership style, 49% reported not receiving regular coaching, and 61% felt underappreciated for their work, with an overall job satisfaction score of only 3.1 out of 5. Academic supervision was also found to be infrequent, averaging only once per semester rather than the recommended two to three times, and only 38% of principals were perceived by teachers as exhibiting transformational leadership characteristics.

Prior evidence on these relationships is mixed. Meta-analyses link transformational leadership to teachers' job satisfaction: across 65 Asian studies it had a positive effect on job satisfaction, organizational commitment, and self-efficacy (Firmansyah et al., 2022), and across 10 Indonesian studies its correlation with job satisfaction was moderate ($r = 0.50$) (Juhji & Tarihoran, 2022). Its link to outcomes beyond teachers' attitudes is weaker. In a meta-analysis of 27 studies, the effect of instructional leadership on student outcomes was three to four times that of transformational leadership (Robinson et al., 2008), and in a large English sample transformational leadership affected teachers' motivation and classroom practices but not student achievement gains (Leithwood & Jantzi, 2006). For supervision, academic supervision and principal leadership were each positively related to teacher performance among elementary teachers in Lebak Regency (Starlinsky et al., 2022), and a meta-analysis of 60 causal studies found that teacher coaching improved instruction by 0.49 SD (Kraft et al., 2018). We found few Indonesian studies that test transformational leadership and supervision together, with job satisfaction as a mediator, among junior high school teachers. These gaps and the conditions observed in the schools studied motivated the present study. It examines transformational leadership and principal supervision together as antecedents of job satisfaction and tests job satisfaction as a mediator between these antecedents and teacher performance.

LITERATURE REVIEW

In this study, transformational leadership is defined, following Bass (1985), through four dimensions: idealized influence, inspirational motivation, intellectual stimulation, and individualized consideration. Principal supervision is defined as a series of professional coaching activities carried out by the principal to help teachers improve their competence and the quality of instruction, encompassing supervision planning, implementation, technique, and follow-up/feedback (Glickman, Gordon, & Ross-Gordon, 2014; Sahertian, 2010). Job satisfaction is conceptualized as teachers' positive emotional state resulting from an evaluation of their work and work environment, covering satisfaction with the job itself, relationships with superiors and colleagues, recognition and rewards, workload balance, and opportunities for self-development (Robbins & Judge, 2017). Teacher performance is defined as the outcome of teachers carrying out their professional duties, comprising lesson planning, instructional implementation, assessment of learning outcomes, and discipline/responsibility (Hasibuan, 2016).

Based on this framework, transformational leadership (X1) and principal supervision (X2) are hypothesized as exogenous variables affecting job satisfaction (Y1), which in turn affects teacher performance (Y2); X1 and X2 are also hypothesized to have direct effects on Y2, and Y1 is hypothesized to mediate the effects of X1 and X2 on Y2.

Research Objectives

This study aimed to: (1) examine the effects of transformational leadership and principal supervision on teachers' job satisfaction (H1, H2); (2) examine the effect of job satisfaction on teacher performance (H3); (3) examine the direct effects of transformational leadership and principal supervision on teacher performance (H4, H5); and (4) test whether job satisfaction mediates the effects of transformational leadership and principal supervision on teacher performance (H6, H7), among teachers at ten State Junior High Schools in Pati Regency.

RESEARCH METHOD

Research Design

This study used a quantitative approach with an explanatory causal design to examine the hypothesized causal relationships between transformational leadership and principal supervision as independent variables and job satisfaction and teacher performance as dependent variables. Structural Equation Modeling (SEM), a multivariate statistical approach combining regression and factor analysis, was used to evaluate direct and indirect relationships among the latent variables simultaneously.

Respondents of the Study

The population consisted of 440 civil-servant and non-civil-servant teachers actively teaching at ten State Junior High Schools in the Batangan, Juwana, Wedarijaksa, and Trangkil districts of Pati Regency (Table 1). Using the Slovin formula with a 5% margin of error, a minimum sample of 210 teachers was required. Respondents were selected using cluster random sampling across the ten schools, and data collection ultimately yielded 226 valid responses, exceeding the minimum requirement.

Table 1. Population and sample distribution across schools

District	School	Teachers (PNS/Non-PNS)	Total
Batangan	SMPN 1 Batangan	22 / 16	38
	SMPN 2 Batangan	28 / 6	34
Juwana	SMPN 1 Juwana	45 / 10	55
	SMPN 2 Juwana	40 / 10	50
	SMPN 3 Juwana	39 / 13	52
	SMPN 4 Juwana	30 / 10	40
Wedarijaksa	SMPN 1 Wedarijaksa	33 / 15	48
	SMPN 2 Wedarijaksa	30 / 10	40
Trangkil	SMPN 1 Trangkil	35 / 8	43
	SMPN 2 Trangkil	25 / 10	35
Total			**440**

Instrument and Data Collection

Data were collected through a closed-ended questionnaire distributed online (Google Form) to the sampled teachers. Four instruments were used to measure transformational leadership (X1), principal supervision (X2), job satisfaction (Y1), and teacher performance (Y2), each comprising 20 items rated on a five-point Likert scale (1 = strongly disagree to 5 = strongly agree), distributed evenly across four indicators per variable.

Instrument validity was assessed on a pilot sample of 30 teachers using corrected item-total correlation, with items considered valid at $r > 0.3$; all items across the four variables met this criterion, with average correlations

above 0.8. Reliability was assessed using Cronbach's Alpha, with all four constructs meeting the acceptable-to-high reliability threshold ($\alpha > 0.7$).

Data Analysis

Hypothesis testing was conducted using SEM in AMOS version 24, following the standard SEM sequence of model specification, identification, estimation via Maximum Likelihood, and Goodness-of-Fit (GOF) evaluation. Model fit was assessed using Chi-square, CMIN/DF (good fit if ≤ 3.00), GFI and AGFI (good fit if ≥ 0.90), TLI and CFI (good fit if ≥ 0.90), and RMSEA (good fit if ≤ 0.08). Indirect (mediation) effects were further tested using the Sobel test, with mediation considered significant at $p < 0.05$.

RESULTS

Respondent Characteristics

Of the 226 respondents, the majority were female (143 teachers, 63%). The largest age group was 45-49 years (70 teachers, 31%), and the largest group of respondents (48%) had 13-22 years of teaching experience, so the sample was largely made up of experienced teachers. Respondents were fairly evenly distributed across the ten schools listed in Table 1.

Descriptive Statistics

Response distributions for all four variables were strongly skewed toward "agree" and "strongly agree", with no respondents selecting "strongly disagree" or "disagree" on any indicator. Mean scores for all indicators were 4.24 or higher on the five-point scale, with standard deviations consistently low (0.38-0.45), indicating little variation among teachers. The highest-rated indicator was "relationship with superiors and colleagues" under job satisfaction (mean = 4.42-4.48), while the lowest-rated, though still high, was "supervision planning" under principal supervision (mean = 4.24-4.28), suggesting that planning is the area with the greatest room for improvement.

Model Fit (Goodness of Fit)

Table 2. Structural model goodness-of-fit results

Fit index	Cut-off value	Model result	Remark
Chi-square (χ^2)	small value expected	266.001	-
Probability	≥ 0.05	0.000	Not fit
CMIN/DF	≤ 3.00	2.354	Good fit
GFI	≥ 0.90	0.875	Marginal fit
AGFI	≥ 0.90	0.831	Marginal fit
TLI	≥ 0.90	0.919	Good fit
CFI	≥ 0.90	0.933	Good fit
RMSEA	≤ 0.08	0.079	Good fit

Although the Chi-square test indicated a lack of exact fit ($p = 0.000$), a common result with larger samples ($N = 226$), the complementary fit indices supported an acceptable model: CMIN/DF (2.354) was below the 3.00 threshold, TLI (0.919) and CFI (0.933) exceeded 0.90, and RMSEA (0.079) was below 0.08. GFI (0.875) and AGFI (0.831) were slightly below the ideal 0.90 but within a marginally acceptable range. Overall, the model was judged to have an acceptable fit and to be suitable for hypothesis testing.

Hypothesis Testing (Path Analysis)

Table 3. Standardized path coefficients and hypothesis test results

Path	Estimate	C.R.	p	Result
X1 -> Y1 (H1)	0.14	1.153	0.249	Not significant (H1 rejected)
X2 -> Y1 (H2)	0.41	4.251	< 0.001	Significant (H2 accepted)
Y1 -> Y2 (H3)	0.46	4.319	< 0.001	Significant (H3 accepted)
X1 -> Y2 (H4)	-0.13	-0.944	0.345	Not significant (H4 rejected)
X2 -> Y2 (H5)	0.51	4.286	< 0.001	Significant (H5 accepted)

Two indirect (mediation) hypotheses were further tested with the Sobel test. For H6 (Y1 mediates X1 -> Y2), the Sobel statistic was 0.339 (p = 0.733), indicating no significant mediation; H6 was rejected. For H7 (Y1 mediates X2 -> Y2), the Sobel statistic was 0.215 (p = 0.829). H7 is therefore only partly supported: the a-path from X2 to Y1 and the b-path from Y1 to Y2 were both significant (Table 3), which is consistent with, but does not by itself establish, an indirect effect of principal supervision on teacher performance.

Coefficient of Determination

The model explained 27.6% of the variance in job satisfaction (R^2 = 0.276) through transformational leadership and principal supervision jointly, and 40.4% of the variance in teacher performance (R^2 = 0.404) through transformational leadership, principal supervision, and job satisfaction jointly, with the remaining variance attributable to factors outside the model.

DISCUSSION

Transformational Leadership and Job Satisfaction

Transformational leadership was not significantly related to teachers' job satisfaction (estimate = 0.14, p = 0.249; Table 3), so H1 was rejected. This differs from meta-analytic evidence of a moderate positive correlation between principals' transformational leadership and teacher job satisfaction in Indonesia (Juhji & Tarihoran, 2022) and from single studies such as Nurhadidjah et al. (2023), who found a correlation of 0.694 among elementary teachers, and Novitasari (2020), who found that several transformational dimensions raised job satisfaction in vocational schools. One explanation is that teachers may regard inspirational and visionary qualities as a baseline expectation rather than a differentiating factor, while more concrete, directly experienced support, such as technical assistance or school policy, matters more for their satisfaction. A second, statistical explanation is overlap: supervision is itself an act of leadership, so when both predictors enter the model, supervision may absorb most of the variance they share. The narrow spread of responses (standard deviations of 0.38-0.45) also limits the variance any predictor can explain.

Principal Supervision and Job Satisfaction

Principal supervision, in contrast, was positively related to job satisfaction (estimate = 0.41, C.R. = 4.251, p < 0.001; Table 3), so H2 was accepted. Clear planning, supportive implementation, and constructive feedback appear to be experienced by teachers as tangible professional support that helps them overcome instructional difficulties, build competence, and feel valued. This interpretation fits evidence that coaching, the most intensive form of instructional supervision, improves teachers' instruction (Kraft et al., 2018), and that principals' promotion of and participation in teacher learning is the leadership dimension most strongly linked to student outcomes (Robinson et al., 2008). In Indonesian elementary schools, principals acting as instructional leaders strengthened teachers' pedagogical competence mainly through supervision, continuous professional development, and a collaborative culture (Hanik et al., 2025).

Effects on Teacher Performance

Both principal supervision (estimate = 0.51) and job satisfaction (estimate = 0.46) had significant positive direct relationships with teacher performance (H5 and H3 accepted), whereas the direct path from transformational leadership was negative and not significant (estimate = -0.13, p = 0.345; H4 rejected) (Table 3). The supervision result agrees with Starlinsky et al. (2022), who found that academic supervision and principal leadership were each related to teacher performance. It differs from studies in which principal leadership itself had a direct effect on teacher performance, including a path analysis of high school teachers in Pati Regency (Ardliana et al., 2021) and a survey of junior high school teachers and principals in Aceh Besar (Sariakin et al., 2025). The difference may lie in how leadership was defined: those studies measured principal leadership broadly, whereas this study separated the inspirational style from the concrete practice of supervision. When the two are separated, the evidence that instructional practices matter more than transformational style for outcomes (Robinson et al., 2008), and that transformational effects run mainly through school conditions rather than directly (Hallinger, 2011; Leithwood & Jantzi, 2005), would predict the pattern found here. The small negative estimate for transformational leadership should not be interpreted, as it may reflect its overlap with supervision.

Mediating Role of Job Satisfaction

The mediation results need cautious reading. For principal supervision, the a-path (X2 to Y1) and the b-path (Y1 to Y2) were both significant, but the reported Sobel statistic was 0.215 (p = 0.829). Recomputing the Sobel statistic from the estimates and critical ratios in Table 3 gives a much larger value, so the reported statistic should be checked; an indirect effect tested with bootstrapped confidence intervals, as now recommended in place of the causal-steps logic, would settle the question (Zhao et al., 2010). If the indirect effect is confirmed, a plausible mechanism is that supervision makes teachers feel valued, competent, and comfortable at work, which in turn strengthens their motivation, commitment, and performance. Job satisfaction did not mediate the effect of transformational leadership (H6 rejected), because the first link in that chain was not significant. In this setting, therefore, strengthening concrete, supportive supervision may do more for teacher performance than relying on an inspirational leadership style alone.

Implications and Limitations

For principals in Pati Regency, the results point to supervision as the practice most closely tied to teachers' satisfaction and performance. The preliminary data showed that academic supervision took place about once per semester rather than the recommended two to three times, and that supervision planning was the lowest-rated indicator. Principals could therefore schedule more frequent classroom visits, plan them with teachers, and follow each visit with specific, appreciative feedback and coaching. The Pati Regency Education and Culture Office and the principals' working group (MKKS) could support this through training in supervision and coaching techniques and by including the quality of supervision in principal performance appraisals. Transformational leadership should not be dismissed, since it may work through school culture and teacher commitment, which this model did not include.

The study has several limitations. It used a cross-sectional survey, so the paths show associations rather than causal effects. All four variables, including teacher performance, were self-reported by the same teachers in one questionnaire, which invites common method bias (Podsakoff et al., 2003); official PKG scores would give an independent measure of performance. Responses clustered near the top of the scale, and the paper does not report the measurement model (factor loadings, composite reliability, and average variance extracted) or whether the estimates in Table 3 are standardized. GFI and AGFI were below 0.90 (Table 2). Teachers are nested in ten schools, but the analysis treated them as independent. Future research should use multi-source data, test indirect effects with bootstrapping, model the school level, and add mediators such as organizational commitment, self-efficacy, or school climate.

CONCLUSION AND RECOMMENDATIONS

Transformational leadership had no significant effect on teachers' job satisfaction, indicating that, in this context, the principal's transformational leadership style is not the primary driver of job satisfaction. Principal supervision, by contrast, had a significant positive effect on job satisfaction, indicating that effective, supportive, and well-planned supervision is associated with higher teacher satisfaction. Job satisfaction had a significant positive effect on teacher performance, and principal supervision had a significant positive direct effect on teacher performance, while transformational leadership did not have a significant direct effect. This suggests that practical supervisory support has a more immediate influence on performance than an inspirational leadership style. Job satisfaction appeared to mediate the effect of principal supervision on teacher performance (both component paths were significant, although the Sobel test was not), but did not mediate the effect of transformational leadership. Supervision may therefore improve performance partly by strengthening job satisfaction.

Based on these findings, school principals are encouraged to prioritize the quality of academic supervision and to treat it as a means of coaching, collaboration, and professional support, with constructive, appreciative, and solution-oriented feedback, rather than as an administrative requirement. The Pati Regency Education and Culture Office is encouraged to design regular training or workshops on effective and humane academic supervision techniques and to consider supervision effectiveness as a key indicator in evaluating principal performance. Teachers, in turn, are encouraged to engage proactively in the supervision process as an opportunity for professional growth rather than merely an evaluation exercise. Future researchers are encouraged to test alternative mediators (such as organizational commitment, teacher self-efficacy, or school climate) and additional predictors, such as work motivation or incentive systems, and to replicate this study in different contexts (e.g., private schools or other education levels), including through qualitative approaches that can further explain why transformational leadership did not show a significant effect in this setting.

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REFERENCES

Ardliana, B., Rusdarti, R., & Suminar, T. (2021). Effect of principal leadership, school culture and pedagogic competence through work motivation on teachers performance. *Educational Management*, *10*(2), 273–283.

Bass, B. M. (1985). Leadership and performance beyond expectations. Free Press.

Bass, B. M., & Riggio, R. E. (2006). Transformational leadership (2nd ed.). Psychology Press.

Firmansyah, F., Prasojo, L. D., Jaedun, A., & Retnawati, H. (2022). Transformational leadership effect on teacher performance in Asia: A meta-analysis. *Cypriot Journal of Educational Sciences, 17*(6), 2127–2146. https://doi.org/10.18844/cjes.v17i6.7552

Glickman, C. D., Gordon, S. P., & Ross-Gordon, J. M. (2014). Supervision and instructional leadership: A developmental approach (9th ed.). Pearson.

Hallinger, P. (2011). Leadership for learning: Lessons from 40 years of empirical research. *Journal of Educational Administration, 49*(2), 125–142. https://doi.org/10.1108/09578231111116699

Hanik, H., Nuphanudin, N., Khamidi, A., Roesminingsih, E., Kristanto, A., Trihantoyo, S., & Haq, M. S. (2025). Kepala sekolah sebagai instructional leader: Penguatan kompetensi pedagogik guru untuk pembelajaran mendalam di sekolah dasar. *Didaktika, 5*(3). https://doi.org/10.17509/didaktika.v5i3.93269

Hasibuan, M. S. P. (2016). Manajemen sumber daya manusia [Human resource management] (Rev. ed.). Bumi Aksara.

Juhji, J., & Tarihoran, N. (2022). A meta-analysis study of principal leadership and teacher job satisfaction. *Al-Ishlah: Jurnal Pendidikan, 14*. https://doi.org/10.35445/alishlah.v14i1.1498

Kraft, M. A., Blazar, D., & Hogan, D. (2018). The effect of teacher coaching on instruction and achievement: A meta-analysis of the causal evidence. *Review of Educational Research, 88*(4), 547–588. https://doi.org/10.3102/0034654318759268

Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven strong claims about successful school leadership revisited. *School Leadership & Management, 40*(1), 5–22. https://doi.org/10.1080/13632434.2019.1596077

Leithwood, K., & Jantzi, D. (2005). A review of transformational school leadership research 1996–2005. *Leadership and Policy in Schools, 4*(3), 177–199. https://doi.org/10.1080/15700760500244769

Leithwood, K., & Jantzi, D. (2006). Transformational school leadership for large-scale reform: Effects on students, teachers, and their classroom practices. *School Effectiveness and School Improvement, 17*(2), 201–227. https://doi.org/10.1080/09243450600565829

Novitasari, D. (2020). Improving job satisfaction and organizational commitment: Analysis of the effects of the principal transformational leadership. *Dinamika Pendidikan, 15*(2), 172–189. https://doi.org/10.15294/dp.v15i2.25111

Nurhadidjah, A., Rusti, E. R., & Hidayat, Z. (2023). Hubungan gaya kepemimpinan transformasional kepala sekolah dan budaya organisasi sekolah dengan kepuasan kerja guru SD di Kecamatan Cidahu. *Journal of Contemporary Issue in Elementary Education, 1*(1), 62–71. https://doi.org/10.33830/jciee.v1i1.5111

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology, 88*(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Robbins, S. P., & Judge, T. A. (2017). Organizational behavior (17th ed.). Pearson.

Robinson, V. M. J., Lloyd, C. A., & Rowe, K. J. (2008). The impact of leadership on student outcomes: An analysis of the differential effects of leadership types. *Educational Administration Quarterly, 44*(5), 635–674. https://doi.org/10.1177/0013161X08321509

Sahertian, P. A. (2010). Supervisi pendidikan dalam rangka peningkatan mutu pendidikan [Educational supervision for improving education quality]. Rineka Cipta.

Sariakin, S., Yeni, M., Usman, M. B., Mare, A. S., Munzir, M., & Saleh, M. (2025). Fostering a productive educational environment: The roles of leadership, management practices, and teacher motivation. *Frontiers in Education, 10*, Article 1499064. https://doi.org/10.3389/feduc.2025.1499064

Starlinsky, L., Belawati, T., & Rosita, T. (2022). Korelasi antara kepemimpinan kepala sekolah dan supervisi akademik terhadap kinerja guru sekolah dasar di Kecamatan Lebakgedong Kabupaten Lebak. *Indonesian Journal of Educational Counseling, 6*(1), 26–33. https://doi.org/10.30653/001.202261.190

Zhao, X., Lynch, J. G., Jr., & Chen, Q. (2010). Reconsidering Baron and Kenny: Myths and truths about mediation analysis. *Journal of Consumer Research, 37*(2), 197–206. https://doi.org/10.1086/651257

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

The Influence of School Principal Leadership and Emotional Quotient on Teachers' Work Culture at Public Junior High Schools in Komda Juwana, Pati

Panji Susilo[1*], Sri Utaminingsih[1] and Gunawan Setiadi[1]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: panjirangga79s@gmail.com

ABSTRACT

This study aimed to: (1) analyze the influence of school principals' leadership on teachers' work culture; (2) examine the effect of teachers' emotional quotient (EQ) on their work culture; and (3) investigate the simultaneous influence of school principals' leadership and teachers' emotional quotient on teachers' work culture. A quantitative approach with an ex post facto design was employed. The sample consisted of 200 civil-servant teachers from public junior high schools in the Komda Juwana area, Pati Regency, selected through proportional random sampling. Data were analyzed using Structural Equation Modeling (SEM) with AMOS. The results show that: (1) school principals' leadership has a positive and significant effect on teachers' work culture (C.R. = 3.999, $p < 0.001$); (2) teachers' emotional quotient has a positive and significant effect on their work culture (C.R. = 6.820, $p < 0.001$); and (3) together, school principals' leadership and teachers' emotional quotient explain 16.9% of the variance in teachers' work culture ($R^2 = 0.169$); the remaining 83.1% is attributable to factors outside the model. The path coefficient from EQ to work culture (0.27) was slightly higher than that from leadership (0.23), and a significant positive correlation (0.26) was found between leadership and EQ. Sobel tests further indicated that EQ significantly mediates the effect of leadership on work culture (Sobel = 1.987, $p = 0.046$), and that leadership significantly mediates the effect of EQ on work culture (Sobel = 2.147, $p = 0.032$), suggesting that the two variables may play complementary roles. School principals, teachers, and the Education and Culture Office are advised to strengthen leadership and emotional quotient competencies as a way of improving teachers' work culture.

KEYWORDS emotional quotient | school principal leadership | teachers' work culture | path analysis

INTRODUCTION

At the junior high school (SMP) level, school principal leadership and emotional quotient (EQ) are two factors that may jointly shape the quality of teachers' work culture. Effective leadership, combined with the ability to understand and manage emotions, has been linked both to individual performance and to a positive, collaborative, and professionally supportive work environment. Strengthening teachers' work culture is therefore an ongoing priority for improving the quality of national education.

Teachers' work culture reflects the values, norms, and professional ethics applied in daily practice within the school environment. A positive work culture is visible in classroom teaching, in social interactions among teachers, and in relationships with students, principals, and parents. A healthy work environment encourages motivation, loyalty, and commitment among teachers, which in turn supports the achievement of learning objectives.

These conditions have not yet been fully realized in many schools, including the public junior high schools in Komda Juwana, Pati Regency. Weak work discipline, including poor punctuality, low accountability and limited collaboration, is a recurring concern in Indonesian schools, and school heads have tried to address it through administrative control, mentoring and personal modelling (Dermawan et al., 2026). In the study area, low participation in professional development, weak communication among teachers, and insufficient responsibility in carrying out tasks suggest that teachers' work culture remains below expectations. The factors that influence it therefore need closer examination.

School principal leadership is one of the main factors shaping work culture, and both theory and empirical studies support this view. Theoretically, transformational leadership positions the principal as an agent of change

who inspires teachers through vision, motivation, and exemplary behavior (Alzoraiki et al., 2024). Instructional leadership centres on supervision, evaluation, and teacher development, and a meta-analysis of 27 studies found its average effect on student outcomes to be three to four times that of transformational leadership (Robinson et al., 2008). Servant leadership emphasizes service and empowerment; a review of 20 quantitative studies associated it with staff commitment, engagement and a positive school climate (Hossain et al., 2026). Empirically, a meta-analysis of 65 Asian studies found positive effects of transformational school leadership on teachers' job satisfaction, organizational commitment and self-efficacy (Firmansyah et al., 2022). In Pati Regency itself, principal leadership and school culture each had a direct effect on the performance of 114 public high school teachers (Ardliana et al., 2021). Ramlah et al. (2023) reported a simultaneous influence of leadership and EQ on teacher work behavior of 45.4%, and Sulaiman et al. (2025) found that leadership and EQ together accounted for 74.1% of the variance in teacher performance in West Aceh.

Teachers' emotional quotient (EQ) also contributes to a healthy work culture. According to Goleman (2015), EQ comprises five components: self-awareness, self-regulation, motivation, empathy, and social skills. These components enable teachers to respond positively to work pressure, interpersonal conflict, and change, and an interview study of teachers and principals in Central Kalimantan described emotional intelligence and work ethic as complementary dimensions of teachers' professionalism (Seprianto & Surya, 2025). Empirically, a survey of 101 teachers in neighbouring Demak Regency found that emotional intelligence and emotional sensitivity significantly shaped teacher performance (Kuswanto et al., 2023). Most of this evidence, however, concerns teachers' individual performance rather than the shared work culture of a school.

Three gaps follow from this literature. First, Indonesian studies of principal leadership and teachers' emotional intelligence usually take teacher performance, motivation or job satisfaction as the outcome (Ardliana et al., 2021; Kuswanto et al., 2023; Sariakin et al., 2025). Work culture, the shared values and norms that shape how teachers carry out these tasks, is measured less often, although qualitative work links it to leadership and to teachers' motivation (Imawati et al., 2025). Second, leadership and EQ are usually examined in separate models, so little is known about how much each contributes when both are estimated together. Third, evidence from public junior high schools in Pati Regency is scarce; the closest study concerned senior high school teachers and did not include EQ (Ardliana et al., 2021). Estimating the separate and joint contributions of the two factors in this setting can show principals and the district education office where support for teachers is most likely to help.

School principal leadership and teachers' EQ can therefore be seen as two foundations of a healthy and productive work culture. Effective leadership builds a collaborative and motivating climate, while teachers' EQ supports sound emotion management and harmonious interpersonal relationships. This study therefore estimates the direct effects of principal leadership and teachers' EQ on teachers' work culture, the joint variance they explain, and the correlation between them, using a structural equation model of survey data from civil-servant teachers in public junior high schools in Komda Juwana, Pati. The results are intended to inform school-level leadership practice and the professional development programmes of the Education and Culture Office.

LITERATURE REVIEW

This study is grounded in leadership theory and emotional intelligence theory. School principal leadership (X1) is conceptualized through transformational, instructional, and servant-leadership perspectives, reflected in commitment, role modeling, effective communication, and participatory decision-making (Alzoraiki et al., 2024; Robinson et al., 2008; Hossain et al., 2026). Teachers' emotional quotient (X2) is conceptualized following Goleman (2015) through five components: self-awareness, self-regulation, motivation, empathy, and social skills. Teachers' work culture (Y) is conceptualized through indicators of involvement in decision-making, trust and empathy, team confidence, professionalism, and honesty.

Based on this framework, school principal leadership (X1) and teachers' emotional quotient (X2) are each hypothesized to have a direct positive effect on teachers' work culture (Y) and to affect it jointly. The two predictors are also expected to be positively correlated, and each is hypothesized to mediate the other's effect on work culture.

Research Objectives

This study aimed to: (1) analyze the influence of school principals' leadership on teachers' work culture; (2) examine the effect of teachers' emotional quotient on their work culture; and (3) investigate the simultaneous influence of school principals' leadership and teachers' emotional quotient on teachers' work culture at public junior high schools in Komda Juwana, Pati Regency.

RESEARCH METHOD

Research Design

This study employed a descriptive quantitative approach with a non-experimental, ex post facto correlational design, which examines relationships among variables without manipulating them. Data were collected through a survey using a closed-ended questionnaire measuring three variables: school principal leadership (X1), emotional quotient (X2), and teachers' work culture (Y).

Respondents of the Study

The research population consisted of 400 civil-servant teachers at public junior high schools in Komda Juwana, Pati Regency. Using the Slovin formula, 200 teachers were selected as the sample through proportional random sampling.

Instrument and Data Collection

The research instrument was a five-point Likert-scale questionnaire developed from the indicators of each variable. A pilot test was conducted on 30 respondents outside the main sample. Validity was assessed using Pearson product-moment correlation and reliability using Cronbach's Alpha; all items were valid and the scales reliable, with Alpha values above 0.9.

Data Analysis

Data were analyzed using Path Analysis through Structural Equation Modeling (SEM) based on Maximum Likelihood Estimation (MLE) in AMOS. Model evaluation referred to several Goodness-of-Fit indices, including Chi-Square and its probability, GFI, AGFI, RMSEA, TLI, NFI, PCFI, and PNFI. Indirect (mediation) effects were tested using the Sobel test, with mediation considered significant at $p < 0.05$. Together, these procedures were used to estimate the direct and indirect effects among the variables in the model.

RESULTS

Model Fit and Path Analysis

Path analysis using AMOS showed that school principal leadership had a significant effect on teachers' work culture, with a Critical Ratio (C.R.) of 3.999 ($p < 0.001$), and that teachers' EQ also had a significant effect, with a C.R. of 6.820 ($p < 0.001$). These findings indicate that higher-quality leadership and greater emotional intelligence among teachers are associated with a more positive work culture in the school environment.

Table 1. Structural model goodness-of-fit results

Fit index	Model result	Remark
Chi-Square (χ2)	189.770	-
Probability	0.109	Good fit
GFI	0.917	Good fit
AGFI	0.896	Marginal fit
RMSEA	0.026	Good fit
TLI	0.985	Good fit
NFI	0.902	Good fit
PCFI	0.867	Good fit
PNFI	0.793	Acceptable

The overall Goodness-of-Fit indices (Chi-square = 189.770, probability = 0.109, GFI = 0.917, AGFI = 0.896, RMSEA = 0.026, TLI = 0.985, NFI = 0.902) indicate that the proposed structural model fits the empirical data adequately (only AGFI falls in the marginal range) and is suitable for hypothesis testing.

Table 2. Standardized path coefficients

Path	Estimate	C.R.	p
X1 -> Y (Leadership -> Work culture)	0.23	3.999	< 0.001
X2 -> Y (EQ -> Work culture)	0.27	6.820	< 0.001
X1 <-> X2 (correlation)	0.26	-	-

Taken together, both variables are associated with teachers' work culture, which supports the third hypothesis (H3). However, the coefficient of determination (R^2) for work culture was only 0.169, which indicates that leadership and EQ explain a modest share of the variance in work culture. The path coefficient from teachers' EQ to work culture (0.27) is slightly higher than the direct influence of school principal leadership (0.23), suggesting that emotional intelligence has a slightly stronger association with work culture. The analysis also showed a positive correlation between school principal leadership and teachers' EQ (0.26). This correlation may reflect effective leadership practices that support teachers' emotional intelligence, including emotion management, empathy, and interpersonal skills. Together, leadership and EQ may contribute to a professional, collaborative, and integrity-driven work culture.

Mediation (Sobel Test)

Sobel tests indicated that teachers' EQ significantly mediates the influence of school principal leadership on teachers' work culture (Sobel = 1.987, p = 0.046), and that school principal leadership also significantly mediates the influence of EQ on teachers' work culture (Sobel = 2.147, p = 0.032). These results suggest that leadership and EQ may play complementary roles in shaping a positive work culture in schools. They should be read with caution, however: the reported structural model treats leadership and EQ as correlated predictors without a path from one to the other, and the a- and b-paths behind the Sobel statistics are not reported.

DISCUSSION

The Influence of School Principal Leadership on Teachers' Work Culture

School principal leadership was found to have a significant influence on teachers' work culture (C.R. = 3.999; p < 0.001). Leadership characterized by commitment, role modeling, effective communication, and participatory decision-making is associated with a disciplined, professional, and collaborative work culture in schools. This finding is consistent with research showing that transformational leadership has strong effects on school organizational conditions such as culture and planning (Leithwood & Jantzi, 2000), and with the view of the principal as the person who sets and models working norms in the school (Mulyasa, 2013).

The standardized path from leadership to work culture (0.23, Table 2) is modest. One explanation is that principals influence teachers mostly through intermediate conditions. Leithwood et al. (2020) concluded that school leadership works largely through teachers' motivation, capacity and working conditions, and in Pati Regency Ardliana et al. (2021) found that work motivation carried part of the effect of principal leadership on teacher performance. A similar process may operate here: principals who communicate clearly and involve teachers in decisions may raise motivation and trust, which then appear as stronger norms of collaboration and professionalism. The coefficient is also smaller than the effect of principal leadership on teacher performance (0.388) reported for junior high schools in Aceh Besar (Sariakin et al., 2025). Work culture is a shared attribute of the staff, whereas performance and motivation are individual outcomes, so a single principal's behaviour may be less closely tied to it. Differences in instruments and estimation (covariance-based SEM here, PLS-SEM there) also limit direct comparison.

For principals in Komda Juwana, the result points to everyday leadership behaviour rather than formal programmes alone. Modelling punctuality and accountability, mentoring teachers who struggle with routine duties, and keeping consistent administrative follow-up were the practices through which one school head improved teacher discipline and collaboration (Dermawan et al., 2026). Supervision that focuses on teachers' learning is another lever, since promoting and participating in teacher development had the largest effect among the leadership dimensions in a meta-analysis by Robinson et al. (2008).

The Influence of Emotional Quotient on Teachers' Work Culture

Teachers' emotional quotient was found to significantly affect work culture (C.R. = 6.820; $p < 0.001$). Teachers with higher emotional intelligence tend to manage emotions effectively, build strong interpersonal relationships, and create a positive and harmonious work environment. Social awareness, motivation, and emotion regulation appear to be key elements in strengthening cultural values in the workplace. This result aligns with Kuswanto et al. (2023), who found that emotional intelligence and emotional sensitivity shaped the performance of teachers in Demak, and with Ramlah et al. (2023), who reported a joint influence of EQ and principal leadership on teacher work behavior.

The path from EQ (0.27) was slightly larger than the path from leadership (0.23), but the difference between the two coefficients was not tested, so the study cannot claim that EQ matters more. Part of the association may also reflect conceptual overlap. The work culture indicators of trust, empathy and team confidence are close to the empathy and social-skills components of EQ (Goleman, 2015), and both scales were completed by the same teachers. Even so, the finding agrees with qualitative evidence that teachers and principals see emotional intelligence and work ethic as complementary parts of professionalism (Seprianto & Surya, 2025). For schools, this suggests that in-service training could include emotion regulation, empathy and conflict handling alongside pedagogy. Such content can be built into existing professional development and peer-reflection sessions rather than offered as a separate programme.

The Joint Influence of Leadership and Emotional Quotient on Teachers' Work Culture

The simultaneous analysis showed that school principal leadership and teachers' EQ together explain 16.9% of the variance in teachers' work culture ($R^2 = 0.169$). Although this contribution is modest, the two factors appear to complement each other in shaping a strong, integrity-driven, and collaborative work ethic. This interpretation is consistent with studies indicating that effective leadership and emotional intelligence are associated with collective efficacy, organizational commitment, and teachers' work engagement (Voelkel et al., 2024; Hossain et al., 2026).

The joint explained variance of 16.9% is well below the shares reported by Ramlah et al. (2023) for teacher work behavior (45.4%) and by Sulaiman et al. (2025) for teacher performance (74.1%), and below the 54% of teacher job satisfaction that Nurhadidjah et al. (2023) attributed to transformational leadership and school culture. These studies used different outcomes, instruments and estimation methods, so the gap should not be over-read. It does indicate that most of the variation in work culture among these teachers (83.1%) lies outside the model. Plausible candidates are work motivation and school culture (Ardliana et al., 2021), work discipline (Kamalia et

al., 2022), workload and school-level conditions. The positive correlation between leadership and EQ (0.26) is consistent with the idea that the two support each other, but the Sobel results should be treated as tentative. In the reported model neither variable has a path to the other, so neither can act as a mediator within it, and a cross-sectional design cannot separate the two directions of mediation that the paper reports. Testing mediation requires a model that specifies the indirect path, preferably with bootstrapped confidence intervals for the indirect effect (Zhao et al., 2010).

The study has several limitations. The ex post facto, cross-sectional design supports statements about association, not cause. The sample covers civil-servant teachers in one sub-district group of Pati Regency, so the results may not hold for non-civil-servant teachers or other regions. All variables were measured by teacher self-report at one time point, which can inflate the relationships through common method variance (Podsakoff et al., 2003). Several results are not reported: indicator loadings and construct reliability for the measurement model, a direct test of the joint effect (H3), the comparison of the two path coefficients, and the a- and b-paths used in the Sobel tests. Model fit was acceptable, with TLI (0.985) and RMSEA (0.026) within the cut-offs proposed by Hu and Bentler (1999), although AGFI (0.896) was marginal. Future studies could add principal or peer ratings of work culture, follow teachers over time, model teachers within schools with multilevel methods, and include work motivation or job satisfaction as mediators tested with bootstrapped indirect effects.

CONCLUSION AND RECOMMENDATIONS

Principal leadership has a positive and significant effect on teachers' work culture in public junior high schools in Komda Juwana, Pati. Leadership characterized by commitment, role modeling, effective communication, and participatory decision-making is associated with a disciplined, professional, and collaborative work culture. Teachers' emotional quotient also has a positive and significant effect on work culture, suggesting that higher emotional intelligence may strengthen teachers' engagement in building a healthy and productive work environment. Together, principal leadership and teachers' EQ explain 16.9% of the variance in teachers' work culture; the remaining 83.1% is attributable to factors outside this research model.

It is recommended that principals enhance leadership quality by strengthening commitment, effective communication, constructive supervision, and role modeling to further reinforce teachers' work culture. Teachers are encouraged to develop their emotional intelligence, particularly emotional regulation, motivation, and social sensitivity, to help create a professional, harmonious, and collaborative work environment. The Education and Culture Office is advised to support this through leadership training, EQ development, and professional development programs that sustain a positive work culture in schools. Future studies could include additional variables, such as work motivation, job satisfaction, or professional competence, to explain more of the variance in teachers' work culture.

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REFERENCES

Alzoraiki, M., Ahmad, A. R., Ateeq, A., & Milhem, M. (2024). The role of transformational leadership in enhancing school culture and teaching performance in Yemeni public schools. Frontiers in Education, 9, 1413607. https://doi.org/10.3389/feduc.2024.1413607

Ardliana, B., Rusdarti, R., & Suminar, T. (2021). Effect of principal leadership, school culture and pedagogic competence through work motivation on teachers performance. Educational Management, 10(2), 273–283.

Dermawan, O., Yusnita, E., & Putri, A. (2026). The role of school leadership in enhancing teacher work discipline. Tadris: Jurnal Keguruan dan Ilmu Tarbiyah, 11(1), 319–327. https://doi.org/10.24042/tadris.v11i1.28890

Firmansyah, F., Prasojo, L. D., Jaedun, A., & Retnawati, H. (2022). Transformational leadership effect on teacher performance in Asia: A meta-analysis. Cypriot Journal of Educational Sciences, 17(6), 2127–2146. https://doi.org/10.18844/cjes.v17i6.7552

Goleman, D. (2015). Emotional intelligence: Why it can matter more than IQ. Bantam Books.

Hossain, M. F., Uddin, M. S., Rana, M. S., & Siddique, M. N.-E.-A. (2026). A systematic literature review of servant leadership in education. Journal of Ethnic and Cultural Studies, 13(1), 1–28. https://doi.org/10.29333/ejecs/2562

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Structural Equation Modeling: A Multidisciplinary Journal, 6(1), 1–55. https://doi.org/10.1080/10705519909540118

Imawati, Maryani, I., & Zuhaery, M. (2025). School culture in fostering teachers' work motivation. JMKSP (Jurnal Manajemen, Kepemimpinan, dan Supervisi Pendidikan), 10(1), 778–801. https://doi.org/10.31851/jmksp.v10i1.19207

Kamalia, Ayub, D., & Sumarno, S. (2022). The influence of principal leadership and teacher work discipline on elementary school teacher performance. Journal of Educational Sciences, 6(3), 444–458. https://doi.org/10.31258/jes.6.3.p.444-458

Kuswanto, E., Malihah, N., Saerozi, M., & Subqi, I. (2023). Attitude in mediating the relationship between emotional maturity, emotional intelligence, emotional sensitivity, and teacher performance in Indonesian schools. Journal of Pedagogical Research, 7(5), 122–135. https://doi.org/10.33902/JPR.202322308

Leithwood, K., & Jantzi, D. (2000). The effects of transformational leadership on organizational conditions and student engagement with school. Journal of Educational Administration, 38(2), 112–129. https://doi.org/10.1108/09578230010320064

Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven strong claims about successful school leadership revisited. School Leadership & Management, 40(1), 5–22. https://doi.org/10.1080/13632434.2019.1596077

Mulyasa, E. (2013). Menjadi kepala sekolah profesional [Becoming a professional school principal]. Remaja Rosdakarya.

Nurhadidjah, A., Rusti, E. R., & Hidayat, Z. (2023). Hubungan gaya kepemimpinan transformasional kepala sekolah dan budaya organisasi sekolah dengan kepuasan kerja guru SD di Kecamatan Cidahu. Journal of Contemporary Issue in Elementary Education, 1(1), 62–71. https://doi.org/10.33830/jciee.v1i1.5111

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal of Applied Psychology, 88(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Ramlah, R., Nurdjan, S., & Mahmud, H. (2023). The influence of emotional intelligence and school principal leadership on teacher work behavior. International Journal of Asian Education, 4(3), 179-189. https://doi.org/10.46966/ijae.v4i3.353

Robinson, V. M. J., Lloyd, C. A., & Rowe, K. J. (2008). The impact of leadership on student outcomes: An analysis of the differential effects of leadership types. Educational Administration Quarterly, 44(5), 635–674. https://doi.org/10.1177/0013161X08321509

Sariakin, S., Yeni, M., Usman, M. B., Mare, A. S., Munzir, M., & Saleh, M. (2025). Fostering a productive educational environment: The roles of leadership, management practices, and teacher motivation. Frontiers in Education, 10, Article 1499064. https://doi.org/10.3389/feduc.2025.1499064

Seprianto, Y. C., & Surya, P. (2025). Teachers' emotional intelligence and work ethic in implementing the Merdeka Curriculum. Jurnal Akuntabilitas Manajemen Pendidikan, 13(1), 87–101. https://doi.org/10.21831/jamp.v13i1.103176

Sulaiman, M., Ismail, R., & Murniati. (2025). The role of emotional intelligence and leadership styles in enhancing teacher performance in high schools. MORFAI, 4(4). https://doi.org/10.54443/morfai.v4i4.2138

Voelkel, R. H., Jr., Prusak, K. J., & Van Tassell, F. (2024). Effective principal leadership behaviors that enhance teacher collective efficacy. Education Sciences, 14(4), 431. https://doi.org/10.3390/educsci14040431

Zhao, X., Lynch, J. G., Jr., & Chen, Q. (2010). Reconsidering Baron and Kenny: Myths and truths about mediation analysis. Journal of Consumer Research, 37(2), 197–206. https://doi.org/10.1086/651257

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

The Influence of Principals' Digital Leadership and Technological Adaptability on ICT-Based Learning Innovation in Elementary Schools

Arif Rifa'i[1*], Gunawan Setiadi[1] and Yuni Ratnasari[1]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: ayix.pati@gmail.com

ABSTRACT

Digital transformation in primary education requires systematic integration of Information and Communication Technology (ICT) to build adaptive, interactive, and student-centered learning environments. This study examines the influence of school principals' digital leadership and technological adaptability on teachers' ICT-based learning innovation across public elementary schools in Sukolilo District, Pati Regency. Grounded in Rogers' Diffusion of Innovations, Davis' Technology Acceptance Model (TAM), and the TPACK framework, the study used an associative quantitative survey with an ex post facto design. Data were gathered from 230 elementary teachers sampled proportionally across 36 schools using validated 5-point Likert questionnaires. The empirical model was analyzed using Structural Equation Modeling (SEM) through IBM SPSS AMOS 22.0. Goodness-of-Fit indices indicated a good structural fit (CMIN/DF = 1.062; GFI = 0.945; AGFI = 0.926; CFI = 0.997; TLI = 0.996; RMSEA = 0.016). Digital leadership had a positive and significant effect on learning innovation ($\gamma = 0.500$; C.R. = 7.925; $p < 0.001$), with visionary leadership ($\lambda = 0.843$) and strategic curriculum alignment ($\lambda = 0.817$) as its strongest indicators. Principals' technological adaptability also had a significant positive effect on learning innovation ($\gamma = 0.535$; C.R. = 6.912; $p < 0.001$), with positive attitudes toward technological change ($\lambda = 0.852$) and active teacher facilitation ($\lambda = 0.846$) as its strongest indicators. Together, digital leadership and technological adaptability accounted for 63.7% of the variance in ICT-based learning innovation ($R^2 = 0.637$). These findings suggest that combining a strategic digital vision with adaptable leadership behavior supports digital transformation in rural and urban primary schools.

KEYWORDS digital leadership | technological adaptability | ICT-based learning innovation | elementary school | TPACK framework

INTRODUCTION

Rapid technological change has disrupted 21st-century education and shifted classroom instruction from conventional teacher-centered models toward collaborative, autonomous, and student-centered learning (Fullan et al., 2018). In Indonesia, this shift is reinforced by the national Merdeka Belajar (Emancipated Learning) policy, which mandates school digitalization, interactive learning platforms, and the development of teachers' digital literacy (Kemendikbudristek, 2022; Saa, 2024). At the primary education level, integrating Information and Communication Technology (ICT) can build foundational digital literacy, critical inquiry, communication, collaboration, and creativity (4C skills) among young learners (Zuhaira, 2025).

Despite these mandates, gaps remain between national policy expectations and classroom practice. Studies in rural and suburban areas of Central Java, particularly Pati Regency, report that elementary teachers often face technical hesitation (gaptek), uneven distribution of digital devices, and unstable network infrastructure (Yusrina et al., 2023; Agustiana et al., 2022). Many teachers limit ICT use to basic administrative communication through instant messaging or one-way video streaming and rarely use more advanced pedagogical applications such as simulations, digital gamification, or automated formative diagnostic assessments (Sutisna et al., 2024; Afrillia & Dafit, 2025).

Theoretical and empirical work suggests that overcoming this inertia depends largely on the quality of school leadership (Hariyadi, 2025). In the digital era, effective principals need to move beyond bureaucratic supervision and combine strategic digital leadership with flexible technological adaptability (Sheninger, 2019). Digital

leadership involves building a shared vision, encouraging a culture in which teachers can experiment with new pedagogy, and investing systematically in teachers' professional development (Kasim & Surya, 2025; Zeng et al., 2025). Principals' technological adaptability, shown through personal tech-savviness, positive attitudes toward digital disruption, and responsive facilitation, may help reduce technostress and resistance among senior teachers. This expectation follows from TAM, in which perceived usefulness and ease of use shape the acceptance of technology (Davis, 1989).

Several studies have linked principals' leadership to teachers' use of technology. Sunu (2022) examined the impact of principals' digital leadership on teachers' acceptance and use of digital technologies, and in a SEM study of 24 elementary schools, principals' digital leadership constructs directly affected teacher performance and students' 21st-century competence (Timan et al., 2022). A survey of 1,200 Indonesian teachers found that principals' leadership affected teachers' innovative work behavior both directly and through the school as a learning organization (Hidayat & Patras, 2022). A review of 14 empirical studies concluded that principals' digital leadership shapes teachers' acceptance and use of new technology through resource allocation, professional development, learning communities and a supportive culture (Zeng et al., 2025). On the teacher side, a meta-analytic SEM of 114 studies found that TAM explains teachers' technology acceptance well, with perceived usefulness and attitudes as key predictors (Scherer et al., 2019).

Much of the writing on digital leadership comes from business and public-sector organizations (Marcel De Araujo et al., 2021; Syafitri et al., 2025), and studies of adaptability to digital education have often involved higher education teachers (Sharma et al., 2024). In Indonesian schools, digital leadership has mostly been related to teacher performance or general technology acceptance rather than to concrete classroom innovation, and principals' own technological adaptability has rarely been measured as a separate construct alongside it. Evidence from elementary schools in regional, non-metropolitan districts, where infrastructure and teacher readiness vary most, is also limited. Primary schools face specific challenges, including thematic curriculum integration and diverse multigenerational teacher demographics. This study therefore examines the effects of principals' digital leadership and technological adaptability on teachers' ICT-based learning innovation across public elementary schools in Sukolilo District, Pati Regency. It estimates how much each leadership attribute contributes to ICT-based learning innovation when both are in one structural model, which can help principals and the Pati Regency Education and Culture Office decide where to direct leadership development.

LITERATURE REVIEW

This study draws on an integrative framework that combines Rogers' (1995) Diffusion of Innovations Theory, Davis' (1989) Technology Acceptance Model (TAM), Sheninger's (2019) Pillars of Digital Leadership, and the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006).

According to Sheninger (2019), digital leadership is defined as a dynamic configuration of mindset, behaviors, and strategic actions that systematically transforms school culture through purposeful technological integration. It comprises seven core dimensions: visionary leadership, strategic curriculum alignment, digital learning culture, digital citizenship, digital communication, public relations, and institutional branding (Sunu, 2022; Timan et al., 2022). Principals who exercise digital leadership set technology roadmaps, secure digital infrastructure, and build an organizational climate that encourages teachers to adopt innovative teaching practices (Zeng et al., 2025).

Complementing digital leadership, technological adaptability is rooted in TAM (Davis, 1989), which posits that behavioral intention and actual technological adoption are governed by Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). In the context of school management, adaptability reflects a principal's cognitive, affective, and operational flexibility in adjusting to continuous technological change (Sharma et al., 2024; Syafitri et al., 2025). Principals who are tech-savvy, remain open to digital applications, use data-driven management (such as the national Education Report Card / Rapor Pendidikan), and actively facilitate teacher training can lower teachers' anxiety and technostress (Tri Mulyani & Lestari Dwi, 2024).

ICT-based learning innovation represents the pedagogical operationalization of TPACK (Mishra & Koehler, 2006; Wangdi et al., 2023), which covers teachers' capacity to combine technological tools with content delivery in lesson planning, interactive classroom execution, digital formative evaluation, and collaborative school culture (Rahma Puteri et al., 2025). The conceptual model linking these constructs is illustrated in Figure 1.

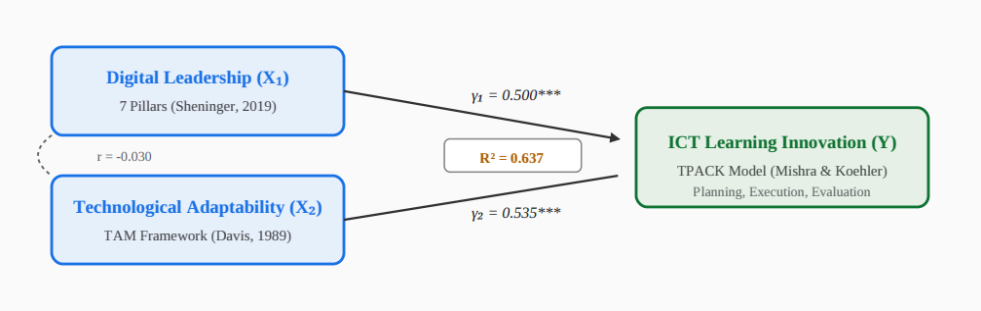

Figure 1. Conceptual and structural path diagram of research variables

Research Objectives

This study aims to analyze:

1. The direct partial effect of principals' digital leadership (X_1) on ICT-based learning innovation (Y) in public elementary schools in Sukolilo District, Pati Regency.
2. The direct partial effect of principals' technological adaptability (X_2) on ICT-based learning innovation (Y) in public elementary schools in Sukolilo District, Pati Regency.
3. The simultaneous predictive effect of principals' digital leadership (X_1) and technological adaptability (X_2) on ICT-based learning innovation (Y).

RESEARCH METHOD

Research Design

This study adopts a quantitative approach with a survey design. A quantitative approach is chosen because the study aims to test structural relationships among measured variables. A survey allows data to be gathered systematically from a representative sample of a defined population to examine perceptions, behaviors, and relationships among variables without intervention or experimental manipulation (Sugiyono, 2013). The research is classified as a correlational (associative) or ex post facto study.

1. Correlational Nature: It examines the strength, direction, and significance of the relationships between the independent variables Principal's Digital Leadership (X1) and Principal's Technological Adaptability (X2) and the dependent variable, ICT-Based Learning Innovation (Y).
2. Ex Post Facto Design: The events and behavioral patterns under examination (i.e., leadership practices, technological adaptability, and classroom learning innovations) have already occurred naturally in the field. The researcher measures and analyzes these phenomena in their natural setting without manipulating any variable.

For the multivariate analysis, this study employs Structural Equation Modeling (SEM) using the Analysis of Moment Structures (AMOS) software package. SEM-AMOS is chosen over multiple regression because it can evaluate complex measurement and structural models simultaneously.

Respondents of the Study

The respondents of this study are civil-servant (PNS) teachers at state primary schools (Sekolah Dasar Negeri) located in Sukolilo District, Pati Regency, Central Java. Teachers are selected because they design, deliver, and evaluate ICT-based learning in the classroom and experience their principal's digital leadership and technological support directly. The target population for this study comprises 267 public elementary school teachers distributed across primary school clusters (Gugus Sekolah Dasar) in Sukolilo District. To determine an adequate and statistically representative sample size from this population, Slovin's formula with an acceptable margin of error (e = 0.05 or 5%) is applied. Based on this calculation, the sample size required for this study is rounded to 160 primary school teachers.

The primary data collection tool for this study is a structured, closed-ended questionnaire administered to public elementary school teachers in Sukolilo District, Pati Regency. The instrument is designed to measure teachers' perceptions regarding three core research variables: Principal's Digital Leadership (X1), Principal's Technological Adaptability (X2), and ICT-Based Learning Innovation (Y). All questionnaire items are evaluated using a 5-point Likert Scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) for favorable items, and reverse-scored for unfavorable items.

Table 1. Mean score intervals and qualitative descriptions

Mean	Qualitative Description
1.00 – 1.80	Negative (Very Poor)
1.81 – 2.60	Poor
2.61 – 3.40	Fair
3.41 – 4.20	Positive
4.21 – 5.00	Excellent (Very Positive)

RESULTS

Descriptive statistics for the 230 respondents are summarized in Table 2, including aggregate scores, means, standard deviations, and categories.

Table 2. Descriptive statistics of research constructs

Construct / Variable	Number of Items	Theoretical Range	Observed Mean	Std. Dev.	Dominant Category
Digital Leadership (X_1)	14	14 – 70	47.83	12.81	High (51.74%)
Technological Adaptability (X_2)	10	10 – 50	34.62	9.59	High (57.83%)
ICT Learning Innovation (Y)	11	11 – 55	37.64	9.29	High (53.05%)

Frequency distributions indicate that most teachers perceived their principals' digital leadership (51.74% in High to Very High categories) and technological adaptability (57.83% in High to Very High categories) positively. Teachers' ICT-based pedagogical innovation was also rated high by most respondents (53.05%), which suggests a favorable starting point for technology diffusion.

Measurement Model: Confirmatory Factor Analysis (CFA) and Construct Reliability

The measurement model was subjected to Confirmatory Factor Analysis (CFA) to assess the unidimensionality, convergent validity, and reliability of each latent construct.

Table 3. Measurement model parameters, factor loadings, AVE, and composite reliability

Latent Construct	Observed Dimension / Indicator Code	Std. Loading (λ)	Error (1-λ²)	AVE	CR	Validity / Reliability
Digital Leadership (X_1)	X1.1 - Visionary Digital Leadership	0.843	0.289	**0.592**	**0.909**	Valid (AVE > 0.50) Reliable (CR > 0.70)
	X1.2 - Strategic Curriculum Alignment	0.817	0.333			
	X1.3 - Digital Learning Culture	0.749	0.439			
	X1.4 - Digital Citizenship & Ethics	0.601	0.639			
	X1.5 - Digital Communication Channels	0.765	0.415			
	X1.6 - Digital Public Relations	0.783	0.387			
	X1.7 - Institutional Digital Branding	0.801	0.358			
Technological Adaptability (X_2)	X2.1 - Basic Tech-Savviness	0.743	0.448	**0.617**	**0.889**	Valid (AVE > 0.50) Reliable (CR > 0.70)
	X2.2 - Positive Attitude toward Change	0.852	0.274			
	X2.3 - ICT Leadership & Data Integration	0.774	0.401			
	X2.4 - Teacher Support & Facilitation	0.846	0.284			
	X2.5 - Challenge Resilience & Coping	0.702	0.507			
ICT Learning Innovation (Y)	Y1.1 - Lesson Planning Innovation (TK/TPK)	0.709	0.497	**0.450**	**0.765**	Acceptable Factor Fit Reliable (CR > 0.70)
	Y1.2 - Classroom Execution (TCK/ TPACK)	0.686	0.529			
	Y1.3 - Digital Evaluation & Assessment	0.605	0.634			
	Y1.4 - School-wide ICT Innovation Culture	0.678	0.540			

As documented in Table 3, all standardized factor loadings exceeded the standard threshold of 0.50 (ranging from 0.601 to 0.852). Composite Reliability (CR) values for X_1 (0.909), X_2 (0.889), and Y (0.765) surpassed the acceptable benchmark of 0.70, indicating acceptable internal consistency. The AVE was 0.592 for X_1 and 0.617 for X_2 but 0.450 for Y, below the usual 0.50 benchmark. Discriminant validity evaluated via the Fornell-Larcker criterion showed that the square root of AVE for X_1 (0.769) and X_2 (0.786) was higher than the inter-construct correlation (r = -0.030), indicating satisfactory discriminant validity (Fornell & Larcker, 1981).

Structural Equation Model Evaluation and Goodness-of-Fit

All fit indices for the full structural model met the usual cut-off values, indicating a good fit between the empirical data and the theoretical model.

Table 4. Full structural model goodness-of-fit indices

Goodness-of-Fit Index	Cut-off Benchmark Value	Model Estimated Value	Model Evaluation Status
Chi-Square (χ^2)	Small value; p ≥ 0.05	107.237 (df = 101, p = 0.317)	Good Fit
CMIN/DF (Normed Chi-Square)	≤ 2.00 (or ≤ 3.00)	1.062	Good Fit (Excellent)
GFI (Goodness of Fit Index)	≥ 0.90	0.945	Good Fit
AGFI (Adjusted GFI)	≥ 0.90	0.926	Good Fit
CFI (Comparative Fit Index)	≥ 0.95	0.997	Good Fit (Outstanding)
TLI (Tucker-Lewis Index)	≥ 0.95	0.996	Good Fit (Outstanding)
NFI (Normed Fit Index)	≥ 0.90	0.946	Good Fit
RMSEA (Root Mean Sq. Error)	≤ 0.08 (Close Fit ≤ 0.05)	0.016	Good Fit (Close Fit)
RMR (Root Mean Square Residual)	≤ 0.05	0.049	Good Fit

Source: IBM SPSS AMOS 22.0 structural output, 2026.

Hypothesis Testing Results

The structural path estimates, critical ratios (t-values), significance levels, and variance explained are presented in Table 5.

Table 5. Structural path coefficients and hypothesis testing summary

Structural Path / Hypothesis	Unstd. Est. (γ)	S.E.	Std. Est. (β)	C.R. (t-value)	p-value	Empirical Decision
H_1: Digital Leadership (X_1) → ICT Innovation (Y)	0.500	0.063	0.610	7.925	< 0.001 (***)	Supported (Sig. Positive)
H_2: Tech. Adaptability (X_2) → ICT Innovation (Y)	0.535	0.077	0.533	6.912	< 0.001 (***)	Supported (Sig. Positive)
Simultaneous Effect (H_3): Squared Multiple Correlations (R^2) = **0.637** (63.7% Variance Explained)						

DISCUSSION

Effect of Principals' Digital Leadership on ICT-Based Learning Innovation

The SEM analysis supported Hypothesis 1: principals' digital leadership had a positive and statistically significant effect on teachers' ICT-based learning innovation (γ = 0.500; C.R. = 7.925; p < 0.001). Its standardized path coefficient (β = 0.610) is the larger of the two in the model, although the difference between the two paths was not tested. The CFA loadings show that Visionary Leadership (X1.1, λ = 0.843) and Strategic Curriculum Alignment (X1.2, λ = 0.817) are the strongest indicators of this construct.

This finding is consistent with Sheninger's (2019) digital leadership framework and with previous studies by Timan et al. (2022), Sunu (2022), and Kasim and Surya (2025). A plausible mechanism is that principals who set a digital roadmap aligned with Kurikulum Merdeka, budget for digital infrastructure in the school plan (RKAS), and build a school-wide learning culture give teachers both the resources and the encouragement to try new practices. This reading is consistent with evidence that principals' leadership relates to teachers' innovative work behavior directly and through the school as a learning organization (Hidayat & Patras, 2022). Digital Citizenship (X1.4, λ = 0.601) contributed least to the construct, which may indicate that digital ethics, copyright, and cybersecurity receive less attention in primary classrooms than basic media skills.

The pattern also agrees with the review by Zeng et al. (2025), in which principals' digital leadership worked through resources, professional development, learning communities and culture rather than through technology alone. In this sample, the indicator loadings suggest that teachers see vision and curriculum alignment as the core of digital leadership. For principals in Sukolilo, a written digital plan linked to the curriculum, followed through in the school budget and in teachers' learning communities (Komunitas Belajar), is therefore a practical starting point. Because digital citizenship had the weakest loading, school programmes may also need explicit attention to safe, legal and ethical use of technology by teachers and pupils.

Effect of Principals' Technological Adaptability on ICT-Based Learning Innovation

Hypothesis 2 was supported: principals' technological adaptability had a statistically significant direct effect on ICT learning innovation (γ = 0.535; C.R. = 6.912; p < 0.001; β = 0.533). Indicator analysis indicates that Positive Attitudes toward Technological Change (X2.2, λ = 0.852) and Teacher Support and Facilitation (X2.4, λ = 0.846) are the strongest indicators of leadership adaptability. This result is consistent with the TAM framework (Davis, 1989) and suggests that a leader's positive perceptions of technological usefulness and ease of use may create a sense of psychological safety for teachers. Case studies of elementary schools describe related processes: teachers' adaptation to the Merdeka Belajar platform (Sutisna et al., 2024) and principals' efforts to encourage Chromebook use in learning (Tri Mulyani & Lestari Dwi, 2024). Technostress itself was not measured in this study. Challenge Resilience and Coping (X2.5, λ = 0.702) had the lowest loading, which may reflect cultural dynamics in rural Indonesian schools, where principals often avoid direct confrontation with senior staff regarding technological hesitation (Anam et al., 2025; Yulihartati & Veri, 2025).

The result extends the TAM evidence from teachers to their principals. A meta-analytic SEM found that teachers' perceived usefulness and attitudes are central to their own technology adoption (Scherer et al., 2019); here, teachers who saw their principal as open to change and supportive also reported more ICT-based innovation. The study measured teachers' perceptions of the principal, not the principal's own attitudes, so the path may partly reflect how teachers interpret the support they receive. Basic tech-savviness (X2.1, $\lambda = 0.743$) loaded lower than attitude toward change and teacher support. This suggests that coaching for principals should focus less on personal technical skill and more on facilitating teachers' experimentation and handling hesitation among senior staff, a challenge also noted in studies of uneven adaptation between younger and senior teachers (Afrillia & Dafit, 2025).

Simultaneous Synergistic Effect on ICT-Based Pedagogical Innovation

Hypothesis 3 was supported: digital leadership (X_1) and technological adaptability (X_2) jointly explain 63.7% of the variance in ICT-based learning innovation ($R^2 = 0.637$). The remaining 36.3% is attributable to factors outside the model, possibly including teachers' intrinsic self-efficacy, household internet access, and peer mentoring networks. Hardware was not measured, but the result is consistent with the view that procurement alone is unlikely to achieve digital transformation. One interpretation is that digital leadership provides institutional direction, governance, and resource allocation, whereas technological adaptability supplies the flexibility and problem-solving needed to deal with practical infrastructure problems. In elementary schools where teacher readiness varies, the combination of the two may help teachers move from using technology to replace existing tasks toward lessons that integrate technology, pedagogy and content, as the TPACK framework describes (Mishra & Koehler, 2006).

One result needs comment. The correlation between digital leadership and technological adaptability was close to zero ($r = -0.030$). Both constructs describe the same principals as rated by the same teachers, so a near-zero correlation is unexpected and should be checked against the raw data. If it holds, it means that teachers distinguish a principal's strategic digital vision from the principal's personal openness and support, and that the two attributes contribute separately to innovation. This near-independence is also why the two standardized paths (0.610 and 0.533) together yield a high R^2 of 0.637.

The study has limitations. The cross-sectional, ex post facto design supports statements about association only, and one teacher questionnaire measured all three constructs, which can inflate the relationships through common method variance (Podsakoff et al., 2003). The sample size is reported inconsistently: 230 respondents in the abstract and results, but 160 by the Slovin calculation in the Method. The AVE for ICT-based learning innovation (0.450) was below 0.50, although its composite reliability (0.765) was acceptable (Fornell & Larcker, 1981), so the outcome construct needs refinement. Data came from civil-servant teachers in one district, and teachers who share a principal are nested in schools, which a single-level model ignores. Future research could use multilevel models, add classroom observation or lesson-plan analysis of ICT use, test teacher self-efficacy and TPACK as mediators, and compare rural and urban districts.

CONCLUSION AND RECOMMENDATIONS

Conclusions

This study indicates that elementary school principals' digital leadership and technological adaptability are important predictors of teachers' ICT-based learning innovation. Digital leadership exerts a significant direct positive effect ($\gamma = 0.500$; $p < 0.001$), with visionary orientation and strategic curriculum alignment as its strongest indicators. Principals' technological adaptability similarly exhibits a significant positive effect ($\gamma = 0.535$; $p < 0.001$), with positive leadership attitudes toward change and proactive teacher facilitation as its strongest indicators. Together, both leadership constructs account for 63.7% of the variance in primary school ICT learning innovation.

Recommendations

(1) For School Principals: Formulate explicit digital transformation roadmaps within school annual plans (RKS/RKAS), establish peer-led School Learning Communities (Komunitas Belajar) to reduce technostress among senior teachers, and actively model digital application usage.

(2) For Elementary Teachers: Move from passive video streaming toward interactive TPACK practices, incorporating gamified assessments (e.g., Quizizz, Wordwall) and collaborative digital student projects.

(3) For Regional Education Authorities (Pati Regency Education and Culture Office): Shift professional development programs from basic technical literacy toward pedagogical integration and adaptive leadership coaching, while prioritizing stable rural network infrastructure.

(4) For Future Researchers: Expand the structural model with mediating variables such as teacher self-efficacy and organizational climate, and use mixed-method designs across a wider range of districts.

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REFERENCES

Afrillia, A., & Dafit, F. (2025). Tantangan guru mengimplementasikan pembelajaran berbasis teknologi digital dalam Kurikulum Merdeka di UPT SDN 023 Pandau Jaya. Pendas: Jurnal Ilmiah Pendidikan Dasar, 10(4), 230-242. https://doi.org/10.23969/jp.v10i04.36163

Agustiana, E., Ahsin, M. N., & Setiadi, G. (2022). *Analisis Proses Pembelajaran Daring Pada Masa Pandemi Covid-19 Di SDN Tondomulyo Jakenan*.

Anam, S., Habibi, N. S., Umbara, S., & Firdaus, T. (2025). *Kepemimpinan* sekolah di era digital: *Studi* kualitatif strategi kepala sekolah dalam mengelola perubahan. 5(2). https://jurnalp4i.com/index.php/manajerial

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319-340. https://doi.org/10.2307/249008

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research, 18(1), 39–50. https://doi.org/10.1177/002224378101800104

Fullan, M., Quinn, J., & McEachen, J. (2018). Deep learning: Engage the world, change the world. Corwin.

Hariyadi, A. (2025). *Manajemen dan Kepemimpinan Pendidikan*. Global Aksara Pers.

Hidayat, R., & Patras, Y. E. (2022). The effect of principals' leadership and learning organization on teachers' innovative work behavior during the COVID-19 pandemic. Tadris: Jurnal Keguruan dan Ilmu Tarbiyah, 7(1), 161-175. https://doi.org/10.24042/tadris.v7i1.11355

Kasim, M., & Surya, P. (2025). Dampak Kepemimpinan Digital Kepala Sekolah terhadap Integrasi Teknologi Guru di Sekolah Dasar. *Jurnal Pendidikan Dan Kebudayaan*, *10*(1), 1–18. https://doi.org/10.24832/jpnk.v10i1.5662

Kemendikbudristek. (2022). Keputusan Menteri Pendidikan, Kebudayaan, Riset, dan Teknologi Nomor 56/M/2022 tentang pedoman penerapan kurikulum dalam rangka pemulihan pembelajaran [Guidelines for implementing the curriculum for learning recovery]. Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi.

Marcel De Araujo, L., Priadana, S., Paramarta, V., & Sunarsi, D. (2021). Digital leadership in business organizations: an overview. In *International Journal of Educational Administration* (Vol. 2, Number 1).

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, *108*(6), 1017-1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal of Applied Psychology, 88(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Rahma Puteri, A., Nur Nasution, W., & Irwan Padli Nasution, M. (2025). Integrasi Teknologi Informasi dan Komunikasi dalam Pendidikan: Konsep, Perkembangan, dan Inovasi Media Pembelajaran. *Jurnal Pendidikan Indonesia*. https://doi.org/10.59818/jpi.v5i4.1760

Rogers, E. M. (1995). Diffusion of innovations (4th ed.). Free Press.

Saa, S. (2024). Merdeka Curriculum: Adaptation Of Indonesian Education Policy In The Digital Era And Global Challenges. *Revista de Gestao Social e Ambiental*, *18*(3). https://doi.org/10.24857/rgsa.v18n3-168

Scherer, R., Siddiq, F., & Tondeur, J. (2019). The technology acceptance model (TAM): A meta-analytic structural equation modeling approach to explaining teachers' adoption of digital technology in education. Computers & Education, 128, 13-35. https://doi.org/10.1016/j.compedu.2018.09.009

Sharma, G., Tripathi, L., & Khatri, E. (2024). A study of teachers' adaptability towards digital education system: An empirical study in higher education perspective. *Journal of Informatics Education and Research*, 4. http://jier.org

Sheninger, E. (2019). Digital leadership: Changing paradigms for changing times (2nd ed.). Corwin.

Sugiyono. (2013). *Metode* penelitian kuantitatif, kualitatif, *dan R&D* [Quantitative, qualitative, and R&D research methods]. Alfabeta.

Sunu, I. G. K. A. (2022). The Impact of Digital Leadership on Teachers' Acceptance and Use of Digital Technologies. *Mimbar Ilmu*, *27*(2), 311–320. https://doi.org/10.23887/mi.v27i2.52832

Sutisna, M. R., Sudarmansyah, R., Lisnawati, A., Asyahidah, N. L., Haifarashin, R., & Sormin, Y. (2024). Adaptasi guru terhadap penggunaan platform Merdeka Belajar (Penelitian studi kasus terhadap guru di SDN Cipaku 03 Kecamatan Paseh). *Jurnal Ilmiah Pendidikan Dasar*, 9(4).

Syafitri, N., Mulyadi, M., Sari, D. P., Sumardin, S., & Sabri, S. (2025). Kepemimpinan Digital sebagai Kunci Adaptasi Karyawan di Tengah Transformasi Teknologi. *MANABIS: Jurnal Manajemen Dan Bisnis*, *4*(2), 168–181. https://doi.org/10.54259/manabis.v4i2.4842

Timan, A., Mustiningsih, M., & Imron, A. (2022). Digital leadership kepala sekolah hubungannya dengan kinerja guru dan kompetensi siswa era abad 21. *Jurnal Administrasi* dan *Manajemen Pendidikan*, 5(4).

Tri Mulyani, E., & Lestari Dwi, S. (2024). *Kepemimpinan* kepala sekolah dalam mendorong integrasi *Chromebook* sebagai alat pembelajaran di sekolah dasar.

Wangdi, T., Dhendup, S., & Gyelmo, T. (2023). Factors Influencing Teachers' Intention to Use Technology: Role of TPACK and Facilitating Conditions. *International Journal of Instruction*, *16*(2), 1017–1036. https://doi.org/10.29333/iji.2023.16254a

Yulihartati, S., & Veri, J. (2025). Adaptasi Guru terhadap Revolusi Teknologi Pendidikan: Analisis Systematic Literature Review (SLR) tentang Kompetensi Digital di Era 5.0. *Jurnal Sains Dan Teknologi: Jurnal Keilmuan Dan Aplikasi Teknologi Industri*, *25*(1), 160–166. https://doi.org/10.36275/7txpjz24

Yusrina, M., Syakroni, A., Af'idah, I. N., & Alnashr, M. S. (*2023*). Kesiapan madrasah ibtidaiyah di Kabupaten Pati dalam implementasi Kurikulum Merdeka. *Research Journal* on *Teacher Professional Development*, *2023*(e).

Zeng, M., Cheah, K. S. L., & Abdullah, Z. (2025). The influence of school principals' digital leadership on teachers' competency in integrating artificial intelligence: A systematic thematic review. Frontiers in Education, 10, Article 1655967. https://doi.org/10.3389/feduc.2025.1655967

Zuhaira, A. (2025). Penerapan inovasi pembelajaran menggunakan media pembelajaran berbasis teknologi di UPT SD Negeri 15 Kampai. *Gudang Jurnal Pengabdian Masyarakat*, 3(1), 36–40. https://doi.org/10.59435/gjpm.v3i1.918

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

Principal Leadership and School Culture Predict Teachers' Technology Competence

Saifuddin Helmi[1*]

[1]*Master of Elementary Education, Faculty of Teacher Training and Education, Universitas Muria Kudus, Indonesia*

Corresponding author: athaullah07@gmail.com

ABSTRACT

This study examined whether principal leadership and school culture predict teachers' educational technology competence in the Mandiri Cluster of elementary schools in Sukolilo District, Indonesia. A quantitative correlational ex post facto design was used. The final analytic dataset comprised 85 teachers who completed 36 Likert-scale items measuring principal leadership, school culture, and educational technology competence; instrument validity and reliability were pilot-tested with 30 respondents. Data were analyzed in SPSS 27 using descriptive statistics, item-total correlations, Cronbach's alpha, residual normality testing, multiple linear regression, t tests, an F test, and the coefficient of determination. In the pilot test, all items were valid, and the three scales showed strong internal consistency (α = .914–.941). The residuals were normally distributed (Kolmogorov-Smirnov p = .068). Principal leadership positively predicted educational technology competence (B = .326, β = .362, t = 5.644, $p < .001$), while school culture showed a stronger positive contribution (B = .538, β = .618, t = 9.629, $p < .001$). The joint model was significant, $F(2, 82) = 165.038$, $p < .001$, and explained 80.1% of the outcome variance ($R^2 = .801$). The findings are consistent with transformational leadership, school culture, and TPACK-based perspectives: teachers' technology competence was higher where principals were perceived to provide direction and support and where collaborative learning norms were part of everyday school practice. Schools should combine leadership development, peer mentoring, practice-oriented professional learning, and sustained technical support to promote meaningful technology integration.

KEYWORDS educational technology competence | elementary school teachers | principal leadership | school culture | technology integration

INTRODUCTION

Digital technologies have become integral to curriculum delivery, assessment, communication, and access to learning resources. Their educational value, however, depends less on the mere presence of devices than on teachers' capacity to align technological tools with pedagogical purposes and subject content. International evidence therefore treats teacher digital competence as a multidimensional professional capability that combines technical fluency, pedagogical judgment, critical reflection, and context-sensitive decision making (Basilotta-Gómez-Pablos et al., 2022; Falloon, 2020; Pettersson, 2018). The rapid shift toward digitally mediated schooling also showed that technology adoption is embedded in institutional routines, support structures, and professional cultures rather than being solely an individual choice (Iivari et al., 2020; UNESCO, 2023).

Teachers may possess basic operational skills but still encounter difficulty selecting tools that deepen understanding, sustain student participation, or fit the learning objectives. The TPACK perspective explains this distinction by emphasizing the interaction of technological, pedagogical, and content knowledge (Mishra & Koehler, 2006). Empirical studies similarly show that technology use is associated with professional digital competence, self-efficacy, collegial collaboration, and contextual support (Hatlevik & Hatlevik, 2018; Lucas et al., 2021). Technology acceptance and classroom application are also influenced by teachers' perceived usefulness, confidence, and opportunities to practice (Scherer et al., 2019).

School-level leadership is one contextual factor that can convert digital initiatives into coherent instructional practice. Principals influence priorities, resource allocation, professional learning, experimentation, and the legitimacy of innovation. Transformational leadership is especially relevant because idealized influence, individualized consideration, inspirational motivation, and intellectual stimulation can encourage teachers to

accept change and develop new competencies (Bass & Avolio, 1994). Research on technology leadership has reported positive relationships between principals' strategic direction and teachers' integration of digital tools (A'mar & Eleyan, 2022; Dexter & Barton, 2021; Kasim & Surya, 2025). A review of 14 empirical studies concluded that principals' digital leadership supports teachers' technology use through resource allocation, professional development, learning communities and a positive school culture (Zeng et al., 2025).

Leadership operates within school culture. Shared values, norms, stories, expectations, and recurring practices shape how staff interpret policies and respond to uncertainty (Deal & Peterson, 2009). A culture that supports collaboration, inclusion, professional learning, and responsible experimentation can reduce the social risk of trying unfamiliar technologies. Conversely, rigid norms, fragmented work, and punitive responses to failure may discourage teachers from moving beyond routine uses. Indonesian studies have linked positive school culture and principal leadership with organizational learning, digital literacy, and instructional improvement (Asmaudin et al., 2024; Rahayuningsih & Iskandar, 2022). Experiences of online learning in elementary schools also indicate that teacher adaptation requires continuing support rather than one-time technical training (Agustiana et al., 2022).

Technology-enhanced learning in Indonesian elementary schools remains uneven. Digital resources can make learning more interactive and expand access to information, yet implementation is constrained by infrastructure, skill gaps, and limited organizational follow-up (Dewi, 2024). Studies on teachers' use of Chromebooks and digital learning tools further indicate variation in teachers' readiness and ability to connect technology with classroom practice (Mulyahati et al., 2025). Innovations such as gamification-based assessment illustrate the instructional potential of digital tools, but their effectiveness still depends on teacher competence and school-level support (Utaminingsih & Setiawaty, 2023).

The Mandiri Cluster of elementary schools in Sukolilo District provides a relevant context for examining these organizational influences. The author's preliminary thesis research identified variation in teachers' educational technology competence and proposed principal leadership and school culture as two predictors. Previous studies often examine digital leadership, organizational culture, or teacher competence separately. Indonesian studies that model principal leadership and school culture together have used teacher performance (Ardliana et al., 2021, in Pati Regency) or job satisfaction (Nurhadidjah et al., 2023) as the outcome rather than technology competence. This study integrates the two school-level predictors in one regression model and compares their relative contributions. The analysis addresses a practical question for elementary education: whether leadership direction and the everyday culture of the school jointly explain teachers' capacity to use technology in educationally meaningful ways.

LITERATURE REVIEW

The first construct is principal leadership, operationalized through the four dimensions of transformational leadership: idealized influence, individualized consideration, inspirational motivation, and intellectual stimulation. Idealized influence can build trust in the school's direction; individualized consideration responds to differences in teachers' readiness; inspirational motivation connects technology use with shared educational goals; and intellectual stimulation encourages teachers to question routines and experiment with new approaches (Bass & Avolio, 1994). These mechanisms are consistent with studies showing that school technology leadership supports professional learning, coordinated implementation, and classroom use (A'mar & Eleyan, 2022; Dexter & Barton, 2021).

The second construct is school culture, represented by discipline, openness and inclusion, ethics and integrity, student empowerment, and learning culture. School culture functions as a social system that stabilizes expectations and patterns of interaction (Deal & Peterson, 2009). Discipline supports consistency, openness facilitates help-seeking and exchange, integrity guides responsible digital practice, student empowerment encourages participatory learning, and a learning culture normalizes professional improvement. These dimensions can make technology integration a collective practice rather than an isolated activity.

The outcome construct is educational technology competence. The instrument reflects teachers' technological knowledge, pedagogical knowledge, and content-related use of technology. This operationalization is informed by

TPACK, which argues that meaningful integration requires teachers to understand not only tools but also how tools interact with teaching methods and subject matter (Mishra & Koehler, 2006). The instrument captures foundational domains and does not separately measure every intersecting TPACK domain. The outcome is therefore interpreted as competence supporting technology integration rather than a complete diagnostic measure of TPACK.

Figure 1 presents the predictive model. The model proposes that principal leadership and school culture each contribute positively to educational technology competence. It also assumes that leadership and culture are complementary: leadership establishes direction and support, while culture embeds those expectations in recurring professional practice.

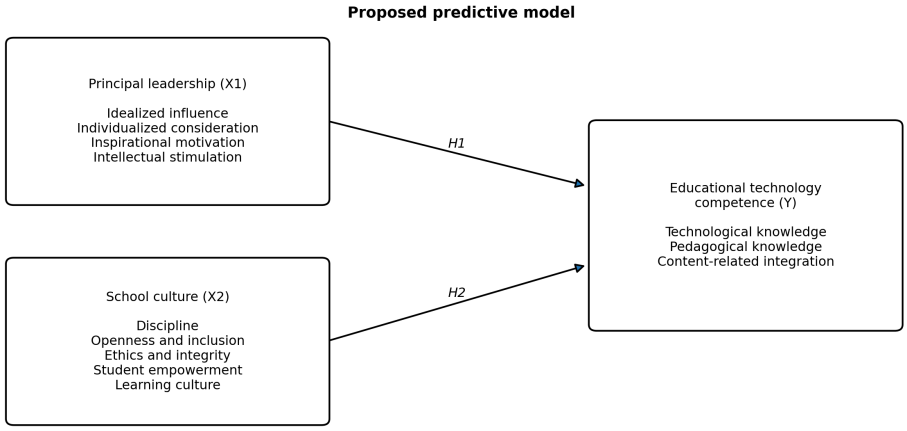

Figure 1. Conceptual model of the study

Source: Developed from Bass and Avolio (1994), Deal and Peterson (2009), and Mishra and Koehler (2006).

Research Objectives

This study aimed to: (1) examine the effect of principal leadership on teachers' educational technology competence; (2) examine the effect of school culture on teachers' educational technology competence; and (3) determine the simultaneous contribution of principal leadership and school culture to teachers' educational technology competence in the Mandiri Cluster of elementary schools in Sukolilo District.

RESEARCH METHOD

Research Design

The study used a quantitative correlational ex post facto design. The design was appropriate because the variables were observed as they occurred in the school setting without experimental manipulation. Multiple linear regression was used to estimate the predictive contribution of principal leadership and school culture to educational technology competence. Accordingly, the term effect in this article refers to a statistically significant predictive association and not to experimental causality.

Participants and Setting

The study was conducted in the Mandiri Cluster of elementary schools in Sukolilo District, Pati Regency, Indonesia. The population frame consisted of 98 teachers from ten schools. The research plan specified proportional random sampling. The final analytic dataset contained 85 complete teacher responses, and all descriptive and inferential results reported in this article are based on N = 85. Instrument pilot testing was conducted separately with 30 respondents.

Instrument and Data Collection

Data were collected through a closed-ended questionnaire using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The principal leadership scale contained 12 items across four transformational leadership dimensions. The school culture scale contained 15 items across five dimensions. Educational technology competence was measured with nine items addressing technological operation, pedagogical use, and the selection of technology in relation to learning content. The 36-item instrument was administered to teachers after the pilot test.

Table 1. Constructs, indicators, and measurement quality

Construct	Indicators	Items	Item-total r	Cronbach's α
Principal leadership	Idealized influence; individualized consideration; inspirational motivation; intellectual stimulation	12	.645–.825	.934
School culture	Discipline; openness and inclusion; ethics and integrity; student empowerment; learning culture	15	.459–.793	.914
Educational technology competence	Technological knowledge; pedagogical knowledge; content-related technology integration	9	.640–.922	.941

Source: Pilot-test output, N = 30.

Data Analysis

Data analysis was performed using SPSS version 27. Item validity was evaluated through item-total correlations against r = .361 at α = .05 for the 30-person pilot sample. Internal consistency was evaluated with Cronbach's alpha using the .60 threshold specified in the research method. The main analysis included descriptive statistics, a one-sample Kolmogorov-Smirnov test of unstandardized residuals, multiple linear regression using the Enter method, partial t tests, a simultaneous F test, and the coefficient of determination. Statistical significance was evaluated at $p < .05$.

RESULTS

Descriptive Results and Measurement Adequacy

In the pilot test (N = 30), all questionnaire items exceeded the validity criterion, and Cronbach's alpha values ranged from .914 to .941 (Table 1), indicating high internal consistency. The strength of the reliability coefficients suggests that the items within each scale were coherently related. High reliability does not by itself establish construct completeness, but it supports the use of the composite scores in the regression analysis.

Table 2. Descriptive statistics of the study variables

Variable	N	Mean total	Mean/item	Minimum	Maximum
Principal leadership	85	39.21	3.27	32	49
School culture	85	51.74	3.45	44	60
Educational technology competence	85	31.08	3.45	22	39

Source: Author's analysis of SPSS output, 2026.

The mean per item for principal leadership was 3.27, while school culture and educational technology competence both averaged 3.45 per item. These scores indicate moderately favorable perceptions and leave room for improvement. The observed ranges show meaningful differences among teachers, which provides sufficient variation for predictive analysis. The unstandardized residuals met the normality assumption, with a Kolmogorov-Smirnov statistic of .093 and p = .068; the Monte Carlo estimate was p = .070.

Principal Leadership and Educational Technology Competence

Principal leadership had a positive and significant coefficient (B = .326, β = .362, t = 5.644, p < .001). With school culture held constant, a one-point increase in the principal leadership score was associated with a .326-point increase in educational technology competence. The result supports the first hypothesis and indicates that leadership remains a significant predictor even when the cultural environment is included in the same model.

School Culture and Educational Technology Competence

School culture had a positive and significant coefficient (B = .538, β = .618, t = 9.629, p < .001). Its standardized contribution was larger than that of principal leadership. The second hypothesis was therefore supported, and school culture had the larger standardized coefficient within the two-variable model.

Simultaneous Contribution of Leadership and Culture

Table 3. Multiple regression and hypothesis-testing results

Predictor / model	B	SE	β	t / F	p
Constant	-9.538	2.265	—	-4.210	< .001
Principal leadership	.326	.058	.362	5.644	< .001
School culture	.538	.056	.618	9.629	< .001
Overall model: R = .895; R^2 = .801; adjusted R^2 = .796	—	SEE = 1.990	—	F(2, 82) = 165.038	< .001

Source: Author's analysis of SPSS output, 2026.

The overall model was statistically significant, F(2, 82) = 165.038, p < .001, with R = .895 and R^2 = .801. Principal leadership and school culture jointly explained 80.1% of the variance in educational technology competence, while 19.9% remained associated with factors outside the model. The fitted equation was $Y = -9.538 + .326X_1 + .538X_2$. The negative intercept is a mathematical feature of the fitted line and has no substantive interpretation because zero lies outside the observed scale ranges.

DISCUSSION

The first finding is that principal leadership predicted teachers' educational technology competence with school culture held constant (B = .326, β = .362, p < .001). This is consistent with transformational leadership theory. Idealized influence gives credibility to a digital learning vision, individualized consideration addresses uneven teacher readiness, inspirational motivation helps teachers view technology as part of instructional improvement, and intellectual stimulation legitimizes experimentation (Bass & Avolio, 1994). The positive coefficient may therefore reflect more than administrative direction, namely the role of leadership in creating psychological and organizational conditions for professional learning.

This interpretation agrees with research showing that principals' technology leadership is associated with teacher technology integration (A'mar & Eleyan, 2022; Kasim & Surya, 2025). Team-based and distributed technology leadership can also build implementation capacity beyond the principal's individual actions (Dexter & Barton, 2021). In the Indonesian elementary-school context, the use of school performance information for reflection and instructional improvement similarly illustrates how leadership can organize teacher learning around evidence (Asmaudin et al., 2024). A similar link has been reported on a larger scale: in a survey of 1,200 Indonesian teachers, principals' leadership affected innovative work behavior both directly and through the school as a learning organization (Hidayat & Patras, 2022).

The standardized coefficient of .362 indicates a meaningful but not dominant contribution. Leadership can establish priorities, allocate time, facilitate training, and recognize innovation, yet teachers also need peer interaction, infrastructure, practice, and technical support. Leadership that merely requests digital outputs without mentoring or follow-up may generate administrative compliance rather than pedagogically meaningful integration. Professional development should therefore be accompanied by coaching, opportunities for classroom application, and ongoing review.

The second finding is that school culture had the larger standardized coefficient (B = .538, β = .618, p < .001). This result supports the view of Deal and Peterson (2009) that school culture is a network of shared values, norms, traditions, symbols, and practices that shapes how staff think and act. The five measured dimensions suggest possible mechanisms. Discipline can sustain agreed programs; openness and inclusion facilitate help-seeking; ethics and integrity guide responsible technology use; student empowerment encourages participatory learning; and learning culture makes competence development a shared expectation. Because these patterns are experienced repeatedly, culture can normalize experimentation or, conversely, make teachers reluctant to disclose difficulty and seek assistance.

The finding is compatible with evidence that collegial collaboration and contextual support are associated with teachers' digital practice (Hatlevik & Hatlevik, 2018; Lucas et al., 2021). It also aligns with Indonesian research emphasizing the role of positive school culture and digital literacy in educational change (Rahayuningsih & Iskandar, 2022). Other work suggests that technology implementation benefits from organizational learning and sustained professional support (Entriza & Puspitasari, 2025; Hidayat & Patras, 2022). Indonesian studies of other teacher outcomes show a comparable pattern. In Pati Regency, principal leadership and school culture each had a direct effect on teacher performance (Ardliana et al., 2021). In Sukabumi, principals' transformational leadership (r = .694) and school organizational culture (r = .620) each correlated with elementary teachers' job satisfaction (Nurhadidjah et al., 2023). The present study extends this pattern to technology competence, where culture had the larger coefficient.

The stronger beta for culture should be interpreted cautiously. It does not mean that the principal is unimportant, because leaders help shape and maintain culture. Rather, it indicates that everyday norms and interactions were more closely associated with teachers' competence in this sample. A formal digital policy is more likely to be sustained when teachers routinely share resources, discuss pedagogical problems, learn from errors, and connect tools with students' needs. School improvement should therefore target both formal leadership practices and the informal professional environment.

Together, the two predictors explained 80.1% of the variance in educational technology competence (R^2 = .801; adjusted R^2 = .796). The high explained variance supports an organizational interpretation of teacher technology competence. Transformational leadership supplies direction, encouragement, individualized support, and intellectual stimulation (Bass & Avolio, 1994). School culture converts these signals into collective expectations and recurring professional behavior (Deal & Peterson, 2009). Teachers then develop the capacity to connect technology, pedagogy, and content through practice and reflection, as proposed by TPACK (Mishra & Koehler, 2006). The two predictors may therefore work in complementary ways. The explained variance is higher than the 54% of teacher job satisfaction that leadership and culture jointly explained in Nurhadidjah et al. (2023), and it is unusually high for two self-reported predictors. Part of it may reflect overlap between the two predictors and shared method variance, which are discussed with the limitations below.

The results are also consistent with broader research showing that teacher digital competence is shaped by personal and contextual variables (Dogan et al., 2021; Falloon, 2020; Instefjord & Munthe, 2017; Pettersson, 2018). Technology adoption is not guaranteed by access alone. Teachers require confidence, relevant professional learning, collegial exchange, and opportunities to adapt tools to curriculum needs (Ertmer & Ottenbreit-Leftwich, 2010; Scherer et al., 2019). Experiences during emergency remote teaching further showed that teachers' readiness and institutional capacity influence the quality of technology-mediated instruction (König et al., 2020; Trust & Whalen, 2020).

Several implications follow. First, principal development should combine digital vision with instructional leadership, mentoring, and resource coordination. Second, schools should institutionalize peer coaching, demonstration lessons, shared repositories, and reflective meetings so that digital learning becomes part of professional culture. Third, training should be practice-oriented and connected to specific content, teaching strategies, assessment, inclusion, and student participation. Fourth, schools should provide accessible technical support and attend to ethical use, data protection, and equitable access. In the Mandiri Cluster, the cluster structure itself offers a practical channel: teacher working groups at cluster level could host peer coaching and

demonstration lessons across the participating schools. These recommendations are consistent with international calls to evaluate technology according to educational purpose and local conditions rather than novelty alone (UNESCO, 2023).

The remaining 19.9% of variance may involve infrastructure, internet access, prior technical skill, professional-development history, teaching experience, self-efficacy, attitudes toward technology, and technical support. The correlational ex post facto design does not establish experimental causation. The self-report instrument may also be affected by perception and social desirability. In addition, the outcome scale did not separately measure all intersecting components of TPACK. The reliability coefficients come from the pilot sample rather than the main sample. The correlation between leadership and culture and collinearity diagnostics (VIF, tolerance) were not reported. Because all three variables were rated by the same teachers at one time point, common method variance may have inflated the explained variance (Podsakoff et al., 2003). Teachers were also nested in schools, which a single-level regression does not take into account, and the way the analysed responses were drawn from the population frame is not fully described. Future research should use larger multi-site samples, observation or performance tasks, and models that incorporate infrastructure, digital self-efficacy, and professional learning.

CONCLUSION AND RECOMMENDATIONS

Principal leadership and school culture were significant positive predictors of teachers' educational technology competence in the Mandiri Cluster of elementary schools. Principal leadership contributed independently, suggesting that teachers benefit when school leaders provide a credible direction, individualized support, motivation, and encouragement to innovate. School culture made the stronger relative contribution, suggesting that daily norms of discipline, openness, integrity, empowerment, and continuous learning are important for sustained technology integration.

Together, the predictors explained 80.1% of the variance in educational technology competence. The result supports the integration of transformational leadership, school culture, and TPACK-based perspectives. In this view, leadership initiates and coordinates change; culture embeds change in collective practice; and teacher competence develops when technology is continually related to pedagogy and content.

Schools are recommended to develop a shared digital-learning vision, map teachers' needs, provide practice-based professional learning, establish peer mentoring and communities of practice, recognize responsible innovation, and ensure continuing technical support. Technology use should be evaluated according to its contribution to learning objectives, subject understanding, student participation, inclusion, and ethical practice. Further studies should examine additional predictors and use longitudinal or mixed-method designs to clarify how leadership and culture influence competence development over time.

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REFERENCES

A'mar, F., & Eleyan, D. (2022). Effect of principal's technology leadership on teacher's technology integration. *International Journal of Instruction*, *15*(1), 781–798. https://doi.org/10.29333/iji.2022.15145a

Agustiana, E., Ahsin, M. N., & Setiadi, G. (2022). Analisis proses pembelajaran daring pada masa pandemi COVID-19 di SDN Tondomulyo Jakenan [Analysis of online learning during the COVID-19 pandemic at SDN Tondomulyo Jakenan]. *WASIS: Jurnal Ilmiah Pendidikan*, *3*(2), 95–100. https://doi.org/10.24176/wasis.v3i2.8374

Ardliana, B., Rusdarti, R., & Suminar, T. (2021). Effect of principal leadership, school culture and pedagogic competence through work motivation on teachers performance. Educational Management, 10(2), 273–283.

Asmaudin, A., Fajrie, N., & Fathurohman, I. (2024). Pemanfaatan Rapor Pendidikan dalam upaya kepala sekolah meningkatkan kualitas pembelajaran melalui refleksi dan perbaikan pembelajaran oleh guru di sekolah dasar [Using the Education Report to improve learning quality through teacher reflection and instructional improvement]. *Journal Prakarsa Paedagogia, 7*(2). https://doi.org/10.24176/jpp.v7i2.12945

Bass, B. M., & Avolio, B. J. (1994). *Improving organizational effectiveness through transformational leadership*. SAGE.

Basilotta-Gómez-Pablos, V., Matarranz, M., Casado-Aranda, L.-A., & Otto, A. (2022). Teachers' digital competencies in higher education: A systematic literature review. *International Journal of Educational Technology in Higher Education, 19*, Article 8. https://doi.org/10.1186/s41239-021-00312-8

Deal, T. E., & Peterson, K. D. (2009). *Shaping school culture: Pitfalls, paradoxes, and promises* (2nd ed.). Jossey-Bass.

Dewi, A. C. (2024). Peran teknologi dalam meningkatkan kualitas pembelajaran di era digital [The role of technology in improving learning quality in the digital era]. *Jurnal Riset Guru Indonesia, 3*(3), 165–170. https://doi.org/10.62388/jrgi.v3i3.473

Dexter, S., & Barton, E. A. (2021). The development and impact of team-based school technology leadership. *Journal of Educational Administration, 59*(3), 367–384. https://doi.org/10.1108/JEA-12-2020-0260

Dogan, S., Dogan, N. A., & Celik, I. (2021). Teachers' skills to integrate technology in education: Two path models explaining instructional and application software use. *Education and Information Technologies, 26*, 1311–1332. https://doi.org/10.1007/s10639-020-10310-4

Entriza, A. N., & Puspitasari, F. F. (2025). Studi literatur: Integrasi teknologi informasi dalam pelatihan guru sebagai upaya meningkatkan kualitas pembelajaran [Information technology integration in teacher training: A literature review]. *Al-Idarah: Jurnal Kependidikan Islam, 15*(1), 62–73.

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. Journal of Research on Technology in Education, 42(3), 255-284.

Falloon, G. (2020). From digital literacy to digital competence: The teacher digital competency framework. *Educational Technology Research and Development, 68*(5), 2449–2472. https://doi.org/10.1007/s11423-020-09767-4

Hatlevik, O. E., & Hatlevik, I. K. R. (2018). Examining the relationship between teachers' ICT self-efficacy for educational purposes, collegial collaboration, lack of facilitation and the use of ICT in teaching practice. *Frontiers in Psychology, 9*, Article 935. https://doi.org/10.3389/fpsyg.2018.00935

Hidayat, R., & Patras, Y. E. (2022). The effect of principals' leadership and learning organization on teachers' innovative work behavior during the COVID-19 pandemic. Tadris: Jurnal Keguruan dan Ilmu Tarbiyah, 7(1), 161-175. https://doi.org/10.24042/tadris.v7i1.11355

Instefjord, E. J., & Munthe, E. (2017). Educating digitally competent teachers: A study of integration of professional digital competence in teacher education. *Teaching and Teacher Education, 67*, 37–45. https://doi.org/10.1016/j.tate.2017.05.016

Iivari, N., Sharma, S., & Ventä-Olkkonen, L. (2020). Digital transformation of everyday life—How the COVID-19 pandemic transformed the basic education of the young generation and why information management research should care. *International Journal of Information Management, 55*, 102183. https://doi.org/10.1016/j.ijinfomgt.2020.102183

Kasim, M., & Surya, P. (2025). Dampak kepemimpinan digital kepala sekolah terhadap integrasi teknologi guru di sekolah dasar [The impact of principals' digital leadership on teachers' technology integration in elementary schools]. *Jurnal Pendidikan dan Kebudayaan, 10*(1), 1–18. https://doi.org/10.24832/jpnk.v10i1.5662

König, J., Jäger-Biela, D. J., & Glutsch, N. (2020). Adapting to online teaching during COVID-19 school closure: Teacher education and teacher competence effects among early career teachers in Germany. *European Journal of Teacher Education, 43*(4), 608–622. https://doi.org/10.1080/02619768.2020.1809650

Lucas, M., Bem-Haja, P., Siddiq, F., Moreira, A., & Redecker, C. (2021). The relation between in-service teachers' digital competence and personal and contextual factors: What matters most? *Computers & Education, 160*, 104052. https://doi.org/10.1016/j.compedu.2020.104052

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x

Mulyahati, B., Ayudia, I., Juliati, J., & Fransyaigu, R. (2025). Profil kemampuan guru sekolah dasar dalam penggunaan Chromebook di Kota Langsa [Elementary teachers' competence in using Chromebooks in Langsa City]. *Innovative: Journal of Social Science Research, 5*(2), 999–1008.

Nurhadidjah, A., Rusti, E. R., & Hidayat, Z. (2023). Hubungan gaya kepemimpinan transformasional kepala sekolah dan budaya organisasi sekolah dengan kepuasan kerja guru SD di Kecamatan Cidahu. Journal of Contemporary Issue in Elementary Education, 1(1), 62–71. https://doi.org/10.33830/jciee.v1i1.5111

Pettersson, F. (2018). On the issues of digital competence in educational contexts—A review of literature. *Education and Information Technologies, 23*, 1005–1021. https://doi.org/10.1007/s10639-017-9649-3

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal of Applied Psychology, 88(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Rahayuningsih, Y. S., & Iskandar, S. (2022). Kepemimpinan kepala sekolah dalam menciptakan budaya sekolah yang positif di era Revolusi Industri 4.0 [Principal leadership in creating a positive school culture in the Industry 4.0 era]. *Jurnal Basicedu, 6*(5), 7850–7857. https://doi.org/10.31004/basicedu.v6i5.3626

Scherer, R., Siddiq, F., & Tondeur, J. (2019). The technology acceptance model: A meta-analytic structural equation modeling approach to explaining teachers' adoption of digital technology in education. *Computers & Education, 128*, 13–35. https://doi.org/10.1016/j.compedu.2018.09.009

Trust, T., & Whalen, J. (2020). Should teachers be trained in emergency remote teaching? Lessons learned from the COVID-19 pandemic. *Journal of Technology and Teacher Education, 28*(2), 189–199.

UNESCO. (2023). *Global education monitoring report 2023: Technology in education—A tool on whose terms?* UNESCO.

Utaminingsih, S., & Setiawaty, R. (2023). Evaluasi pembelajaran dengan Plickers berbasis gamifikasi: Literature review [Learning evaluation using gamification-based Plickers: A literature review]. *Journal Prakarsa Paedagogia, 6*(2), 826–834. https://doi.org/10.24176/jpp.v6i2.11224

Zeng, M., Cheah, K. S. L., & Abdullah, Z. (2025). The influence of school principals' digital leadership on teachers' competency in integrating artificial intelligence: A systematic thematic review. Frontiers in Education, 10, Article 1655967. https://doi.org/10.3389/feduc.2025.1655967

ICISFS-UMK 2026 EDUCATIONAL TECHNOLOGY & MEDIA

The Development of a Problem-Based Learning E-Module on Plane Geometry to Enhance Mathematics Learning Outcomes of Fourth-Grade Elementary School Students

Isnah Hidayati[1*], Henry Suryo Bintoro[1] and Sri Utaminingsih[1]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: 202303069@std.umk.ac.id

ABSTRACT

This study aimed to develop a Problem-Based Learning (PBL)-based e-module for teaching plane geometry to fourth-grade elementary school students and to evaluate its validity, practicality, and effectiveness in improving mathematics learning outcomes. The study employed a Research and Development (R&D) approach using the ADDIE model, which consists of Analysis, Design, Development, Implementation, and Evaluation. The participants included 25 fourth-grade students from SD Negeri 1 Panggang, Jepara, as the experimental group and 20 fourth-grade students from SD Negeri 5 Panggang, Jepara, as the control group. Data were collected through expert validation sheets, teacher and student response questionnaires, observation, documentation, and learning achievement tests. The developed e-module was designed as an interactive digital flipbook integrating the syntax of Problem-Based Learning, multimedia resources, problem-based worksheets, formative assessments, and interactive learning activities. Expert validation gave an average validity score of 91%, which falls into the very valid category. Teacher and student responses gave an average practicality score of 91%, which falls into the very practical category. In the effectiveness test, the experimental group's posttest scores were significantly higher than those of the control group ($p < 0.001$), and the N-gain score of 0.7614 falls into the high category. These findings indicate that the PBL-based e-module is valid and practical and that it was effective in this setting, as shown by the higher posttest scores and the high N-gain. It can therefore serve as a digital learning resource for mathematics instruction in elementary schools.

KEYWORDS digital learning | elementary mathematics | e-module | learning outcomes | problem-based learning

INTRODUCTION

Advances in digital technology have transformed educational practice and encouraged the integration of technology into teaching and learning. In the digital era, teachers are expected both to deliver knowledge and to facilitate meaningful learning by developing students' digital literacy, critical thinking, creativity, and problem-solving skills. This transformation is in line with the implementation of the Merdeka Curriculum, which emphasizes student-centered learning and the effective use of digital learning resources to improve learning quality *(Sadriani et al., 2023; Salsabila et al., 2024)* .

Mathematics is one of the fundamental subjects in elementary education because it develops logical reasoning, analytical thinking, and problem-solving abilities that are essential for students' daily lives. However, mathematics is often perceived as a difficult subject, particularly when students are required to understand abstract concepts such as plane geometry. Many elementary school students have difficulty identifying geometric shapes, describing their characteristics, and applying geometric concepts to solve contextual problems. These challenges are frequently associated with teacher-centered instructional practices and the limited availability of innovative learning media *(Mashuri, 2019;* Safari & Nurhida, 2024). The problem is visible in assessment data: Indonesia's mathematics results in PISA 2022 remained well below the OECD average (OECD, 2023), and a case study of a fourth-grade student's work on AKM numeracy geometry items found low ability to solve them (17.65%; Sari et al., 2021).

The use of digital learning media provides opportunities to create more engaging and meaningful learning experiences. Compared with conventional printed teaching materials, electronic modules (e-modules) can

integrate text, images, videos, animations, hyperlinks, and interactive exercises into a single digital learning resource. Such features can support independent learning, increase students' motivation, and aid conceptual understanding through multimedia presentation. Sunaryo et al. (2022) reported that Flip PDF-based e-modules significantly improved elementary students' mathematics learning outcomes by providing interactive and accessible learning resources. The development of interactive e-modules has therefore become an important strategy for improving mathematics learning in elementary schools (Azkiya et al., 2022; Lastri, 2023) .

To make digital learning media more effective, an appropriate instructional model should be built into the learning process. Problem-Based Learning (PBL) is a student-centered instructional model that encourages learners to construct knowledge through authentic problems, collaborative discussions, investigation, and reflection. A meta-analysis of Indonesian elementary studies reported a large mean effect of PBL on critical thinking (ES = 1.065; Setyowati & Sutikno, 2024), and a review of 20 studies concluded that PBL consistently improves elementary students' academic performance (Ningrum, 2025). When PBL is built into a digital e-module, a problem-based interactive flipbook improved junior high school science outcomes with an N-gain of 0.70 (Kharomah et al., 2024). In mathematics, Bintoro et al. (2021) designed an ethnomathematics mobile module to facilitate students' mathematical thinking ability.

Preliminary observations conducted in fourth-grade elementary schools in Jepara Regency indicated that mathematics learning was still dominated by textbook-based instruction and teacher explanations. Interactive digital learning resources designed for plane geometry were rarely used, and student engagement and learning outcomes were low. These conditions indicate the need for a learning medium that combines digital technology with an effective instructional model to support meaningful mathematics learning.

Several gaps remain. Many e-module studies in Indonesian elementary schools report expert validity and user practicality but test effectiveness with a single group only (Firman et al., 2024), and PBL e-modules evaluated against learning outcomes have mostly been developed for science or for secondary school (Kharomah et al., 2024). For plane geometry in grade 4, an earlier geoboard medium was evaluated with a limited trial against the minimum mastery criterion rather than a comparison class (Aflia et al., 2020). A PBL-based e-module on plane geometry for fourth graders, tested against a class taught with conventional materials, has not yet been reported for the Jepara schools where the problem was observed.

Therefore, this study aimed to develop a Problem-Based Learning (PBL)-based e-module on plane geometry for fourth-grade elementary school students using the ADDIE instructional design model (Branch, 2009). The study further evaluated the validity, practicality, and effectiveness of the developed e-module in improving students' mathematics learning outcomes. The findings are expected to inform the development of digital learning media and to provide practical recommendations for elementary school teachers in implementing technology-supported mathematics instruction. The study thus contributes an e-module on a topic where fourth graders often struggle, together with validity, practicality and comparison-class evidence that teachers and schools can use when they choose digital materials.

LITERATURE REVIEW

This study is grounded in constructivist learning theory, which emphasizes that students actively construct knowledge through meaningful learning experiences rather than passively receiving information from teachers. In mathematics education, meaningful learning can be achieved by engaging students in authentic problem-solving activities that encourage exploration, reasoning, collaboration, and reflection. The Problem-Based Learning (PBL) model was therefore adopted because it promotes student-centered learning and can improve critical thinking and problem-solving skills *(Huda, 2013*; Risandy et al., 2023; Setyowati & Sutikno, 2024).

An electronic module (e-module) is an interactive digital learning resource that integrates text, images, animations, videos, hyperlinks, and self-assessment activities into a single learning platform. Compared with conventional printed teaching materials, e-modules provide greater flexibility for independent learning and enable students to access learning resources anytime and anywhere. Integrating the PBL approach into an e-module

allows students to learn mathematical concepts through contextual problems while using multimedia features that can increase motivation and engagement *(Lastri, 2023*; *Azkiya et al., 2022; Huda et al., 2022).*

The development of the e-module in this study followed the ADDIE instructional design model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model provides a systematic framework for designing, developing, validating, implementing, and evaluating instructional products to ensure their quality and effectiveness. The quality of the e-module was evaluated against three criteria: validity, practicality, and effectiveness in improving students' mathematics learning outcomes (Branch, 2009; Rahayu et al., 2024).

Based on this conceptual framework, it is assumed that a valid and practical PBL-based e-module can create a more interactive and meaningful learning environment that encourages active student participation and enhances conceptual understanding of plane geometry. Consequently, students who learn using the developed e-module are expected to achieve better mathematics learning outcomes than those who learn through conventional instructional materials.

Research Objectives

The objectives of this study were to develop a Problem-Based Learning (PBL)-based e-module for teaching plane geometry to fourth-grade elementary school students and to evaluate the quality of the developed product. Specifically, this study aimed to: (1) determine the validity of the developed e-module through expert validation, (2) examine its practicality based on teachers' and students' responses, and (3) evaluate its effectiveness in improving the mathematics learning outcomes of fourth-grade elementary school students.

RESEARCH METHOD

Research Design

This study employed a Research and Development (R&D) approach to develop a Problem-Based Learning (PBL)-based e-module for teaching plane geometry to fourth-grade elementary school students. Research and Development is a systematic research method aimed at developing, validating, and evaluating educational products to improve learning quality (*Gall* et al., 2007).

The development process adopted the ADDIE instructional design model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model provides a systematic framework for designing instructional products that are effective, efficient, and aligned with learners' needs.

During the analysis stage, students' learning needs, curriculum requirements, and existing learning problems were identified through classroom observations, interviews, and document analysis *(Sugiyono*, 2022). The design stage focused on planning the learning objectives, instructional content, Problem-Based Learning activities, assessment strategies, and multimedia components of the e-module. The development stage involved producing the e-module and having it validated by subject matter, media, and language experts to ensure its content validity and media quality (Branch, 2009).

After revisions based on expert feedback, the e-module was implemented in classroom learning during the implementation stage. Finally, the evaluation stage was conducted to examine the quality of the developed product based on its validity, practicality**,** and effectiveness in improving students' mathematics learning outcomes (Sugiyono, 2022).

Respondents of the Study

The respondents of this study were fourth-grade students from three public elementary schools in Jepara Regency, Central Java, Indonesia. A limited trial of the developed e-module was conducted with fourth-grade students at SD Negeri 6 Panggang to obtain initial feedback on the usability and practicality of the product. The field implementation involved 25 fourth-grade students from SD Negeri 1 Panggang as the experimental group and 20 fourth-grade students from SD Negeri 5 Panggang as the control group. In addition to the student participants, the developed e-module was evaluated by experts in mathematics education, instructional media, and language to assess its validity before classroom implementation. The respondents were selected using purposive sampling based on the objectives of the study and the schools' readiness to implement digital learning media.

RESULTS

This section presents the findings obtained from the development and evaluation of the Problem-Based Learning (PBL)-based e-module on plane geometry for fourth-grade elementary school students. The findings are organized into three aspects: validity, practicality, and effectiveness of the developed e-module. The results are reported first and then discussed and compared with previous studies.

Validity of the Developed E-Module

The validity of the developed e-module was evaluated by three experts: a material expert, a media expert, and a language expert. The validation aimed to determine the appropriateness of the content, instructional design, and language before the product was implemented in classroom learning. The results of the expert validation are presented in Table 1.

Table 1. Expert validation results

Validator	Score (%)	Category
Material Expert	91 %	Very Valid
Media Expert	91 %	Very Valid
Language Expert	92 %	Very Valid
Average	91 %	Very Valid

The validation results indicate that the developed e-module achieved an average score of 91%, which falls into the very valid category. The material was considered appropriate for the learning objectives, while the media design and language were suitable for fourth-grade elementary school students. The validators also suggested minor revisions, including improving navigation buttons, correcting typographical errors, and standardizing the use of foreign terms. These revisions were incorporated before the classroom implementation.

Practicality of the Developed E-Module

The practicality of the developed e-module was evaluated through teacher and student response questionnaires after the implementation stage. The questionnaire assessed the ease of use, attractiveness, clarity of the learning materials, and usefulness of the e-module during classroom learning. The results are presented in Table 2.

Table 2. Practicality results (teacher and student responses)

Respondents	Score (%)	Category
Teacher and Students	91 %	Very Practical

The results show that the developed e-module obtained an average practicality score of 91%, indicating that it is very practical for classroom use. Both teachers and students responded positively to the interactive digital flipbook, particularly its multimedia content, problem-based activities, and simple navigation. The high practicality score suggests that teachers and students found the e-module easy to use and helpful in mathematics lessons.

Effectiveness of the Developed E-Module

The effectiveness of the developed e-module was determined by comparing the mathematics learning outcomes of students in the experimental and control groups using the Independent Samples *t*-test and N-Gain analysis. The experimental class consisted of 25 students from SD Negeri 1 Panggang, while the control class consisted of 20 students from SD Negeri 5 Panggang. The results of the effectiveness analysis are presented in Table 3.

Table 3. Effectiveness of the developed e-module

Indicator	Result
Mean Posttest (Experimental)	86.76
Mean Posttest (Control)	53.10
T-value	-9.611
Df	43
Sig. (2-tailed)	0.000
Average N-Gain	0.7614
N-Gain Category	High

The results indicate a significant difference between the experimental and control groups ($t = -9.611$, $df = 43$, $p < 0.001$). Students who learned with the PBL-based e-module achieved a higher mean posttest score (86.76) than those who received conventional instruction (53.10). The average N-Gain score of 0.7614 was classified as high, indicating a substantial pretest-to-posttest improvement among students who used the e-module. These findings suggest that integrating Problem-Based Learning into an interactive digital flipbook improved students' mathematics learning outcomes in this setting.

DISCUSSION

Expert validation placed the e-module in the very valid category, with an average of 91% (material 91%, media 91%, language 92%; Table 1). These ratings are close to those reported for other digital or manipulative materials developed for elementary mathematics and science, such as a geoboard medium for plane figures in grade 4 (90% from the material expert and 88% from the media expert; Aflia et al., 2020) and a problem-based flipbook e-module in science (84-87%; Kharomah et al., 2024). The high ratings are plausible because the content followed the PBL syntax and the curriculum outcomes for plane geometry, and the validators' comments concerned surface features such as navigation buttons, typographical errors and foreign terms rather than content. Percentage ratings from one validator per aspect are nevertheless a coarse index of validity, and agreement between validators could not be assessed.

The practicality score of 91% (Table 2) indicates that teachers and students found the flipbook easy to use, which matches their positive comments on its multimedia content, problem-based activities and simple navigation. Comparable practicality has been reported for a problem-based flipbook e-module rated by teachers (97%; Kharomah et al., 2024). Two cautions apply. Table 2 combines teacher and student responses into one score, so it is not possible to see whether teachers, who must manage devices and lesson time, rated the e-module as favourably as students. The questionnaire was also given after a short implementation, when novelty may have raised students' ratings. For teachers, practicality in daily use will depend on access to devices and a stable connection in each classroom.

The effectiveness test showed a large difference in posttest means between the experimental class (86.76) and the control class (53.10; $t = -9.611$, $df = 43$, $p < 0.001$; Table 3), and the experimental class reached an average N-gain of 0.7614, which is high by the usual categories (Hake, 1998). This gain is similar to the N-gain of 0.77 reported for a problem-solving-oriented e-module in grade 5 (Firman et al., 2024) and above the 0.70 reported for a problem-based flipbook in junior high school science (Kharomah et al., 2024). It is also consistent with a meta-analysis of Indonesian experimental studies in which interactive multimedia had its largest effect on learning outcomes at the elementary level (Khaeruman et al., 2023). A plausible mechanism is the combination of the two

design elements. The PBL stages ask students to work on a problem, identify the properties of shapes and explain their solutions, while images and animations make those properties visible. Learning from words and pictures together is the core idea of multimedia learning theory (Mayer, 2014), and PBL adds a reason to use that information. This study did not test the two elements separately, so their relative contributions are unknown.

Taken together, the e-module met the three quality criteria used in this study. Many elementary e-module studies stop at validity and practicality or test effectiveness with a single group (Firman et al., 2024). The comparison class used here makes the evidence for effectiveness stronger than a one-group pretest-posttest design would, although, as discussed below, a comparison between two schools cannot rule out other explanations for the difference.

For teachers in Jepara Regency, the e-module offers a ready resource for plane geometry that fits the student-centred aims of the Merdeka Curriculum. It can be used in class with shared devices or assigned for independent study, and its flipbook format allows teachers to revise problems to suit local contexts. A similar flipbook approach improved elementary students' learning of integers (Sunaryo et al., 2022), which suggests the design can be transferred to other mathematics topics. Schools that adopt it will need to plan device access and give teachers time to practise the PBL stages, because the e-module supports but does not replace the teacher's role in guiding problem solving. At district level, teacher working groups (KKG) could share the e-module file, run short workshops on facilitating PBL with digital materials, and collect teachers' revisions so that the resource improves with use. Such follow-up matters because a well-designed product is only effective if teachers can run the problem stages within normal lesson time.

The findings should be read with the design in mind. The experimental and control classes came from different schools, were selected purposively, and were compared on posttest scores only; without reported pretest equivalence, differences between the schools may account for part of the gap in posttest means (Shadish et al., 2002). The N-gain was reported for the experimental class only, the samples were small (25 and 20 students), and no effect size was reported. The validation and practicality instruments, the achievement test and its reliability, and the size of the limited trial are not described in the Method. Future studies should use a pretest-posttest control-group design with several classes per condition, analyse gains with ANCOVA, report effect sizes and the control-group N-gain, and measure geometric reasoning and engagement directly. A delayed posttest would also show whether the gains are retained.

CONCLUSION AND RECOMMENDATIONS

This study developed a Problem-Based Learning (PBL)-based e-module on plane geometry for fourth-grade elementary school students using the ADDIE instructional design model *(Branch, 2009)*. The e-module met the criteria for a good-quality instructional product, as shown by an average expert validation score of 91%, an average teacher and student response score of 91%, and a statistically significant difference in posttest scores between the experimental and control groups ($p < 0.001$). The average N-Gain score of 0.7614, which falls into the high category, indicates that students' mathematics learning outcomes improved after they used the e-module. Therefore, the developed e-module is considered a valid, practical, and effective digital learning medium that can support mathematics instruction in elementary schools.

Future research should implement the e-module in a broader range of elementary schools involving larger and more diverse student populations to enhance the generalizability of the findings. In addition, future studies may enrich the e-module by incorporating more advanced digital features, such as gamification, adaptive assessment, artificial intelligence (AI)-assisted feedback, and learning analytics, to further enhance students' engagement, independent learning, and mathematics achievement in technology-supported learning environments.

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REFERENCES

Aflia, K., Yuhana, Y., & Alamsyah, T. (2020). Pengembangan media pembelajaran geoboard untuk kemampuan pemahaman matematis siswa sekolah dasar. Primary: Jurnal Pendidikan Guru Sekolah Dasar, 9(5), 680–689. https://doi.org/10.33578/jpfkip.v9i5.8028

Azkiya, H., Tamrin, M., Yuza, A., & Madona, A. S. (2022). Pengembangan E-Modul Berbasis Nilai-Nilai Pendidikan Multikultural di Sekolah Dasar Islam. Jurnal Pendidikan Agama Islam Al-Thariqah, 7(2), 409–427. https://doi.org/10.25299/al-thariqah.2022.vol7(2).10851

Bintoro, H. S., Rahayu, R., & Murti, A. C. (2021). Design of ethnomathematics mobile module to facilitate students mathematical thinking ability. Aksioma: Jurnal Program Studi Pendidikan Matematika, 10(4), 2362–2372.

Branch, R. M. (2009). Instructional design: The ADDIE approach. Springer. https://doi.org/10.1007/978-0-387-09506-6

Firman, S., Nurlina, Rahmawati, Ma'ruf, & Imran, M. E. (2024). The effectiveness of developing problem-solving oriented digital e-modules on Theme 7: Events in life for grade V elementary school. Didaktika: Jurnal Kependidikan, 13(4). https://doi.org/10.58230/27454312.1045

Gall, M. D., Gall, J. P., & Borg, W. R. (2007). Educational research: An introduction (8th ed.). Pearson.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. American Journal of Physics, 66(1), 64–74. https://doi.org/10.1119/1.18809

Huda, M. (2013). Model-model Pengajaran dan Pembelajaran: Isu-isu Metodis dan Paradigmatis. Pustaka Pelajar.

Huda, S., Muhammad, D. H., & Susandi, A. (2022). Pengembangan E-modul Berbasis Model Problem Based Learning (PBL). Jurnal Pendidikan Dan Konseling, 4(2), 148–156. https://jpdk.org/index.php/jpdk/article/view/250/195

Khaeruman, K., Sudiatmika, A. R., Suma, I. K., & Suardana, I. N. (2023). Meta-analisis: Efektivitas multimedia interaktif terhadap peningkatkan hasil belajar siswa. Bioscientist: Jurnal Ilmiah Biologi, 11(2), 1630–1639. https://doi.org/10.33394/bioscientist.v11i2.9497

Kharomah, S., Mulyati, Y., Marsuki, M. F., Fardhani, I., Hamimi, E., Ichsan, M. H. H., Hasan, S., & Sugiyanto, S. (2024). Enhancing students' science outcomes through problem-based interactive flipbook e-module. Research and Development in Education, 4(2), 788–803. https://doi.org/10.22219/raden.v4i2.34572

Lastri, Y. (2023). Pengembangan Dan Pemanfaatan Bahan Ajar E-Modul Dalam Proses Pembelajaran. Jurnal Citra Pendidikan, 3(3), 1139–1146. https://doi.org/10.38048/jcp.v3i3.1914

Mashuri. (2019). Dasar-Dasar Matematika. Media Eduka.

Mayer, R. E. (2014). Introduction to multimedia learning. In R. E. Mayer (Ed.), The Cambridge handbook of multimedia learning (2nd ed., pp. 1–24). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369.002

Ningrum, A. S. (2025). Studi literatur: Efektifitas model problem based learning terhadap hasil belajar siswa SD. Pendas: Jurnal Ilmiah Pendidikan Dasar, 10(4), 610-621. https://doi.org/10.23969/jp.v10i04.31698

OECD. (2023). PISA 2022 results (Volume I): The state of learning and equity in education. OECD Publishing. https://doi.org/10.1787/53f23881-en

Rahayu, E., Sadikin, A., & Hamidah, A. (2024). Pengembangan E-Modul Interaktif Berbasis Flipbook pada Materi Sistem Ekskresi untuk Kelas XI SMA (Development of an Interactive E-Module in the Shape of a Flipbook on Excretory System Material for Class XI SMA). Biodik: Jurnal Ilmiah Pendidikan Biologi, 10(2), 210–220.

Risandy, L. A., Sholikhah, S., Ferryka, P. Z., & Putri, A. F. (2023). Penerapan Model Based Learning (PBL) dalam Pembelajaran Tematik Terpadu di Kelas 5 Sekolah Dasar. Jurnal Kajian Dan Penelitian Umum, 1(4), 95–105. https://doi.org/10.47861/jkpunalanda.v1i4.379

Sadriani, Ahmad, M. R. S., & Arifin, I. (2023). Peran Guru Dalam Perkembangan Teknologi Pendidikan di Era Digital. Seminar Nasional Dies Natalis 62, 1, 32–37. https://doi.org/10.59562/semnasdies.v1i1.431

Safari, Y., & Nurhida, P. (2024). Pentingnya pemahaman konsep dasar matematika dalam pembelajaran matematika. Karimah Tauhid, 3(9), 9817–9823.

Salsabila, S., Nugraha, A. B., & Gusmaneli, G. (2024). Konsep Dasar Belajar dan Pembelajaran dalam Pendidikan. PUSTAKA: Jurnal Bahasa Dan Pendidikan, 4(2), 100–110. https://doi.org/10.56910/pustaka.v4i2.1390

Sari, D. R., Lukman, E. N., & Muharram, M. R. W. (2021). Analisis kemampuan siswa dalam menyelesaikan soal geometri pada asesmen kompetensi minimum-numerasi sekolah dasar. Fondatia: Jurnal Pendidikan Dasar, 5(2), 153–162. https://doi.org/10.36088/fondatia.v5i2.1387

Setyowati, N., & Sutikno, P. Y. (2024). Meta analisis: Model pembelajaran problem based learning (PBL) terhadap keterampilan berpikir kritis siswa sekolah dasar. Jurnal Inovasi Pendidikan dan Pembelajaran Sekolah Dasar, 8(2), 587-599. https://doi.org/10.24036/jippsd.v8i2.127679

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). Experimental and quasi-experimental designs for generalized causal inference. Houghton Mifflin.

Sugiyono. (2022). Metode Penelitian Kuantitatif, Kualitatif, dan R&D. Alfabeta.

Sunaryo, S., Utaminingsih, S., Suryani, F. B., Sumaji, S., & Mamad, N. B. (2022). E-module based on Flip PDF Corporate of integer materials to improve mathematics learning outcomes elementary school. Numerical: Jurnal Matematika dan Pendidikan Matematika, 6(2), 153–162. https://doi.org/10.25217/numerical.v6i2.2654

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

Pedagogical Competence, Work Discipline, and Instructional Supervision as Predictors of Classroom Management

Jasti Wiyani[1*], Nur Fajrie[1] and Ahmad Irfai[1]

[1]*Master of Basic Education, Universitas Muria Kudus, Indonesia*

Corresponding author: 202403110@std.umk.ac.id

ABSTRACT

Orderly primary classrooms depend on teachers' professional capability, their use of instructional time, and the support they receive from school leaders. This study examines the partial and simultaneous effects of teacher pedagogical competence, work discipline, and principals' academic supervision on the classroom management of elementary school teachers in Grobogan Regency, Central Java, Indonesia. The study used an explanatory quantitative design with a cross-sectional survey. The population comprised 5,541 public and private elementary school teachers in 19 sub-districts. A sample of 361 teachers was drawn using the Slovin formula and proportional stratified random sampling. Data were gathered through a closed, self-administered five-point Likert questionnaire adapted from validated scales: the Teacher Pedagogical Capacity Framework for pedagogical competence, the Biometric Time-Compliance Index for work discipline, the Principal Instructional Management Rating Scale (PIMRS) for academic supervision, and the Classroom Ecology Matrix for the dependent variable. The data were analyzed by multiple linear regression in SPSS version 29, after item purification and classical assumption tests. The descriptive data suggest that, despite the changes introduced under the Kurikulum Merdeka, inconsistent instruction and transition downtime account for temporary learning loss in 15% of the observed intervals. The regression model tests whether pedagogical competence, work discipline, and academic supervision each relate positively to classroom management and jointly explain part of its variance. Regional education offices are encouraged to standardize multi-method coaching to protect instructional time.

KEYWORDS classroom engineering | educational ecology | instructional supervision | pedagogical competence | work discipline

INTRODUCTION

Primary education is the foundation of a nation's long-term human resource development. At this level, young learners build core capabilities in literacy, numeracy, character, and pro-social behavior, and most of this learning takes place in the classroom. Classroom management, meaning the teacher's organization of time, space, routines, and behavior so that students can learn, is therefore a precondition for instructional quality. Controlled intervention studies in primary schools show that better classroom management raises students' academic, behavioral, social-emotional, and motivational outcomes, although the average gain is small (Korpershoek et al., 2026). When classrooms are unstable, instructional time is lost and students spend less of each lesson on task.

International large-scale assessments point to the need to improve teaching at the classroom level. The Programme for International Student Assessment (PISA) 2022 results show that only a small percentage of Indonesian students reach the higher proficiency levels in mathematics, reading, and science (OECD, 2023). In response, recent policy, notably the *Kurikulum Merdeka*, requires a shift toward child-centered pedagogy, differentiated instruction, and formative assessment. However, introducing these changes in classrooms that lack stable routines can create friction. First-grade teachers in the early years of the Kurikulum Merdeka reported difficulty with its new terminology, teaching modules, and project work, and coped by using Ministry resources, webinars, and peer discussion (Asmahasanah et al., 2023). Teachers may struggle to manage heterogeneous groups or coordinate tiered assignments, and instructional time is lost as a result. It is therefore important to understand how teacher competence, work discipline, and leadership support together relate to classroom order.

Prior research links each of the three predictors examined here to teachers' work, although mostly to overall teacher performance rather than to classroom management. In a path analysis of 114 teachers in Pati Regency, pedagogic competence, principal leadership, and school culture each had a direct effect on teacher performance, partly through work motivation (Ardliana et al., 2021). A study of 37 elementary teachers in Riau found that teacher work discipline and principal leadership each had a positive, significant effect on performance (Kamalia et al., 2022), and a case study in Lampung showed that a school head raised teachers' punctuality and accountability through administrative control, mentoring, and personal modelling (Dermawan et al., 2026). For supervision, a survey of 64 elementary teachers in Lebak Regency found that principal leadership and academic supervision were each positively related to teacher performance (Starlinsky et al., 2022). International syntheses point the same way. Instructional leadership has a larger effect on student outcomes than transformational leadership, and the largest effect comes from leaders who promote and take part in teacher learning (Robinson et al., 2008). Instructional leadership is also moderately related to teacher self-efficacy (Alanoglu, 2022), and teacher coaching, the core of clinical supervision, improves observed instruction by about half a standard deviation (Kraft et al., 2018).

Two gaps follow from this evidence. First, the Indonesian studies reviewed here treat competence, discipline, or supervision as predictors of overall teacher performance; they do not test them against classroom management, the daily practice through which teacher capability becomes students' time-on-task. Second, these predictors are usually studied one or two at a time, so little is known about their joint contribution now that the Kurikulum Merdeka asks teachers to run more differentiated and group-based lessons. Leadership research adds a reason to look at the classroom: principals appear to influence learning mainly indirectly, through teachers' capacity, motivation, and working conditions (Hallinger, 2011; Leithwood et al., 2020). Classroom management is a plausible channel for that influence.

Grobogan Regency has a large and diverse school network. Regional statistics record 5,541 active primary school teachers across 19 sub-districts. At this scale, schools are likely to differ in instructional resources, teacher discipline, and the quality of supervision by principals. National civil service rules require full digital reporting (for example, through PMM and E-Kinerja), yet classroom management practice varies across rural and suburban schools. This study therefore examines whether teacher pedagogical competence (X_1), work discipline (X_2), and principal academic supervision (X_3) partially and simultaneously influence classroom management (Y) among primary school teachers in Grobogan Regency.

LITERATURE REVIEW

Classroom management (Y) is the dependent variable. It is defined as a teacher's capability to create, maintain, and restore an orderly classroom environment that maximizes students' time-on-task. In the classroom ecology tradition, good management is more than punitive control or reactive discipline. It relies on prevention, smooth transitions, purposeful arrangement of physical space, and positive behavioral reinforcement.

To explain variation in classroom management, this study examines three predictors:

Pedagogical competence (X_1) refers to the knowledge and skills a teacher uses to identify student profiles, set differentiated lesson goals, guide classroom dialogue, and use formative assessment to adjust instruction. Well-designed lessons keep students engaged, which reduces downtime and helps prevent off-task behavior.

Work discipline (X_2) refers to a teacher's compliance with employment regulations, teaching timetables, and reporting deadlines, and to the consistent enforcement of class rules. Teachers with high work discipline protect instructional time, limit interruptions, and model accountability for their students.

Academic supervision (X_3) is the organizational support that the principal provides through clinical observation, data-based feedback, and coaching. Under instructional leadership models such as the PIMRS framework (Hallinger, 2011), supervision that evaluates instructional clarity and gives specific recommendations helps teachers move from administrative compliance to active adjustment of their practice.

Based on this framework, four hypotheses are proposed:

- H_1: Teacher pedagogical competence has a significant positive effect on classroom management.
- H_2: Teacher work discipline has a significant positive effect on classroom management.
- H_3: Principals' academic supervision has a significant positive effect on classroom management.
- H_4: Pedagogical competence, work discipline, and academic supervision simultaneously exert a significant positive effect on classroom management among elementary school teachers in Grobogan Regency.

Research Objectives

This survey aims to obtain empirical evidence on the partial and simultaneous effects of pedagogical competence (X_1), work discipline (X_2), and academic supervision (X_3) on classroom management (Y) in primary schools in Grobogan Regency. The study adds district-level evidence on which teacher and leadership factors are associated with classroom order, which the Education Office can use to target supervision and professional development.

RESEARCH METHOD

Research Design

This study used an explanatory quantitative design with a cross-sectional survey. This non-experimental approach measures the variables as they occur naturally and tests the hypothesized relationships by multiple regression.

Population and Sample

The population comprised all 5,541 certified public and private elementary school teachers listed in the regional databases of Grobogan Regency. Applying the Slovin formula with a margin of error of 5% (e = 0.05) gives a sample size of 361 respondents. To keep the sample geographically balanced, it was allocated proportionally across all 19 sub-districts by stratified random sampling.

Table 1. Target teacher population and sample stratification across 19 sub-districts

No	Sub-District Location	Teacher Population (N_i)	Percentage Allocation (%)	Proportional Sample (n_i)
1	Purwodadi	580	10.47%	38
2	Karangrayung	430	7.76%	28
3	Toroh	410	7.40%	27
4	Gubug	390	7.04%	25
5	Pulokulon	370	6.68%	24
6	Wirosari	340	6.14%	22
7	Kradenan	310	5.59%	20
8	Grobogan	300	5.41%	20
9	Godong	320	5.78%	21
10	Tegowanu	260	4.69%	17
11	Ngaringan	270	4.87%	18
12	Penawangan	250	4.51%	16
13	Gabus	240	4.33%	16
14	Geyer	230	4.15%	15
15	Tawangharjo	200	3.61%	13
16	Tanggungharjo	190	3.43%	12
17	Brati	170	3.07%	11
18	Kedungjati	160	2.89%	10
19	Klambu	121	2.18%	8
-	**Total Regional Context**	**5,541**	**100.00%**	**361**

Note: Sub-district allocation uses the equation $n_i = (N_i / N) \times n$, with values rounded to preserve the target total of 361.

Instruments and Analysis

Data were collected with a closed, online self-report questionnaire on a five-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

- **Pedagogical Competence (X_1):** Measured with 12 items covering lesson design, matching of differentiated strategies, orchestration of interactive talk, and formative assessment cycles.
- **Work Discipline (X_2):** Measured with 10 items covering instructional punctuality, schedule adherence, and the completion of student progress records.
- **Academic Supervision (X_3):** Measured with 12 items derived from the PIMRS, covering pre-observation clarity, classroom data collection, and continuity of coaching.
- **Classroom Management (Y):** Measured with 12 items covering spatial planning, maintenance of routines, transition efficiency, and restorative behavior correction.

The data were analyzed in SPSS version 29. The analysis comprised item purification using corrected item-total correlations, scale verification using Cronbach's alpha (Cronbach, 1951; $\alpha \geq 0.70$), classical assumption tests (including residual normality, linearity, homoscedasticity, and multicollinearity checks using VIF values), and multiple linear regression modeling.

RESULTS

Descriptive Analysis of Classroom Interaction Profiles

Preliminary field evaluations and supervisor logs indicate that the new curriculum requires substantial adjustments in classroom practice. Although completion rates on the digital platform are high, approximately half of the supervisors reported that teachers often struggle with transitions between classroom activities. This friction is associated with an estimated 15% drop in student attention during high-risk instructional hours.

Inferential Regression Path Analysis

Multiple linear regression was used to test the partial and simultaneous effects of the three predictors on classroom management. Table 2 sets out the hypothesized paths, the expected direction of each, and its theoretical anchor.

Table 2. Hypothesized regression paths and theoretical anchors

Path	Variable Relationship Dynamic	Expected Direction	Theoretical Anchor
H_1	Pedagogical Competence → Classroom Management	Positive / Significant	Classroom Ecology Theory
H_2	Work Discipline → Classroom Management	Positive / Significant	Task Performance Framework
H_3	Academic Supervision → Classroom Management	Positive / Significant	Instructional Leadership Model

The discussion below interprets each hypothesized path in the order of the hypotheses, compares it with earlier studies, and draws implications for schools in Grobogan Regency.

DISCUSSION

The study reports a positive relationship between pedagogical competence and classroom management (H1). The likely mechanism is preventive. When tasks match students' readiness and teachers check understanding during the lesson, fewer students are left idle or confused, so there are fewer occasions for off-task behavior. This reading agrees with Ardliana et al. (2021), who found a direct effect of pedagogic competence on teacher performance in Pati Regency, and with the intervention literature, in which narrowly targeted classroom management programmes produced larger gains than broad ones (Korpershoek et al., 2026). It also fits the view that teachers' efficacy for instructional strategies and their efficacy for classroom management are related parts of the same professional confidence (Tschannen-Moran & Hoy, 2001), and that teacher self-efficacy is linked to the quality of classroom practice (Zee & Koomen, 2016). For Grobogan, the implication is that training on differentiation under the Kurikulum Merdeka should include the routines that make differentiated lessons workable: grouping procedures, clear task instructions, and agreed signals for transitions.

The second hypothesis concerns work discipline (H2). Teachers who start lessons on time, keep to the timetable, and complete student records also report better classroom management. Discipline in this sense protects allocated time. A lesson that begins late or is interrupted by unfinished administration loses minutes that students cannot recover, and a teacher who applies class rules consistently gives students a predictable structure. The result is consistent with Kamalia et al. (2022), who found that work discipline predicted elementary teachers' performance, and with Dermawan et al. (2026), whose case study showed that discipline improved when the school head combined administrative control with mentoring and personal modelling. That case also suggests a caution. Attendance systems and digital reporting such as PMM and E-Kinerja record punctuality, but they do not show whether the recorded time is used for instruction. Principals in Grobogan could pair attendance data with short classroom visits that look at how lessons start, how transitions are handled, and how much of the lesson students spend on task.

The third hypothesis concerns principals' academic supervision (H3). Teachers who receive observation-based feedback and continued coaching report more orderly classrooms. Supervision may work through two routes: it gives teachers specific information about their routines, and it may raise their confidence to manage the class. The first route is supported by the coaching meta-analysis of Kraft et al. (2018), in which coaching improved instruction substantially but student achievement less, with smaller effects in larger programmes. The second route is consistent with the positive link between instructional leadership and teacher self-efficacy (Alanoglu, 2022) and with Leithwood and Jantzi (2006), who found that school leadership affected teachers' classroom practices but not student achievement. In Indonesia, Starlinsky et al. (2022) reported that academic supervision was related to elementary teachers' performance, and Amzat et al. (2022) found that principals' instructional leadership predicted teachers' professional development in Jakarta. Hanik et al. (2025) described how instructional leadership in three Jombang elementary schools strengthened teachers' pedagogical competence under the Kurikulum Merdeka through supervision, continuous professional development, and a collaborative

culture. Supervision that only checks lesson documents offers neither route, so the observation and feedback cycle deserves priority.

Taken together (H4), the three predictors describe a chain from school leadership to classroom practice. Principals act on classrooms mainly through teachers' capacity, motivation, and working conditions (Leithwood et al., 2020; Robinson et al., 2008), and pedagogical competence and work discipline are the teacher conditions most directly tied to how a lesson runs. In one elementary school, teachers' adaptation to the Kurikulum Merdeka was high where school leadership and collaborative culture were rated high, even though individual capacity was rated low (Nuravifah et al., 2026). This suggests that a principal's support may partly offset gaps in individual competence. The present model enters the three predictors side by side but does not test their interplay, so whether supervision strengthens the effect of competence or discipline remains open.

For Grobogan Regency, the results point to three practical steps. Principals can move from document checks to short, regular observation cycles with specific feedback on routines and transitions. The Education Office can direct professional development toward classroom routines within differentiated learning rather than toward curriculum terminology alone. Schools can treat punctuality and record-keeping as part of instructional quality, not only as administrative compliance, and discuss them with teachers in that light.

Several limitations qualify these conclusions. The design is cross-sectional and correlational, so the hypothesized paths describe associations, not causal effects. All four variables were measured by teachers' self-reports on one questionnaire, which can inflate the relationships through common method variance and social desirability (Podsakoff et al., 2003); classroom management in particular would be better measured by observation or student reports. This version of the paper does not report the regression coefficients, t and p values, or the R^2 of the model, and the reliability and assumption tests are described but their results are not shown, so the relative weight of the three predictors cannot yet be judged. Future studies could combine teacher surveys with classroom observation, test teacher self-efficacy as a mediator and supervision quality as a moderator, and follow teachers over time to see whether changes in supervision precede changes in classroom order.

CONCLUSION AND RECOMMENDATIONS

The model tested in this study, supported by the prior research reviewed above, proposes that teacher pedagogical competence, work discipline, and principals' academic supervision are positively related to classroom management in primary schools in Grobogan Regency. Administrative compliance alone appears insufficient; schools also need to build instructional skills, support professional discipline, and provide mentoring.

School leaders should move from routine inspection toward clinical supervision cycles that give clear, development-focused feedback. The Grobogan Regency Education Office is advised to design targeted professional development programs focused on classroom differentiation strategies and efficient time management. Future research could examine mediating variables, such as teacher self-efficacy or organizational trust, to extend this model.

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REFERENCES

Alanoglu, M. (2022). The role of instructional leadership in increasing teacher self-efficacy: A meta-analytic review. *Asia Pacific Education Review, 23*, 233–244. https://doi.org/10.1007/s12564-021-09726-5

Amzat, I. H., Yanti, P. G., & Suswandari, S. (2022). Estimating the effect of principal instructional and distributed leadership on professional development of teachers in Jakarta, Indonesia. *SAGE Open, 12*. https://doi.org/10.1177/21582440221109585

Ardliana, B., Rusdarti, R., & Suminar, T. (2021). Effect of principal leadership, school culture and pedagogic competence through work motivation on teachers performance. *Educational Management*, *10*(2), 273–283.

Asmahasanah, S., Chairunnissa, I. C., & Hakim, N. (2023). Navigating Merdeka curriculum in first grade: Teacher challenges and strategies. *Journal of Integrated Elementary Education*, *3*(2), 137–149. https://doi.org/10.21580/jieed.v3i2.17592

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, *16*(3), 297–334. https://doi.org/10.1007/BF02310555

Dermawan, O., Yusnita, E., & Putri, A. (2026). The role of school leadership in enhancing teacher work discipline. *Tadris: Jurnal Keguruan dan Ilmu Tarbiyah*, *11*(1), 319–327. https://doi.org/10.24042/tadris.v11i1.28890

Hallinger, P. (2011). Leadership for learning: Lessons from 40 years of empirical research. *Journal of Educational Administration*, *49*(2), 125–142. https://doi.org/10.1108/09578231111116699

Hanik, H., Nuphanudin, N., Khamidi, A., Roesminingsih, E., Kristanto, A., Trihantoyo, S., & Haq, M. S. (2025). Kepala sekolah sebagai instructional leader: Penguatan kompetensi pedagogik guru untuk pembelajaran mendalam di sekolah dasar. *Didaktika*, *5*(3). https://doi.org/10.17509/didaktika.v5i3.93269

Kamalia, Ayub, D., & Sumarno, S. (2022). The influence of principal leadership and teacher work discipline on elementary school teacher performance. *Journal of Educational Sciences*, *6*(3), 444–458. https://doi.org/10.31258/jes.6.3.p.444-458

Korpershoek, H., de Boer, H., & Mouw, J. M. (2026). An update of the meta-analysis of the effects of classroom management interventions on students' academic, behavioral, social-emotional, and motivational outcomes. *Review of Educational Research*, *96*(5), 1640–1680. https://doi.org/10.3102/00346543251361903

Kraft, M. A., Blazar, D., & Hogan, D. (2018). The effect of teacher coaching on instruction and achievement: A meta-analysis of the causal evidence. *Review of Educational Research*, *88*(4), 547–588. https://doi.org/10.3102/0034654318759268

Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven strong claims about successful school leadership revisited. *School Leadership & Management*, *40*(1), 5–22. https://doi.org/10.1080/13632434.2019.1596077

Leithwood, K., & Jantzi, D. (2006). Transformational school leadership for large-scale reform: Effects on students, teachers, and their classroom practices. *School Effectiveness and School Improvement*, *17*(2), 201–227. https://doi.org/10.1080/09243450600565829

Nuravifah, S., Amelia, L., Zakiyah, N. S., & Pujiasti, D. A. (2026). Tingkat adaptasi guru terhadap Kurikulum Merdeka. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, *11*(2), 263–271. https://doi.org/10.23969/jp.v11i02.47141

OECD. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education*. OECD Publishing. https://doi.org/10.1787/53f23881-en

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology*, *88*(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Robinson, V. M. J., Lloyd, C. A., & Rowe, K. J. (2008). The impact of leadership on student outcomes: An analysis of the differential effects of leadership types. *Educational Administration Quarterly*, *44*(5), 635–674. https://doi.org/10.1177/0013161X08321509

Starlinsky, L., Belawati, T., & Rosita, T. (2022). Korelasi antara kepemimpinan kepala sekolah dan supervisi akademik terhadap kinerja guru sekolah dasar di Kecamatan Lebakgedong Kabupaten Lebak. *Indonesian Journal of Educational Counseling*, *6*(1), 26–33. https://doi.org/10.30653/001.202261.190

Tschannen-Moran, M., & Hoy, A. W. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and Teacher Education*, *17*(7), 783–805. https://doi.org/10.1016/S0742-051X(01)00036-1

Zee, M., & Koomen, H. M. Y. (2016). Teacher self-efficacy and its effects on classroom processes, student academic adjustment, and teacher well-being: A synthesis of 40 years of research. *Review of Educational Research*, *86*(4), 981–1015. https://doi.org/10.3102/0034654315626801

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

The Influence of Classroom Management Competence and Teacher Self-Efficacy on Classroom Management Effectiveness among Public Elementary School Teachers

Joko Supriyanto[1*], Khamdun[2] and Nur Fajrie[2]

[1]*Master Program in Primary Education, Faculty of Teacher Training and Education, Universitas Muria Kudus, Indonesia*
[2]*Faculty of Teacher Training and Education, Universitas Muria Kudus, Indonesia*

Corresponding author: 202403111@std.umk.ac.id

ABSTRACT

Classroom management effectiveness is an essential component of quality teaching and learning in primary education. This study aimed to examine the influence of classroom management competence and teacher self-efficacy on classroom management effectiveness among public elementary school teachers in Pulokulon District, Grobogan Regency, Indonesia. The study used a quantitative, causal-associative survey design. The population consisted of 360 public elementary school teachers, from which 190 respondents were selected using the Slovin formula and proportionate random sampling. Data were collected using validated Likert-scale questionnaires measuring classroom management competence, teacher self-efficacy, and classroom management effectiveness. Data analysis was performed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS 4, including measurement model evaluation, structural model assessment, and bootstrapping with 5,000 resamples. Classroom management competence had a positive and significant effect on classroom management effectiveness ($\beta = 0.524$; $t = 11.188$; $p < 0.001$). Teacher self-efficacy also had a positive and significant effect on classroom management effectiveness ($\beta = 0.507$; $t = 9.759$; $p < 0.001$). Together, the two variables explained 51.14% of the variance in classroom management effectiveness (Adjusted $R^2 = 0.506$). These findings suggest that strengthening teachers' classroom management competence and self-efficacy may improve classroom management effectiveness in public elementary schools. The results support professional development programs that combine classroom management skills with activities that build teacher self-efficacy.

KEYWORDS classroom management competence | classroom management effectiveness | PLS-SEM | public elementary school teachers | teacher self-efficacy

INTRODUCTION

Classroom management is the teacher's work of organizing time, space, routines, and student behavior so that instruction can proceed. It is one of the three basic dimensions of teaching quality, together with student support and cognitive activation (Praetorius et al., 2020). In elementary schools, where students are still developing self-regulation and learning habits, a well-managed classroom protects learning time and reduces disruption, while poor management is associated with off-task behavior, lower engagement, and weaker achievement (Marder et al., 2023). An updated meta-analysis of controlled studies in primary education found that classroom management interventions have a small but significant positive effect on students' academic, behavioral, social-emotional, and motivational outcomes, with narrowly targeted programmes outperforming broad ones (Korpershoek et al., 2026). A related meta-analysis links teachers' provision of clear structure to students' engagement and achievement (Patall et al., 2024).

Effective classroom management nevertheless remains a challenge in many Indonesian public elementary schools, where teachers are also adapting to the Kurikulum Merdeka and its new modules and project work (Asmahasanah et al., 2023). Preliminary observations conducted in public elementary schools in Pulokulon District, Grobogan Regency, indicated considerable variation in teachers' classroom management practices. While some teachers successfully maintained classroom order, implemented consistent routines, and encouraged student participation, others experienced difficulties in organizing learning transitions, managing instructional time,

responding appropriately to disruptive behaviors, and sustaining students' attention throughout lessons. These differences suggest that teacher-related factors may influence classroom management effectiveness and warrant empirical investigation.

Classroom management competence is one factor likely to affect classroom management effectiveness. It refers to teachers' professional ability to plan, implement, monitor, and evaluate strategies that keep learning orderly and productive: setting rules and routines, organizing activities, handling transitions, and preventing disruption. Research on teacher education treats this competence as something that develops over time and can be trained. A longitudinal study followed the development of classroom management competencies across teacher education (Bauersfeld et al., 2025), and video-based learning environments have been used to sharpen teachers' professional vision of classroom management, that is, their ability to notice and interpret classroom events (Gold et al., 2021). Measures of classroom management in school settings remain varied, and many rely on teacher reports (Chow et al., 2024).

Teacher self-efficacy has also been identified as a determinant of successful classroom management. In social cognitive theory, self-efficacy is the belief in one's capability to organize and carry out the actions needed to reach a goal (Bandura, 1977). For teachers, efficacy for classroom management is one of three factors of the widely used teacher efficacy scale, together with efficacy for instructional strategies and for student engagement (Tschannen-Moran & Hoy, 2001). A synthesis of 165 articles found that teacher self-efficacy is positively linked to the quality of classroom practice and to students' academic adjustment (Zee & Koomen, 2016). Longitudinal studies have related teachers' classroom management self-efficacy to students' perceptions of teaching behaviors and enjoyment (Hettinger et al., 2021) and to perceived classroom management from the beginning to mid-career (Lazarides et al., 2020), and a meta-analysis has summarized the correlates of this belief (Duan et al., 2024).

Most of this evidence comes from European, North American, and Australian samples, and competence and self-efficacy are usually studied separately. Few studies have tested both as joint predictors of classroom management effectiveness in Indonesian public elementary schools, where class composition, school culture, and curriculum demands differ. It is therefore unclear whether teachers' skills and their confidence contribute independently to classroom management, or whether one matters more than the other in this setting.

This study therefore examines the influence of classroom management competence and teacher self-efficacy on classroom management effectiveness among public elementary school teachers in Pulokulon District, Grobogan Regency. The results can inform principals, supervisors, and the district education office when they design professional development on classroom management.

LITERATURE REVIEW

This study assumes that classroom management effectiveness depends on both teachers' professional competence and their psychological readiness to implement effective instructional practices. The conceptual framework integrates two complementary perspectives: classroom management research and social cognitive theory. Classroom management research emphasizes that teachers' knowledge and skills in organizing the learning environment are essential for creating productive and orderly classrooms, while social cognitive theory (Bandura, 1977) explains that teachers' beliefs about their own capabilities (self-efficacy) influence their instructional decisions, persistence, and performance. Together, these theories explain how classroom management competence and teacher self-efficacy may contribute to classroom management effectiveness.

The first construct, classroom management competence, covers rules and routines, organization of learning activities, time management, transitions, behavior management, and organization of the learning environment, the five indicators measured in the questionnaire. Teachers with stronger competence are expected to reduce interruptions and protect learning time.

The second construct, teacher self-efficacy, is teachers' belief in their capability to carry out instructional tasks, engage students, and manage classroom situations. Teachers with higher self-efficacy tend to persist and adapt when classroom problems arise, and are therefore expected to manage their classes more effectively.

The dependent construct, classroom management effectiveness, represents the degree to which teachers successfully establish orderly, safe, productive, and supportive learning environments. Effective classroom management is reflected in consistent classroom procedures, efficient use of instructional time, smooth learning transitions, minimal disruptive behaviors, active student engagement, and positive teacher-student interactions. Effective classroom management therefore extends beyond maintaining discipline to creating an environment that supports meaningful learning.

Accordingly, this study proposes three hypotheses. First, classroom management competence has a positive and significant effect on classroom management effectiveness. Second, teacher self-efficacy has a positive and significant effect on classroom management effectiveness. Third, classroom management competence and teacher self-efficacy simultaneously have a positive and significant effect on classroom management effectiveness among public elementary school teachers in Pulokulon District, Grobogan Regency. The conceptual model positions classroom management competence (X_1) and teacher self-efficacy (X_2) as exogenous variables influencing classroom management effectiveness (Y). This model was tested with Partial Least Squares Structural Equation Modeling (PLS-SEM).

Research Objectives

The study aimed to analyze (1) the effect of classroom management competence on classroom management effectiveness, (2) the effect of teacher self-efficacy on classroom management effectiveness, and (3) the simultaneous effect of both variables, among public elementary school teachers in Pulokulon District, Grobogan Regency, Indonesia.

RESEARCH METHOD

Research Design

This study employed a quantitative research approach using a causal associative survey design (Creswell & Creswell, 2018) to examine the relationships among classroom management competence, teacher self-efficacy, and classroom management effectiveness. A quantitative approach was selected because the study aimed to test hypotheses concerning the influence of independent variables on a dependent variable through statistical analysis. This design allowed the individual (partial) and combined (simultaneous) effects of classroom management competence and teacher self-efficacy on classroom management effectiveness to be examined.

The research was conducted in public elementary schools located in Pulokulon District, Grobogan Regency, Central Java, Indonesia, from January to June 2026. The target population consisted of 360 public elementary school teachers, and 190 teachers were selected using the Slovin formula and proportionate random sampling so that each school was represented proportionally. Data were collected through structured questionnaires using a five-point Likert scale. The research instruments measuring classroom management competence, teacher self-efficacy, and classroom management effectiveness were reviewed by experts before data collection to establish content validity.

Data analysis was performed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS 4 software (Ringle et al., 2024). The analytical procedure consisted of evaluating the measurement model (outer model), assessing the structural model (inner model), and testing the proposed hypotheses through the bootstrapping procedure with 5,000 resamples. PLS-SEM was chosen because it suits predictive models with several latent constructs and evaluates measurement reliability, construct validity, and structural relationships in one analysis (Hair et al., 2019, 2022).

Respondents of the Study

The respondents of this study were 190 public elementary school teachers from public elementary schools in Pulokulon District, Grobogan Regency, Central Java, Indonesia. The target population consisted of 360 teachers, from which the sample size was determined using the Slovin formula (Sugiyono, 2019). Proportionate random sampling was used so that all schools were represented in proportion to their size and each teacher had an equal chance of selection.

Prior to data collection, official research permission was obtained from the relevant educational authorities and school principals. Participation in the study was voluntary, and all respondents were informed about the purpose of the research. Respondents' confidentiality and anonymity were maintained throughout the study. Data collection was conducted between January and June 2026 using structured questionnaires administered directly to the selected teachers. All respondents were classroom teachers actively engaged in teaching in public elementary schools, which made them appropriate participants for examining the relationships among classroom management competence, teacher self-efficacy, and classroom management effectiveness.

The research instrument consisted of a structured questionnaire divided into three sections corresponding to the study variables. The first section measured classroom management competence (X_1), the second section measured teacher self-efficacy (X_2), and the third section measured classroom management effectiveness (Y). All questionnaire items were developed based on established theoretical indicators and adapted to the context of public elementary schools. The instrument employed a five-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Before data collection, two educational experts reviewed the questionnaire for content validity and clarity. The collected data were subsequently analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS 4.

Table 1. Mean interpretation for questionnaire responses

Mean	Qualitative Description
4.21 – 5.00	Very High
3.41 – 4.20	High
2.61 – 3.40	Moderate
1.81 – 2.60	Low
1.00 – 1.80	Very Low

These ranges were used to classify the respondents' perceptions of classroom management competence, teacher self-efficacy, and classroom management effectiveness based on the average scores obtained for each construct. Higher mean scores indicate stronger classroom management competence, greater teacher self-efficacy, and higher classroom management effectiveness, respectively.

RESULTS

The descriptive results for classroom management competence are presented below.

Descriptive Statistics

Classroom Management Competence

Table 2 presents the descriptive statistics of classroom management competence among public elementary school teachers in Pulokulon District, Grobogan Regency. Respondents reported a high level of classroom management competence (overall mean = 4.12), which suggests that teachers generally have adequate knowledge and skills for organizing and managing classroom learning. The highest mean score was for learning environment organization, followed by classroom rules and routines, while the lowest means were for classroom transitions and time management, which suggests that these aspects need further professional development.

Table 2. Mean, standard deviation, and qualitative description of classroom management competence

Indicators	Mean	SD	Qualitative Description
Classroom rules and routines	4.18	0.56	High
Classroom time management	4.05	0.61	High
Classroom transitions	4.01	0.59	High
Student behavior management	4.16	0.54	High
Learning environment organization	4.20	0.52	Very High
Overall Classroom Management Competence	**4.12**	**0.56**	**High**

SD = Standard Deviation.

The findings indicate that teachers in public elementary schools generally possess sufficient competence to create orderly, productive, and supportive learning environments. Their ability to establish routines, organize learning activities, and manage student behavior is likely to help maintain effective classroom conditions. However, the comparatively lower scores for classroom transitions and instructional time management suggest that teachers continue to experience challenges in maintaining smooth learning flow during changes in classroom activities. Improving these competencies through continuous professional development and classroom-based mentoring is expected to further enhance instructional effectiveness.

These findings are consistent with the view that classroom management competence is a core component of teacher professionalism. Teachers who effectively plan classroom procedures, organize learning environments, monitor student behavior, and maintain classroom routines are more capable of creating learning conditions that maximize student engagement and minimize instructional disruptions. Meta-analytic evidence points the same way: classroom management interventions improve students' outcomes (Korpershoek et al., 2026), and teachers' provision of structure is linked to students' engagement and achievement (Patall et al., 2024).

Structural Model

The structural model tests the effects of classroom management competence and teacher self-efficacy on classroom management effectiveness. Bootstrapping with 5,000 resamples showed a positive and significant path from classroom management competence to classroom management effectiveness ($\beta = 0.524$; $t = 11.188$; $p < 0.001$) and from teacher self-efficacy to classroom management effectiveness ($\beta = 0.507$; $t = 9.759$; $p < 0.001$). Together, the two predictors explained 51.14% of the variance in classroom management effectiveness (adjusted $R^2 = 0.506$).

DISCUSSION

The first finding is that classroom management competence was positively related to classroom management effectiveness ($\beta = 0.524$; $t = 11.188$; $p < 0.001$). Teachers rated their own competence as high overall ($M = 4.12$), with the highest mean for organizing the learning environment and the lowest for classroom transitions ($M = 4.01$) and time management ($M = 4.05$; Table 2). The likely mechanism is preventive. Teachers who set clear rules, plan routines, and arrange the room in advance meet fewer disruptions, so less lesson time is spent restoring order. This agrees with the meta-analytic evidence that classroom management programmes improve student outcomes (Korpershoek et al., 2026) and that clear structure supports engagement and achievement (Patall et al., 2024). It also fits studies that link teachers' classroom management and students' disruptive behavior to achievement (Marder et al., 2023). The weaker scores for transitions and time management suggest where training should start. Video-based programmes that train teachers to notice classroom events (Gold et al., 2021) and longitudinal work showing that these competencies grow over the course of teacher education (Bauersfeld et al., 2025) indicate that such skills can be developed through practice and feedback, not only through workshops.

The second finding is that teacher self-efficacy was also positively related to classroom management effectiveness ($\beta = 0.507$; $t = 9.759$; $p < 0.001$). In social cognitive terms (Bandura, 1977), teachers who believe they can handle a disruptive class are more likely to try a strategy, persist when it does not work at once, and stay calm, which makes their management more consistent. The result agrees with the synthesis of Zee and Koomen

(2016), who linked teacher self-efficacy to the quality of classroom practice, and with longitudinal studies that relate classroom management self-efficacy to students' perceptions of teaching (Hettinger et al., 2021) and to perceived classroom management across the career (Lazarides et al., 2020). Wettstein et al. (2021) likewise examined teachers' self-efficacy alongside students' own perceptions of classroom management and classroom disruptions, which shows that the link can be tested with ratings from a source other than the teacher. Because self-efficacy and the outcome were both rated by the same teachers in this study, part of the association may reflect a general tendency to rate oneself positively. Studies that combine teacher self-efficacy with student or observer ratings, as several of these did, give a stronger test.

Taken together, the two predictors explained 51.14% of the variance in classroom management effectiveness (adjusted $R^2 = 0.506$), and their path coefficients were of similar size. This pattern suggests that skill and confidence make complementary contributions: competence gives teachers the strategies, and self-efficacy makes it more likely that they apply those strategies under pressure. The near-equal coefficients also mean that neither factor can substitute for the other in professional development: a skilled but unconfident teacher, or a confident teacher with few strategies, would be expected to manage less effectively than a teacher who has both. Competence and self-efficacy are usually positively correlated, and the paper does not report their correlation, so the separate contribution of each should be read with caution until the latent variable correlations are shown. About half of the variance remains unexplained, so other factors are likely to matter, such as class size, student composition, curriculum demands, and the support teachers receive from school leaders.

For schools in Pulokulon District, these results have practical implications. Principals and supervisors can focus classroom observation and feedback on transitions and the use of lesson time, the two weakest indicators. Self-efficacy grows mainly through mastery experience (Bandura, 1977), so professional development should give teachers repeated chances to try a strategy in their own class and see it work. Coaching cycles are one way to do this; a meta-analysis of causal studies found that coaching improved teachers' instruction substantially (Kraft et al., 2018). Principals' instructional leadership is also moderately related to teacher self-efficacy (Alanoglu, 2022). Teacher working groups (KKG) at sub-district level could serve as the setting for sharing routines and for peer observation, which would also help teachers who are still adjusting to the Kurikulum Merdeka (Asmahasanah et al., 2023).

Several limitations should be noted. The design is cross-sectional, so the paths show associations, not causal effects. All three constructs were measured by teacher self-report on one questionnaire, which can inflate their relationships through common method variance (Podsakoff et al., 2003); a full collinearity test would help to assess this in PLS-SEM (Kock, 2015). The paper does not yet report the measurement model (outer loadings, Cronbach's alpha, composite reliability, AVE, and HTMT), which is needed to judge construct validity and discriminant validity between competence and self-efficacy (Hair et al., 2019; Henseler et al., 2015). Descriptive statistics are reported for only one of the three variables, and the correlation between the two predictors is not shown. The sample comes from one district. Future research could use observation-based or student-reported measures of classroom management, drawing on the range of instruments reviewed by Chow et al. (2024), follow teachers over time, and test whether self-efficacy mediates the link between competence and classroom management effectiveness.

CONCLUSION AND RECOMMENDATIONS

The findings indicate that classroom management competence and teacher self-efficacy are significant predictors of classroom management effectiveness among public elementary school teachers in Pulokulon District, Grobogan Regency. The structural model analysis revealed that classroom management competence has a positive and significant influence on classroom management effectiveness ($\beta = 0.524$; $p < 0.001$), while teacher self-efficacy also exerts a positive and significant influence ($\beta = 0.507$; $p < 0.001$). Together, the two variables explain 50.6% of the variance in classroom management effectiveness (adjusted R^2), which suggests that strengthening teachers' professional competence and confidence may improve classroom management practice.

The results suggest that teachers with stronger classroom management competence are better able to organize classroom activities, maintain discipline, manage instructional time, and create supportive learning environments. Likewise, teachers with higher self-efficacy may show more confidence, persistence, and adaptability when facing classroom challenges, which can make their classroom management more effective. These findings support combining professional competence development with support for teachers' self-efficacy in public elementary schools.

Based on these findings, several recommendations are proposed. First, school principals and education authorities should design continuous professional development programs focusing on classroom management strategies, classroom organization, behavior management, and effective instructional practices. Second, teacher development initiatives should incorporate activities that strengthen teacher self-efficacy through mentoring, peer collaboration, classroom coaching, reflective practice, and professional learning communities. Third, schools should provide a supportive environment that encourages innovation, collaboration, and continuous professional growth so that teachers can manage their classrooms consistently.

Finally, future researchers are encouraged to investigate additional factors influencing classroom management effectiveness, such as instructional leadership, organizational climate, teacher motivation, emotional intelligence, digital competence, and job satisfaction. Future studies could also use longitudinal or mixed-method designs across wider geographical areas to examine the factors that contribute to effective classroom management in elementary education.

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REFERENCES

Alanoglu, M. (2022). The role of instructional leadership in increasing teacher self-efficacy: A meta-analytic review. *Asia Pacific Education Review, 23*, 233–244. https://doi.org/10.1007/s12564-021-09726-5

Asmahasanah, S., Chairunnissa, I. C., & Hakim, N. (2023). Navigating Merdeka curriculum in first grade: Teacher challenges and strategies. *Journal of Integrated Elementary Education, 3*(2), 137–149. https://doi.org/10.21580/jieed.v3i2.17592

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191–215. https://doi.org/10.1037/0033-295X.84.2.191

Bauersfeld, J. L., Gold, B., & Holodynski, M. (2025). Development of classroom management competencies throughout teacher education: A longitudinal study. *Teacher Development*. Advance online publication. https://doi.org/10.1080/13664530.2025.2455113

Chow, J. C., Sayers, R., Fu, Y., Granger, K. L., McCullough, S., Kingsbery, C., & Morse, A. (2024). A systematic meta-review of measures of classroom management in school settings. *Assessment for Effective Intervention, 49*(2), 60–74. https://doi.org/10.1177/15345084231208671

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.

Duan, S., Bissaker, K., & Xu, Z. (2024). Correlates of teachers' classroom management self-efficacy: A systematic review and meta-analysis. *Educational Psychology Review, 36*, Article 43. https://doi.org/10.1007/s10648-024-09881-2

Gold, B., Pfirrmann, C., & Holodynski, M. (2021). Promoting professional vision of classroom management through different analytic perspectives in video-based learning environments. *Journal of Teacher Education, 72*(5), 626–642. https://doi.org/10.1177/0022487120963681

Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2022). *A primer on partial least squares structural equation modeling (PLS-SEM)* (3rd ed.). SAGE Publications.

Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. *European Business Review, 31*(1), 2–24. https://doi.org/10.1108/EBR-11-2018-0203

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science, 43*, 115–135. https://doi.org/10.1007/s11747-014-0403-8

Hettinger, K., Lazarides, R., Rubach, C., & Schiefele, U. (2021). Teacher classroom management self-efficacy: Longitudinal relations to perceived teaching behaviors and student enjoyment. *Teaching and Teacher Education, 103*, Article 103349. https://doi.org/10.1016/j.tate.2021.103349

Kock, N. (2015). Common method bias in PLS-SEM: A full collinearity assessment approach. *International Journal of e-Collaboration, 11*(4), 1–10. https://doi.org/10.4018/ijec.2015100101

Korpershoek, H., de Boer, H., & Mouw, J. M. (2026). An update of the meta-analysis of the effects of classroom management interventions on students' academic, behavioral, social-emotional, and motivational outcomes. *Review of Educational Research, 96*(5), 1640–1680. https://doi.org/10.3102/00346543251361903

Kraft, M. A., Blazar, D., & Hogan, D. (2018). The effect of teacher coaching on instruction and achievement: A meta-analysis of the causal evidence. *Review of Educational Research, 88*(4), 547–588. https://doi.org/10.3102/0034654318759268

Lazarides, R., Watt, H. M. G., & Richardson, P. W. (2020). Teachers' classroom management self-efficacy, perceived classroom management and teaching contexts from beginning until mid-career. *Learning and Instruction, 69*, Article 101346. https://doi.org/10.1016/j.learninstruc.2020.101346

Marder, J., Thiel, F., & Göllner, R. (2023). Classroom management and students' mathematics achievement: The role of students' disruptive behavior and teacher classroom management. *Learning and Instruction, 86*, Article 101746. https://doi.org/10.1016/j.learninstruc.2023.101746

Patall, E. A., Yates, N., Lee, J., Chen, M., Bhat, B. H., Lee, K., Beretvas, S. N., Lin, S., Yang, S. M., Jacobson, N. G., Harris, E., & Hanson, D. J. (2024). A meta-analysis of teachers' provision of structure in the classroom and students' academic competence beliefs, engagement, and achievement. *Educational Psychologist, 59*(1), 42–70. https://doi.org/10.1080/00461520.2023.2274104

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology, 88*(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Praetorius, A.-K., Klieme, E., Kleickmann, T., Brunner, E., Lindmeier, A., Taut, S., & Charalambous, C. (2020). Towards developing a theory of generic teaching quality: Origin, current status, and necessary next steps regarding the Three Basic Dimensions model. In A.-K. Praetorius, J. Grünkorn, & E. Klieme (Eds.), *Empirische Forschung zu Unterrichtsqualität: Theoretische Grundfragen und quantitative Modellierungen* (pp. 15–36). Beltz Juventa. https://doi.org/10.25656/01:25861

Ringle, C. M., Wende, S., & Becker, J.-M. (2024). *SmartPLS 4* [Computer software]. SmartPLS. https://www.smartpls.com

Sugiyono. (2019). *Metode penelitian kuantitatif, kualitatif, dan R&D*. Alfabeta.

Tschannen-Moran, M., & Hoy, A. W. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and Teacher Education, 17*(7), 783–805. https://doi.org/10.1016/S0742-051X(01)00036-1

Wettstein, A., Ramseier, E., & Scherzinger, M. (2021). Class- and subject teachers' self-efficacy and emotional stability and students' perceptions of the teacher-student relationship, classroom management, and classroom disruptions. *BMC Psychology, 9*, Article 103. https://doi.org/10.1186/s40359-021-00606-6

Zee, M., & Koomen, H. M. Y. (2016). Teacher self-efficacy and its effects on classroom processes, student academic adjustment, and teacher well-being: A synthesis of 40 years of research. *Review of Educational Research, 86*(4), 981–1015. https://doi.org/10.3102/0034654315626801

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

The Effect of Academic Supervision and Achievement Motivation on the Performance of Class Teachers in Undaan District

Arif Wijayanto[1*], Gunawan Setiadi[1] and Ahmad Hariyadi[1]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: arifwjy22@gmail.com

ABSTRACT

Teacher performance may be shaped by achievement motivation and academic supervision. This study aims to determine the effect of academic supervision and achievement motivation on the performance of civil servant elementary school teachers. Data were collected with a questionnaire that had been tested for validity and reliability. The final questionnaire consisted of 85 items, including 25 items on academic supervision, 30 items on achievement motivation, and 30 items on teacher performance. The questionnaire was distributed to 149 respondents in Undaan District. Regression analysis showed a significant joint effect of academic supervision and achievement motivation on teacher performance ($F = 5.349$, $p = 0.006$), but the two variables explained only 6.8% of the variance in performance.

KEYWORDS academic supervision | achievement motivation | teacher performance

INTRODUCTION

Education is considered successful when it produces a well-qualified generation, and teachers play a central role in this. Rochim (2022, p. 5) describes teachers as the spearhead of educational success. Teachers must meet professional criteria to carry out their main duty of educating students, and they are expected to perform well. Yulia (2021) explain that teacher performance is a key factor in the educational success of a school. Teacher performance depends on both personal and organizational conditions. School leadership research shows that leaders influence student learning largely through teachers' motivation, capacity, and working conditions (Leithwood et al., 2020), which places teacher motivation and principal support at the center of efforts to improve performance.

Teachers' performance results are expected to motivate them to achieve more and develop their abilities (Andini et al., 2022). Teachers with high achievement motivation are likely to have the enthusiasm, desire, and energy to achieve educational goals (Satriani et al., 2023). A survey of 119 junior high school teachers and principals in Aceh Besar found that teacher motivation had a positive effect on teacher performance, although a smaller one than principal leadership (Sariakin et al., 2025).

Academic supervision, especially by principals, is also important. Fitri et al. (2021) stated that teacher performance is influenced by the guidance provided by principals through supervision. Supervision is one way for principals to develop teachers' potential and so improve the quality of education. In practice, however, principals' supervision of teachers is still considered inadequate, even though it is important for school quality. Hariyadi et al. (2023, p. 1) state that school-level supervision is key to ensuring that educational programs function properly.

Evidence on both variables is consistent but mostly local. Reviews of four decades of research conclude that school leaders affect learning mainly indirectly, through the conditions in which teachers work (Hallinger, 2011), and principals' instructional leadership is moderately related to teachers' self-efficacy (Alanoglu, 2022). Among leadership practices, promoting and taking part in teachers' learning has shown the largest association with student outcomes (Robinson et al., 2008), and coaching, the core of academic supervision, has improved teachers' instruction in experimental studies (Kraft et al., 2018). In Indonesian elementary schools, academic supervision and principal leadership were each positively related to teacher performance in Lebak Regency (Starlinsky et al., 2022), and supervision together with school culture was related to teacher performance in Rembang Regency

(Kristiningsih et al., 2022). For motivation, a path analysis of 114 teachers in Pati Regency found that work motivation affected teacher performance directly and carried part of the effect of leadership and competence (Ardliana et al., 2021), and a study of preschool teachers reported that work motivation and competence were related to performance (Nurwati et al., 2025).

Most of these studies report that an effect is significant but say little about its size, and few examine supervision and achievement motivation together among civil servant class teachers in one district. In Undaan District, Kudus Regency, there is no published evidence on how much of the variation in teacher performance these two factors account for. This study addresses that gap by testing their joint effect on the performance of civil servant elementary class teachers and by reporting the proportion of variance explained.

LITERATURE REVIEW

Improved teacher performance affects how teachers plan lessons and assess learning outcomes. Teacher performance focuses on meaningful learning for students. Learning must meet process standards, including efficient and effective planning, implementation, and assessment of learning outcomes.

Academic supervision is the principal's professional support for teachers' instruction. It has three stages: planning the supervision, carrying it out through classroom observation and discussion, and following it up with feedback, coaching, or training (Table 1). Supervision that is continuous, planned, and systematic is more likely to change classroom practice than a one-off inspection (Ulinnuha et al., 2023). Achievement motivation is the teacher's drive to do the work well, shown in a sense of achievement, responsibility, readiness to evaluate one's own work, moderate risk-taking, creativity, and enjoyment of challenge.

Teachers must be able to provide education that is relevant to the times. This requires achievement motivation to improve learning, for example by mastering current technology so that students absorb the material more easily. Such motivation also supports good teacher performance and makes these teachers role models for their colleagues. Research Objectives.

This study examined the joint effect of academic supervision and achievement motivation on the performance of elementary school teachers in Undaan District. The hypothesis was that academic supervision and achievement motivation jointly have a significant positive effect on teacher performance.

RESEARCH METHOD

This study used a quantitative approach with a questionnaire survey.

Research Design

This study used a quantitative correlational design to determine the extent to which the independent variables influence the dependent variable.

Population and Sample

The population comprised 237 civil servant elementary school teachers in Undaan District, Kudus Regency. The sample of 149 teachers was determined with the formula given by Sugiyono.

Data Collection Techniques

Data were collected through questionnaires sent to respondents via Google Forms and through interviews.

Table 1. Instrument grid of the research variables

No	Variable	Indicator	No item
1	Supervision	Planning of supervisory activities	1, 2, 3, 4, 7, 8, 9, 10
		Implementation of supervisory activities	11, 12, 13, 14, 20, 21, 22, 23, 24
		Follow-up of supervisory activities	5*, 6, 15, 16, 17, 18*, 19, 25*
2	Achievement Motivation	Strong sense of achievement	3, 4, 5, 11, 18, 20*
		Responsibility	1, 2, 17*, 27, 29
		Evaluative	15*, 16*, 28
		Risk-taking tendency	9, 10*,13*, 22, 30
		Creative and Innovative	14, 23, 24, 25*, 26
		Enjoys challenges	6, 7, 8, 12*, 19, 21*
3	Teacher Performance	Planning learning activities	1,2,3,4*,5,30
		Implementation of learning activities	8,9,10*,11,12,16*, 19, 21, 24
		Evaluation of learning assessments	6,14,20, 23*, 26, 28, 29
		Implementing improvements and enrichment	7,15, 22, 25
		Developing teacher professionalism	13, 17,18, 27

*Note: * Negative statement (16 items)*

The instrument grid above was developed into statements arranged in columns to make the questionnaire easier for respondents to complete.

RESULTS

The joint effect of academic supervision and achievement motivation on teacher performance is shown in the following table.

Table 2. Regression results (ANOVA) of academic supervision and achievement motivation on teacher performance

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	853.727	2	426.864	5.349	.006[b]
	Residual	11651.494	146	79.805		
	Total	12505.221	148			

Note: a. Dependent variable: teacher performance (kinerja). b. Predictors: (constant), achievement motivation (motivasi berprestasi), supervision (supervisi).

The table above shows a significance value of 0.006. Because 0.006 < 0.05, academic supervision and achievement motivation together have a significant effect on teacher performance. The two variables together explain 6.8% of the variance in teacher performance (R^2 = 853.727 / 12,505.221 = 0.068).

DISCUSSION

The main finding is that academic supervision and achievement motivation together had a significant effect on teacher performance (F = 5.349, p = 0.006), but they explained only 6.8% of its variance (Table 2). Expressed as Cohen's f^2, the effect is about 0.07, which is small by conventional benchmarks (Cohen, 1988). The significance of the test therefore shows that the relationship is unlikely to be zero; it does not show that the two variables are major determinants of performance. About 93.2% of the variance is related to other factors. Because only the joint test is reported, it is also not possible to say whether supervision, motivation, or both carry the effect.

The direction of the result agrees with earlier Indonesian studies. Kristiningsih et al. (2022) found that academic supervision was related to teacher performance, Starlinsky et al. (2022) reported the same for elementary teachers in Lebak Regency, and Afriantoni et al. (2025) linked principals' supervision to teachers'

professionalism and dedication. The size of the effect here is smaller than these studies suggest. One likely reason is the way supervision is carried out. Ulinnuha et al. (2023) argue that supervision improves educational services only when it is ongoing, planned, and systematic rather than a one-off activity. Research on coaching points the same way: it improves instruction when it is intensive and specific, and its effects shrink in large programmes (Kraft et al., 2018). If supervision in Undaan schools is mostly administrative, its link with performance would be weak.

Achievement motivation shows a similar pattern. Teachers with high achievement motivation are described as having the drive and energy to reach educational goals (Satriani et al., 2023), and Darsiah (2023) and Andini et al. (2022) associate it with better teaching. Yet in a larger survey of junior high school teachers and principals, teacher motivation had a much smaller effect on performance than principal leadership (Sariakin et al., 2025), and in Pati Regency work motivation acted partly as a channel for the effects of leadership and competence (Ardliana et al., 2021). Motivation may therefore matter mostly in combination with the conditions that allow teachers to act on it. Those conditions are partly in the principal's hands: a qualitative study found that a school culture of innovation, results orientation, and support for professional growth raised teachers' work motivation, with leadership central to building a collaborative atmosphere (Imawati et al., 2025). Supervision and motivation may thus work through the same channel, the principal's daily contact with teachers, which a joint test of the two variables cannot separate.

Several of these other conditions are likely to account for the unexplained variance. Work discipline is one: Kurniasih (2024) found that better discipline went with higher performance, and work discipline predicted elementary teachers' performance in Riau (Kamalia et al., 2022). The work environment is another (Setyawibowo & Jaenullah, 2024), and the way teachers are motivated by their principal can raise their enthusiasm for their duties (Ramplang et al., 2022).

Technological mastery also plays a role in improving teacher performance (Sodikun et al., 2023). Pratiwi and Purbojo (2025) stated that current technological developments require teachers to provide digital learning materials and media that can be accessed at any time and place, and to use digital technology in teaching and other tasks. Baihaqi and Yusuf (2023) stated that the principal acts as an academic supervisor and motivates teachers to continuously strive for achievement. Darsiah (2023) stated that high achievement motivation among teachers has a positive effect on teaching and learning and increases teachers' competitiveness.

Principal leadership is another factor in teacher performance. Kushariyanto et al. (2025) and Munziati et al. (2024) stated that principal leadership and work motivation have a positive and significant influence on teacher performance. Collaborative GROW coaching by the principal has also been found to improve teacher performance (Budiono, Surachmi, & Setiadi, 2022). Handayani et al. (2021) developed a peer-based academic supervision model for public junior high schools in Kudus Regency, which offers another route for supporting teachers.

For principals in Undaan District, the results suggest that supervision should be judged by what it changes in classrooms, not by whether it was carried out. Supervision cycles with a planning meeting, an observation, and specific follow-up are more likely to affect performance than document checks. The Kudus education office could support principals with training in classroom observation and coaching, and could combine supervision with attention to the conditions discussed above, such as workload, discipline, and the work environment, which appear to account for most of the variation in teacher performance.

This study has limitations. The design is correlational and cross-sectional, so the result shows an association, not a causal effect. All three variables were measured by teachers' self-reports, which can inflate relationships through common method variance (Podsakoff et al., 2003), and teachers' self-rated performance may differ from performance assessed by principals. Only the joint F test is reported; the regression coefficients for each predictor, descriptive statistics, and the validity and reliability results are not shown, and the interview data mentioned in the method are not reported. The sample comes from one district. Future studies could report the partial effect of each predictor, use principals' performance appraisals as the outcome, and include work discipline, workload, and leadership in the model.

CONCLUSION AND RECOMMENDATIONS

Academic supervision and achievement motivation jointly have a significant effect on the performance of elementary school teachers in Undaan District, as shown by the regression analysis (Sig. < 0.05), although together they explain only 6.8% of the variance in performance.

Principals should supervise teachers continuously and support their motivation through awards or guidance.

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REFERENCES

Afriantoni et al. (2025). Evaluation of teacher performance improvement in educational quality at SD Negeri 230 Palembang. WASIS: Scientific Journal of Education, 6(1), 51–57.

Alanoglu, M. (2022). The role of instructional leadership in increasing teacher self-efficacy: A meta-analytic review. *Asia Pacific Education Review, 23*, 233–244. https://doi.org/10.1007/s12564-021-09726-5

Andini, N. W., et al. (2022). Professionalism, achievement motivation, principal supervision, and their impact on teacher performance. Empire Journal, 2(1).

Ardliana, B., Rusdarti, R., & Suminar, T. (2021). Effect of principal leadership, school culture and pedagogic competence through work motivation on teachers performance. *Educational Management*, *10*(2), 273–283.

Baihaqi, & Yusuf, M. (2023). Analysis of principal academic supervision and achievement motivation on teaching performance (Case study at SMP Sub-Rayon 05, Bireuen Regency). *Indomera* Journal of Management Masters, 4(7).

Budiono, A., Surachmi, S., & Setiadi, G. (2022). Implementation of Collaborative Coaching on the Performance of Penambuhan Public Elementary School Teachers. *Wahana Pendidikan Scientific Journal, 8(18), 45-52.*

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates.

Darsiah. (2023). Teacher achievement motivation in improving teacher performance at MA Syaikh Zainuddin NW Anjani. MANAZHIM: Journal of Management and Educational Sciences, 5(1).

Fitri, A., et al. (2021). The influence of principal academic supervision and work motivation on the performance of kindergarten teachers in Tampan District, Pekanbaru City. *JUMPED Journal (Journal of Educational Management).*

Hallinger, P. (2011). Leadership for learning: Lessons from 40 years of empirical research. *Journal of Educational Administration, 49*(2), 125–142. https://doi.org/10.1108/09578231111116699

Handayani, Madjdi, H., & Su'ad. (2021). Development of a peer-based academic supervision model in public junior high schools in Bae District, Kudus Regency. *Journal of Teacher Studi*es and Learning, 4(2).

Hariyadi, A., et al. (2023). Supervision & educational quality: How to get quality teaching for quality learning. Cakra.

Imawati, Maryani, I., & Zuhaery, M. (2025). School culture in fostering teachers' work motivation. *JMKSP (Jurnal Manajemen, Kepemimpinan, dan Supervisi Pendidikan), 10*(1), 778–801. https://doi.org/10.31851/jmksp.v10i1.19207

Kamalia, Ayub, D., & Sumarno, S. (2022). The influence of principal leadership and teacher work discipline on elementary school teacher performance. *Journal of Educational Sciences, 6*(3), 444–458. https://doi.org/10.31258/jes.6.3.p.444-458

Kraft, M. A., Blazar, D., & Hogan, D. (2018). The effect of teacher coaching on instruction and achievement: A meta-analysis of the causal evidence. *Review of Educational Research*, *88*(4), 547–588. https://doi.org/10.3102/0034654318759268

Kristiningsih, N., Madjdi, A., & Suad, S. (2022). The Influence of School Culture and Principal Academic Supervision on Improving Teacher Performance at Hasanudin Cluster Elementary Schools, Kaliori District, Rembang Regency. *Wahana Pendidikan Scientific Journal, 8(18), 269-282.*

Kurniasih, N. (2024). The contribution of discipline, work experience, and achievement motivation to the effectiveness of teacher performance at State Islamic Junior High Schools in Purworejo Regency. Journal of Education Policy and Management Studies, 1(2), 78–93.

Kushariyanto, Setiadi, G., & Hariyadi, A. (2025). The Influence of Principal Leadership, Work Motivation, and Workload on the Performance of Public Junior High School Teachers in Pati Regency. *Lencana: Journal of Educational Innovation*, 3(3), 1–17.

Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven strong claims about successful school leadership revisited. *School Leadership & Management*, *40*(1), 5–22. https://doi.org/10.1080/13632434.2019.1596077

Munziati, Utaminingsih, S., & Rismiyanto. (2024). The Influence of the Principal's Leadership on Teacher Work Motivation. *Uniglobal Journal of Social Sciences and Humanities, 3(1), 36–43.*

Nurwati, S., Surachmi, S., & Setiadi, G. (2025). The influence of work motivation and teachers' competence on the performance of preschool teachers. Social, Humanities, and Educational Studies (SHES): Conference Series, 8(1), 782–791. https://doi.org/10.20961/shes.v8i1.99791

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology, 88*(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Pratiwi, Y. D., & Purbojo, R. (2025). The effect of digital competence and work discipline on teacher performance with achievement motivation as the mediator at XYZ Elementary School. Journal of Innovation, Evaluation, and Learning Development (JIEPP), 5(1), 7–13.

Ramplang et al. (2022). The effect of academic supervision and motivation on the performance of Liukang Tangaya Public Junior High School teachers. *Jambura* Economic Education Journal, 4(1).

Robinson, V. M. J., Lloyd, C. A., & Rowe, K. J. (2008). The impact of leadership on student outcomes: An analysis of the differential effects of leadership types. *Educational Administration Quarterly, 44*(5), 635–674. https://doi.org/10.1177/0013161X08321509

Rochim, A. (2022). Collaborative supervision in Sanjung. CV. Kanaka Media.

Sariakin, S., Yeni, M., Usman, M. B., Mare, A. S., Munzir, M., & Saleh, M. (2025). Fostering a productive educational environment: The roles of leadership, management practices, and teacher motivation. *Frontiers in Education, 10*, Article 1499064. https://doi.org/10.3389/feduc.2025.1499064

Satriani, F., Eddy, S., & Ahyani, N. (2023). The Influence of Motivation and Work Ethic on the Performance of Senior High School Teachers in the School Mover Program. *Journal of Administration and Educational Management (ALIGNMENT), 6(1), 93-103.*

Setyawibowo, B., & Jaenullah. (2024). The contribution of principals' perceptions of managerial competence, achievement motivation, and work environment to the performance of public junior high school teachers in Sapuran District, Wonosobo. Indonesian Journal of Educational Management and Leadership, 2(2), 108–120.

Sodikun, Suwarno, Mustofa, Su'ad, & Hariyadi, A. (2023). ICT-Based Academic Supervision to Improve Teacher Performance in Implementing Learning. *Equity in Education Journal, 5(1), 65–72.* https://doi.org/10.37304/eej.v5i1.8259

Starlinsky, L., Belawati, T., & Rosita, T. (2022). Korelasi antara kepemimpinan kepala sekolah dan supervisi akademik terhadap kinerja guru sekolah dasar di Kecamatan Lebakgedong Kabupaten Lebak. *Indonesian Journal of Educational Counseling, 6*(1), 26–33. https://doi.org/10.30653/001.202261.190

Ulinnuha, M., Utomo, S., & Utaminingsih, S. (2023). Analysis of the Principal's Academic Supervision Implementation (Case Study at Sitirejo Public Elementary School). *Wahana Pendidikan Sci*entific Journal, 9(10), 421–430.

Yulia, H. (2021). The effect of academic supervision, work motivation, and work environment on improving teacher performance in State Islamic Senior High Schools in Malang Regency. Maulana Malik Ibrahim State Islamic University.

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

Strategy for Developing a Boarding School-Based Memorization School at Tasywiquth Thullab Salafiyah Elementary School (TBS) Kudus

Jamalludin Muhammad[1*], Erik Aditia Ismaya[1] and Ahmad Hariyadi[1]

[1]*Universitas Muria Kudus, Indonesia*

ABSTRACT

Pesantren-based tahfidz schools are formal educational institutions that integrate the national school curriculum with intensive Qur'an memorization programs within the pesantren environment. This study aims to formulate development strategies for the tahfidz program at Sekolah Dasar Tasywiquth Thullab Salafiyah (TBS) Kudus. A mixed-method approach with a sequential exploratory design was employed, beginning with qualitative data collection through in-depth interviews, observations, and documentation, followed by quantitative analysis using questionnaires. The strategic analysis involved identifying internal factors (strengths and weaknesses) and external factors (opportunities and threats), which were then synthesized using the SWOT matrix. To complement the analysis, the Business Model Canvas (BMC) was applied to map key elements in managing and developing the school. The strategies from the SWOT analysis were then ranked with the Quantitative Strategic Planning Matrix (QSPM) to identify the most attractive alternatives. The findings indicate that the strengths of the school lie in the support of pesantren culture, the quality of Qur'an teachers, and integrated curricula, while weaknesses include limited facilities and management systems. External opportunities include the growing demand for tahfidz education, whereas threats stem from increasing competition among Islamic schools. The analysis points to strengthening curriculum integration and teacher competence through continuous training. The study offers practical recommendations for developing pesantren-based tahfidz schools and contributes to the literature on strategic management in Islamic education.

KEYWORDS tahfidz school | Islamic boarding school | SWOT | BMC | QSPM | development strategy

INTRODUCTION

One way to improve the quality of human resources is to improve the quality of education in each institution. In education, quality covers four aspects (input, process, output, and outcome), all of which are relative. Religious educational institutions such as Islamic boarding schools, madrasas, majlis taklim, and Islamic universities emerged in response to the conditions of their times. During the Dutch colonization of Indonesia, there were three types of Islamic educational institutions: places for studying the Qur'an that provided basic religious education, Islamic boarding schools that provided structured religious education, and tarekat led by scholars, which provided training in Islamic creed.

The modernization of the education system, particularly the integrated pesantren model, has changed how Al-Qur'an memorization is managed. The integration of religious and general education requires more systematic time management and methods to reach memorization targets within an already dense santri curriculum. Historically, pesantren have been associated with both Islam and Indonesian identity (Madjid, 1997).

Religious education can now combine a Qur'an memorization curriculum with the boarding school system. Al-Qur'an learning has been a main pillar of Islamic education for centuries (Anwar, 2021). Tasywiquth Thullab Salafiyyah Elementary School (SD TBS) Kudus is a pesantren-based tahfiz elementary school established to meet the need for Islamic basic education for girls, integrating religious and general knowledge.

Kudus offers a particular setting for such schools. The town's Gusjigang tradition (*bagus*, *ngaji*, *dagang*) joins good character, religious study, and trade, and has been proposed as a source of values for school learning (Abid, 2018). A study of four madrasah ibtidaiyah in Kudus found that religious character was strengthened through pesantren-based literacy, religious traditions, role modelling, and value internalization, and that it flourished where a religious culture was rooted in the school (Zuhri et al., 2025).

Studies of pesantren-based schools describe both the strengths and the management problems of this model. In a pesantren-based madrasah ibtidaiyah in Malang, religious character values were instilled through curricular integration, religious routines, and community programmes (Priatmoko et al., 2025), and in a student pesantren an integrative curriculum linked academic study with daily practices such as congregational prayer and Qur'an reading (Yusuf et al., 2024). For memorization itself, structured scheduling, consistent teacher supervision, linking reading with memorization targets, and continuous evaluation were associated with more accurate memorization and better student discipline (Khofsah et al., 2025). A case study of a pesantren curriculum, however, found that Islamic values and modern knowledge appeared in classroom practice but were not yet built into curriculum planning, and that limited teacher digital skills and weak infrastructure held back change (Rohim et al., 2026).

Strategic management offers tools for turning such observations into plans. The SWOT matrix matches internal strengths and weaknesses with external opportunities and threats, and the Quantitative Strategic Planning Matrix (QSPM) ranks the resulting alternatives (David & David, 2017). The Business Model Canvas (BMC) describes how an organization creates and delivers value through nine building blocks, from customer segments and value propositions to key resources, cost structure, and revenue streams (Osterwalder & Pigneur, 2010). In Islamic education, SWOT analysis has been applied to a Qur'an boarding school in Depok (Aisyi & Zulkarnain, 2020), and a study of the business units of Pondok Pesantren Sidogiri used SWOT to point to new branches beyond the pesantren's immediate area (Setiawati & Tantriana, 2024). Indonesian studies have also examined principals' strategies for raising the quality of education and of learning (Anisari et al., 2016; Noprika et al., 2020).

Most of these studies describe a single programme, such as memorization methods or character education, or apply a single tool. We found no study that combines SWOT, QSPM, and the BMC to plan the development of a formal elementary school that integrates tahfidz with the national curriculum, and none on a pesantren-based elementary school for girls in Kudus. This study therefore analyzes the internal and external factors that affect SD TBS Kudus, formulates and prioritizes development strategies, and proposes an improved business model. The results are intended to help the foundation and school leaders plan the school's growth.

LITERATURE REVIEW

The framework links the research stages to the research objectives. This study focuses only on SD TBS Kudus as the research object. In the first stage, the current business model and the internal and external factors that influence the development of SD TBS Kudus were identified. These factors were used to determine the school's position, from which alternative strategies were formulated and then prioritized. The strategy priorities and the priorities for improving business model elements then served as input for designing a new business model for SD TBS, the final output of this research. The conceptual framework is shown in Figure 1.

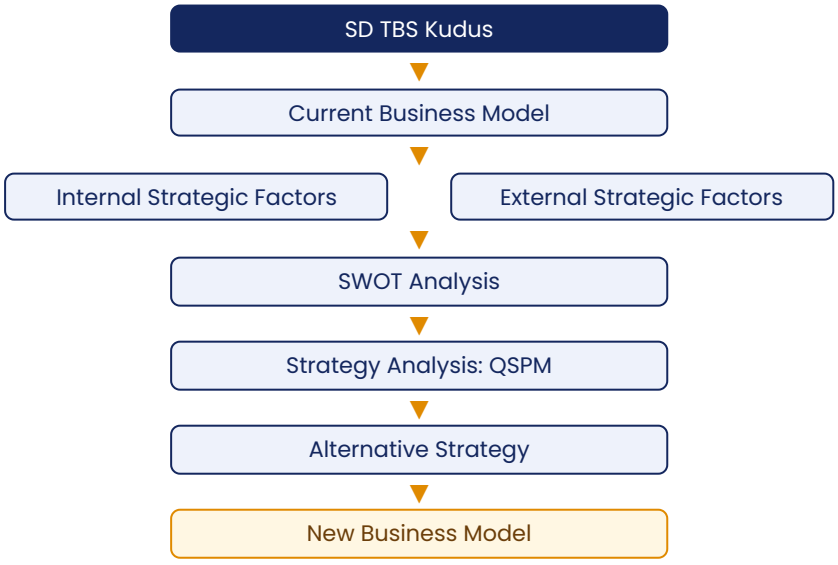

Figure 1. Conceptual framework of the study

Strategy formulation develops the steps needed to achieve organizational goals in three stages: the input stage, the matching stage, and the decision-making stage (David & David, 2017). In the input stage, basic input information needed to formulate a strategy is collected and summarized. Methods that can be used in this input stage include the External Factor Evaluation (EFE) Matrix, Internal Factor Evaluation (IFE) Matrix, and/or Competitive Profile Matrix (CPM). The matching stage then produces strategic alternatives by aligning internal and external strategic factors. The methods that can be used in the matching stage consist of the SWOT Matrix, IE Matrix, BCG Matrix, SPACE Matrix, and/or Grand Strategy Matrix. In the third, decision-making stage, the Quantitative Strategic Planning Matrix (QSPM) shows the relative attractiveness of the alternative strategies and serves as the basis for selecting a strategy.

Research Objectives

This study aims to develop alternative strategies for SD TBS by:

1. Analyzing management models in terms of internal and external factors that influence the development of SD TBS.
2. Formulating alternative strategies and strategic priorities in the development of SD TBS.
3. Designing a new management model for the development of SD TBS.

RESEARCH METHOD

Research Design

The study used a mixed-methods approach with a sequential exploratory design (Creswell & Plano Clark, 2018), beginning with qualitative data collection through in-depth interviews, observation, and documentation, followed by quantitative analysis using a questionnaire instrument.

Respondents of the Study

Internal respondents were selected by judgment sampling on the basis of their expertise. External respondents were selected by convenience sampling, based on ease of access and availability (Amirullah, 2015).

Internal respondents were individuals with expertise in, or an in-depth understanding of, SD TBS: the chairperson of the TBS Foundation, the principal, and teachers and other educators. External respondents consist of parents and community members who are familiar with SD TBS. Because not all community members are familiar with the school, only those living near SD TBS were selected. The number of external respondents followed a commonly used minimum of 30 respondents per group: 30 parents and 30 community members.

Table 1 summarizes the analytical tool used for each research objective.

Table 1. Research objectives, analytical tools, and results

No.	Objective	Analytical Tool	Result
1	Business model analysis	Business Model Canvas (BMC)	Business model elements
2	Internal factor analysis	Functional aspects, Internal Factor Evaluation (IFE)	Strengths and weaknesses, Evaluation of internal strategic factors
3	External factor analysis	Porter's Five Forces; Political, Economic, Social, and Technological (PEST) aspects; External Factor Evaluation (EFE) Evaluation	Opportunities and threats, Evaluation of external strategic factors
4	Formulation of alternative strategies	Internal-External (IE) Matrix, SWOT Matrix	Position of SD TBS, Strategies to be developed
5	Strategy prioritization	QSPM Matrix	Sequence of alternative strategies
6	Designing a new business model	Business Model Canvas (BMC)	New business model

RESULTS

The current SD TBS business model was mapped with the Business Model Canvas (BMC), which has nine key elements. The content of each element was drawn from interviews with respondents and school documents. The resulting BMC is shown in Table 2.

Table 2. Current SD TBS management model mapped with the BMC

<table>
<tr><td rowspan="2">Key Partnerships
Education authorities,
TBS Foundation,
Teachers and administrative staff
School committee,
Parents
Donations</td><td>Key Activities
Formal Tahfidz (Quran memorization),
National curriculum learning,
Women's Fiqh (Islamic jurisprudence),
Character building</td><td rowspan="2">Value Propositions
Formal integrated Tahfidz boarding school for girls,
Women's Fiqh program,
Habituation of Adab (etiquette) and worship</td><td>Customer Relationships
Memorization control book,
WhatsApp Group,
Committee meetings</td><td rowspan="2">Customer Segments
Muslim parents, Boarding school (Pesantren) families,
Communities interested in girls' Tahfidz</td></tr>
<tr><td>Key Resources
Tahfidz teachers,
Specialized curriculum
Boarding school culture,
School facilities,
Teachers and administrative staff</td><td>Channels
Boarding school network,
Word of mouth,
Social media,
Print media</td></tr>
<tr><td colspan="3">Cost Structure
Salaries for teachers and administrative staff,
Operations,
Facilities</td><td colspan="2">Revenue Streams
Monthly tuition fees (SPP),
Development funds,
Donations</td></tr>
</table>

Improvements to the TBS Elementary School Business Management Model

The qualitative phase of this sequential exploratory study consisted of in-depth interviews with:

1. The principal
2. Class teachers
3. Tahfidz teachers
4. Administrative staff
5. Foundation administrators
6. Parents

The qualitative data were analyzed through reduction, categorization, and extraction of main themes (Miles et al., 2020). The results were then used as the basis for the IFE, EFE, SWOT, and QSPM matrices.

The analysis had three stages:

1. open coding, which is the identification of important statements,
2. axial coding, which is grouping into categories, and
3. selective coding, which is the identification of major strategic themes.

The results of open coding of the interviews are shown in Table 3.

Table 3. Results of open coding of interviews with respondents

No.	Key Quotes	Initial Code
1	Tahfidz is included in formal hours	Tahfidz integration
2	Women's Fiqh program is a key advantage	Female differentiation
3	Differences in students' memorization abilities	Ability variation
4	Administration is not yet digital	Manual system
5	Communication with parents is going well	Parent relations
6	Building is still shared with PAUD (Early Childhood Education)	Facility limitations
7	Monthly routine evaluation	Periodic monitoring
8	Strong foundation support	Structural support
9	Values of sincerity and brotherhood (ukhuwah)	Pesantren culture
10	Competition with modern Islamic schools	External competition

The results of *axial coding* are shown in Table 4.

Table 4. Axial coding results of interviews with respondents

No.	Key Quotes	Initial Code
1	Academic and Tahfidz Excellence	Tahfidz integration, Female differentiation
2	Organizational Culture	Pesantren values, Periodic monitoring
3	Internal Management	Manual system, Ability variation
4	External Support	Structural support, Parent relations
5	External Challenges	External competition

Selective coding produced three main strategic themes, which formed the basis of the strategic analysis:

1. Differentiation based on tahfidz and women's fiqh as the school's identity
2. The need to strengthen management and administrative systems
3. Opportunities for expansion with the support of foundations and the community

DISCUSSION

The first theme is differentiation based on formal tahfidz and women's fiqh. In the open coding, respondents named the inclusion of tahfidz in formal school hours and the women's fiqh programme as the school's main advantages (Table 3), and the BMC lists both as value propositions for Muslim parents and pesantren families (Table 2). This identity gives SD TBS a clear position among Islamic elementary schools in Kudus, where religious study is part of the local tradition (Abid, 2018). The finding agrees with studies in which pesantren values took root when they were built into the curriculum and daily routines rather than offered as an extra (Priatmoko et al., 2025; Yusuf et al., 2024; Zuhri et al., 2025). It also echoes Rohim et al. (2026), who found that integration was visible in classroom practice before it was written into curriculum planning. For SD TBS, the practical step is to put the identity into documents: memorization targets for each grade, a written women's fiqh syllabus, and clear rules for how tahfidz hours fit alongside the national curriculum. Continuous training for tahfidz and class teachers, the priority named in the abstract, would support this step, because the teachers who run the programme are the ones who must apply common targets and assessment rules.

The second theme is the need to strengthen management and administrative systems. Respondents reported that administration is not yet digital and that students differ in memorization ability, although the school already holds a routine monthly evaluation (Table 3). These codes were grouped under internal management (Table 4). The pattern suggests a school whose programme runs on commitment and pesantren culture but whose records do not yet show how each student is progressing. Khofsah et al. (2025) found that structured scheduling, consistent supervision, and continuous evaluation went with more accurate memorization, which points to the value of systematic records. Moving to digital records is not only a technical change. In three junior high schools, budget limits, teachers' low digital competence, and uneven infrastructure held back digital initiatives, while principal

support and small innovation teams helped (Ofita et al., 2024). SD TBS could therefore start with a simple shared record of each student's memorization, reviewed at the existing monthly meeting, and add teacher performance indicators once the record is in regular use. The variation in memorization ability also argues against a single target for every student: graded targets, with additional *muroja'ah* (revision) time for slower memorizers, would let teachers report progress fairly and plan support where it is needed.

The third theme is the opportunity for expansion with the support of the foundation and the community. Strong foundation support and good communication with parents were recurring codes, and the BMC shows that the school relies on a memorization control book, WhatsApp groups, and committee meetings to maintain relations with parents (Tables 2 and 3). Against this, respondents named competition with modern Islamic schools and a building still shared with the early childhood unit (Table 3). Similar strategy studies in Islamic institutions reached comparable conclusions: SWOT analysis of the Sidogiri pesantren pointed to growth through new branches supported by its alumni network (Setiawati & Tantriana, 2024), and SWOT was likewise used to plan the development of a Qur'an boarding school (Aisyi & Zulkarnain, 2020). For SD TBS, the existing parent channels could carry regular reports on memorization progress, which would make the school's main advantage visible to parents and to families considering enrolment.

Together, the three themes describe a school that is strong in values and identity but that has not yet turned these strengths into managed systems. This is the pattern the strategy tools are designed to address. The BMC shows that revenue depends on monthly fees, development funds, and donations (Table 2), so growth in enrolment and in donor confidence will depend on visible quality. The QSPM stage is intended to rank the strategies that follow from the SWOT matrix by their attractiveness (David & David, 2017), and the short-, medium-, and long-term plan in the conclusion follows the order of the three themes. Studies of principals' strategies in Indonesian schools similarly frame quality improvement as a matter of leadership and planning (Anisari et al., 2016; Noprika et al., 2020).

This study has limitations. It is a single case, so its strategies are specific to SD TBS and may not transfer to other pesantren-based schools without adaptation. The interview data come from school insiders and parents, and the paper does not describe how the trustworthiness of the coding was checked, for example by triangulation across sources or member checking (Lincoln & Guba, 1985). Most importantly, the quantitative phase of the sequential exploratory design is not reported: the IFE and EFE weights and scores, the IE matrix position, the SWOT strategies, and the QSPM attractiveness scores do not appear in the Findings, so the ranking of strategies stated in the abstract and conclusion cannot yet be checked against data, and the integration of the qualitative and quantitative phases cannot be judged (Creswell & Plano Clark, 2018). Future work could report these matrices in full, follow the implementation of the chosen strategies over several years, and compare SD TBS with other tahfidz elementary schools in Central Java.

CONCLUSION AND RECOMMENDATIONS

The planning of the TBS elementary school program is based on the vision of Islamic boarding schools, with the main differentiation being formal tahfidz and women's fiqh. The program is implemented consistently in daily learning activities. However, planning still needs to be strengthened in the form of standardizing memorization targets for each level, developing teacher performance indicators, and a data-based monitoring system. In substance, the program runs well, but its management still needs to be professionalized.

The IFE Matrix places the internal condition of SD TBS in the moderate category, tending toward strong. The school's main strengths lie in the integration of tahfidz in the formal curriculum, the women's fiqh program as a differentiation for girls' schools, a strong pesantren culture, and stable foundation support. However, there are still weaknesses in the management system, such as administration that has not been digitized, the absence of formal performance indicators, and unstructured quality standards. The school is therefore strong in values and identity but needs to professionalize its management system.

SD TBS can develop short-, medium-, and long-term work plans. In the short term (1 year), it can develop memorization target standards for each grade level, develop teacher performance indicators, and create a simple

digital-based monitoring system. In the medium term (2–3 years), TBS Elementary School can implement e-reports for parents, data-based management training, and quality audits of memorization and academics. In the long term (4–5 years), SD TBS can make full use of the new building, strengthen its reputation through tangible achievements, and assess its readiness for expansion once the system is stable.

REFERENCES

Abid, N. (2018). Integrating soft skill and Gusjigang local value in the learning process. *Elementary: Islamic Teacher Journal, 5*(1), 169–190. https://doi.org/10.21043/elementary.v5i1.2986

Aisyi, G. R., & Zulkarnain, L. (2020). SWOT analysis in an educational institution (Case study: Baitul Qur'an Islamic Boarding School, Depok). *Jurnal Ekonomi dan Perbankan Syariah, 8*(1), 85–101. https://doi.org/10.46899/jeps.v8i1.177

Amirullah. (2015). *Metode penelitian manajemen*. Bayumedia.

Anisari, Purwanti, E., & Masrur, M. (2016). Strategi kepala sekolah dalam meningkatkan mutu pembelajaran di SMP Nurul Islam Kelurahan Garuntang Kecamatan Bumi Waras Kota Bandar Lampung. *Jurnal Manajemen Pendidikan Islam Al-Idarah, 1*(1), 137–152.

Anwar, S. S. (2021). *Kurikulum pendidikan Islam nonformal (Aqidah, ilmu al-Qur'an, ilmu hadits, ushul fiqih, praktik ushul fiqih)*. Yayasan Do'a Para Wali.

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). SAGE.

David, F. R., & David, F. R. (2017). *Strategic management: A competitive advantage approach, concepts and cases* (16th ed.). Pearson Education Limited.

Khofsah, S., Kusuma, I., Kunta, I. H., Rahman, M., Dewi, A. T. A., & Rozi, F. (2025). Management of the habit of reading the Qur'an as an effective memorization strategy for tahfidz class students at madrasahs. *Journal of Education Management and Policy, 1*(3), 198–207. https://ejournal.unuja.ac.id/index.php/jemp/article/view/13703

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Sage.

Madjid, N. (1997). *Bilik-bilik pesantren: Sebuah potret perjalanan*. Paramadina.

Miles, M. B., Huberman, A. M., & Saldaña, J. (2020). *Qualitative data analysis: A methods sourcebook* (4th ed.). SAGE.

Noprika, M., Yusro, N., & Sagiman, S. (2020). Strategi kepala sekolah dalam peningkatan mutu pendidikan. *Andragogi: Jurnal Pendidikan Islam dan Manajemen Pendidikan Islam, 2*(2), 224–243.

Ofita, C., Komariah, A., & Abubakar, A. (2024). Assessing digital leadership of junior high school principals. *Journal of Educational Management and Instruction, 4*(1), 127–139. https://doi.org/10.22515/jemin.v4i1.9502

Osterwalder, A., & Pigneur, Y. (2010). *Business model generation: A handbook for visionaries, game changers, and challengers*. John Wiley & Sons.

Priatmoko, S., Rahman, S. A., Inayah, S. R., Ekawati, R., & Mustakim, S. S. (2025). Exploration of religious character education in pesantren-based madrasah ibtidaiyah. *Mudarrisa: Jurnal Kajian Pendidikan Islam, 17*(1), 1–28. https://doi.org/10.18326/mudarrisa.v17i1.3329

Rohim, F., Jamaludin, M., & Hidayat, M. R. (2026). Reconstructing pesantren curriculum in the digital era: Integrating Islamic values and modern knowledge. *Sunan Kalijaga International Journal on Islamic Educational Research, 10*(1), 1–19. https://doi.org/10.14421/skijier.2026.101.01

Setiawati, R. A., & Tantriana, D. (2024). Rekonstruksi manajemen pengelolaan pesantren berbasis social entrepreneurship untuk mendorong kemandirian pesantren (Studi kasus Pondok Pesantren Sidogiri). *Jurnal Manajemen dan Inovasi (MANOVA), 7*(1), 117–129. https://doi.org/10.15642/manova.v7i1.1634

Yusuf, M., Ali, N., & Nur, M. A. (2024). Integrative curriculum management in shaping Muslim character in pesantren. *Ta'dib, 28*(2), 136–149. https://doi.org/10.19109/td.v28i2.20122

Zuhri, A., Mas'ud, A., & Syukur, F. (2025). Strengthening religious character in madrasah: Integrating pesantren values as an educational strategy. *Al-Tarbawi Al-Haditsah: Jurnal Pendidikan Islam, 10*(1), 71–92. https://doi.org/10.24235/tarbawi.v10i1.19819

ICISFS-UMK 2026 EARLY CHILDHOOD & INCLUSIVE EDUCATION

The Influence of Educational Media Based on Recycled Materials Using the Phonics Method on Letter and Number Literacy Ability

Ning Winantu[1*], Nur Fajrie[1] and Moch. Widjanarko[1]

[1]*Elementary Education Study Program, Faculty of Education, Universitas Muria Kudus, Indonesia*

ABSTRACT

Early childhood literacy and numeracy are basic skills that shape children's readiness for later learning. This study developed and implemented educational media made from recycled materials and combined with the phonics method to improve early childhood literacy and numeracy skills in Boyolali Regency. A mixed-methods approach was used, with a quasi-experimental non-equivalent control group pre-test and post-test design. Samples were selected by purposive sampling. The samples were (1) the experimental group: RA Nurul Ihsan, TK Pertiwi 4, and TK Batik Magersari (99 children); and (2) the control group: RA Rizky Karimah and TK LKMD Randusari (94 children). Data were collected through tests, observation, interviews, and documentation and were analysed in two stages: quantitative and qualitative. The results showed that (1) the recycled-material media with the phonics method had a significant effect on letter literacy and number numeracy; (2) according to observations and interviews, the learning process that combined concrete media with systematic phonics stages increased children's enthusiasm and active involvement and helped them understand abstract symbols more meaningfully; and (3) the mean ability of the experimental group was higher than that of the control group. The experimental group's mean post-test scores were 13.96 for letter literacy and 17.96 for number numeracy, compared with 11.95 and 11.95 in the control group.

KEYWORDS recycled materials-based educational media | phonics method | letter literacy | number numeracy | early childhood education

INTRODUCTION

Early Childhood Education (PAUD) institutions develop children's potential through activities matched to their growth and development. As stipulated in Article 3 of the National Education System Law No. 20 of 2003, formal early childhood education takes the form of Kindergarten (TK), which serves children aged four to six years and aims to develop every aspect of their development through engaging learning activities. Regulation of the Minister of Education and Culture No. 146 of 2014, Article 1, also frames PAUD around children's developmental needs (Kementerian Pendidikan dan Kebudayaan, 2014).

The PAUD curriculum rests on the Child Development Achievement Level Standards (STPPA), which cover six aspects: religious and moral values, physical-motor skills, cognitive skills, language, social-emotional skills, and arts (Hidayat & Nurlatifah, 2023). Cognitive and language growth at this age depends on what children can see, touch and manipulate. Media that let children handle objects make play easier to follow and more engaging (Nur Maulida et al., 2023), and young children learn best when they can manipulate objects directly and use several senses at once (Santrock, 2018).

Early literacy covers letter recognition, the link between sounds and written symbols, and the first steps in reading. Phonics instruction teaches the relationship between phonemes (sounds) and graphemes (letters) explicitly and in a planned sequence, which helps children grasp how the alphabetic system works (Campbell et al., 2025). In Indonesian kindergartens, phonics taught with letter cards improved the letter recognition of five-year-olds (Mayarita et al., 2024), and phonics supported by flash cards was reported to improve language development and early reading (Istiqomah et al., 2023). In a Jakarta kindergarten, children taught with phonics videos scored higher in pronunciation than children taught with flashcards (Patrisia et al., 2025).

Children differ in ability and developmental pace, so media for language learning need to be matched to the child (Rohlfing et al., 2024). Phonics for this age group also has to be concrete. Multisensory activities that

combine seeing, hearing, touching and moving have been linked to stronger phonemic awareness in first-grade literacy (Kilat & Apas, 2025). Phonics routines are also used at the pre-phonic level in Indonesian kindergartens, where songs and posters helped most children listen to and repeat the words they heard (Putri et al., 2022).

Numeracy at this age also needs concrete experience. Children have to link number symbols with real quantities before they can count meaningfully or carry out simple operations (Cahayani et al., 2022). Recycled materials such as cardboard, bottle caps and used paper are cheap, easy to find and can be turned into manipulative media. In one early childhood centre, activities with bottle caps, newspapers and cardboard increased children's engagement and supported fine motor skills, creativity and early ecological responsibility (Royani et al., 2025), and such media also build the reduce, reuse and recycle (3R) habit (Hajar et al., 2025). For numeracy, recycled-material games raised early numeracy mastery from 53.00% to 89.17% over two action research cycles with 15 children aged 5-6 (Pujiantie et al., 2026), and a bottle-cap counting activity improved quantity-numeral matching in a small design study in Pati Regency (Mahmud et al., 2026).

Even so, many PAUD units in Indonesia still make little use of recycled materials. Learning is dominated by printed books and manufactured toys, which tend to position children as passive recipients (Maghfiroh & Suryana, 2021). Literacy and numeracy are often taught through abstract writing and counting tasks, although young children need tangible objects to understand symbols. Loose parts made from natural or used materials offer an alternative. Teachers have used them to let children form letters with leaves and to support language and cognitive development (Rianti et al., 2022), and loose-parts media were reported to improve the literacy and numeracy of young children in Tasikmalaya (Mardia, 2023). Recycled media have also been used to teach early English reading (Novitasari et al., 2021).

Initial observations conducted in January 2026 at five kindergartens in Boyolali Regency (RA Nurul Ihsan, TK Pertiwi 4 Boyolali, TK Batik Magersari, RA Rizky Karimah, and TK LKMD Randusari) showed that children's literacy and numeracy skills were still low. Children had difficulty recognizing letters as language symbols, understanding the relationship between letters and their sounds, and applying numerical knowledge in real-world contexts. Reading and arithmetic learning was mostly conducted conventionally using textbooks and worksheets without interactive teaching aids. As a result, children's motivation to learn was low, and learning outcomes fell short of expectations. Previous research has shown that recycled media can enhance creativity, but few studies have assessed their effectiveness when combined with the phonics method (Royani et al., 2025). This gap motivates the present study of PAUD in Boyolali Regency.

Two theoretical ideas link these strands. In Piaget's account, children in the preoperational stage come to understand abstract symbols by acting on concrete objects (Marinda, 2020). In Vygotsky's account, learning advances when an adult gives graded support within the child's Zone of Proximal Development, and phonics taught with concrete aids gives teachers a natural way to provide this scaffolding (Istiqomah et al., 2023). Phonics itself focuses on sound-letter relationships so that children can recognize and spell words (Hildayanti et al., 2023). Using waste materials adds an environmental dimension, because environmental habits form through repeated practice (Rezeki et al., 2024). The approach also fits the Kurikulum Merdeka for PAUD, in which the teacher facilitates exploration and discovery (Motimona & Maryatun, 2023).

Earlier studies have examined parts of this combination. Adawiyah et al. (2022) used recycled water bottles in early childhood learning with an environmental focus, and Kilat and Apas (2025) studied multisensory approaches to phonemic awareness. Other studies paired concrete media with literacy and numeracy, such as STEAM with loose parts (Nufus et al., 2024) and a literacy suitcase (Nur Maulida et al., 2023), and Hirsh-Pasek et al. (2020) argued for playful learning with concrete materials. None of these studies used phonics as the language component. In practice, many teachers regard phonics as difficult and teach letters by rote, while recycled media are used mainly for creativity and motor skills. The studies reviewed here did not combine recycled-material media with the phonics method or measure letter literacy and number numeracy against a comparison group. This study addresses that gap in kindergartens in Boyolali Regency.

LITERATURE REVIEW

In this study, educational media based on recycled materials are educational games (APE) made from environmental waste such as cardboard, bottle caps, ice cream sticks and plastic, reprocessed into concrete learning tools (Novitasari et al., 2021). Letter literacy is the child's ability to connect letter sounds with their written symbols as a foundation for early reading, which goes beyond memorizing the alphabet (Hildayanti et al., 2023). Number numeracy is the child's ability to understand number concepts and quantities and apply them in everyday situations rather than counting by rote (Cahayani et al., 2022).

Research Objectives

This study aimed to determine and analyze: (1) the influence of educational media based on recycled materials using the phonics method on literacy and numeracy skills; (2) the process and results of literacy and numeracy learning with educational media made from recycled materials and the phonics method; (3) the extent of the influence of educational media based on recycled materials using the phonics method on improving literacy and numeracy skills in early childhood in Boyolali Regency.

RESEARCH METHOD

This study used a mixed methods approach (Sugiyono, 2019). The design was explanatory sequential mixed methods (Creswell & Creswell, 2018), and the quantitative strand used a quasi-experimental non-equivalent control group pre-test and post-test design. Subjects were divided into an experimental group (learning using recycled-based educational media and phonics methods) and a control group (conventional learning using worksheets).

The population comprised all RA and TK children in Boyolali Regency in the 2025/2026 academic year. Purposive *sampling* was used, based on sub-district location, ease of access, and number of students. The selected samples included: (1) Experimental Group consisting of RA Nurul Ihsan, TK Pertiwi 4 Boyolali, and TK Batik Magersari with a total of 99 children; (2) Control Group consisting of RA Rizky Karimah and TK LKMD Randusari with a total of 94 children. The total sample was 193 children.

Data collection techniques included tests (measuring literacy and numeracy skills), observation, interviews, and documentation. The test instruments were checked for validity, and their reliability was tested with *Cronbach's* alpha. The trial results showed that all test items were valid and reliable. The credibility of the qualitative data from observations and interviews was checked through source and method triangulation.

Data analysis was conducted in two stages. Quantitative analysis used descriptive and inferential statistics. Descriptive statistics were used to describe the mean, median, mode, maximum, minimum, and standard deviation values. Inferential statistics included assumption tests (the Kolmogorov-*Smirnov* normality test and the *One-Way ANOVA* homogeneity test) and hypothesis testing using non-parametric tests *(Wilcoxon Signed Ranks Test* and *Mann-Whitney U Test)* because the data were not normally distributed. Qualitative analysis followed the Miles and Huberman interactive model, which includes data collection, data reduction, data presentation, and drawing conclusions (Sugiyono, 2019).

RESULTS

Data Normality and Homogeneity Test

The assumption tests comprised a normality test and a homogeneity test. The results of the normality test using the *Kolmogorov-Smirnov* method showed that all data on literacy and numeracy abilities (both *pre-test* and *post-test)* in the experimental and control groups had a significance value *of Asymp. Sig. (2-tailed)* of *0.000 < 0.05*. This indicates that all data were not normally distributed. Therefore, the hypotheses were tested with non-parametric statistics, namely *the Wilcoxon Signed Ranks Test* and *the Mann-Whitney U Test. Levene's Test* of homogeneity of variance gave an ANOVA p-*value* of 0.582 (> 0.05) for the literacy pre-test and 0.978 (> 0.05) for the numeracy pre-test. These results indicate that the pre-test variances of the experimental and control groups were homogeneous.

Hypothesis Testing

Table 1. Results of the test of differences in literacy skills of the experimental and control groups (post-test)

Ranks				
	code	N	Mean Rank	Sum of Ranks
literacy_letter_posttest	experiment	99	137.46	13608.50
	control	94	54.39	5112.50
	Total	193		

Test Statistics[a]	
	literacy_letter_posttest
Mann-Whitney U	647.500
Wilcoxon W	5112.500
Z	-10.624
Asymp. Sig. (2-tailed)	.000
a. Grouping Variable: code	

Table 1 shows a Z value of -10.624 with p = *0.*000 (< *0.*05). This indicates a significant difference in literacy skills between the experimental and control groups after treatment. The mean score of the experimental group *(13.96 ± 0.81)* was higher than that of the control group *(11.95 ± 1.01)*. Thus, educational media based on recycled materials with the phonics method improved young children's literacy skills more than conventional learning did.

Table 2. Results of the difference test between the numeracy ability of the experimental and control groups (post-test)

Ranks				
	kode	N	Mean Rank	Sum of Ranks
numeracy_number_posttest	experiment	99	142.59	14116.00
	control	94	48.99	4605.00
	Total	193		

Test Statistics[a]	
	literacy_number_posttest
Mann-Whitney U	140.000
Wilcoxon W	4605.000
Z	-11.868
Asymp. Sig. (2-tailed)	.000
a. Grouping Variable: code	

Table 2 shows a Z *value* of -11.868 with p = *0.000* (< 0.05). This indicates a significant difference in number numeracy between the experimental and control groups at *post-test*. The experimental group's mean score (*17.96* ±

0.90) was higher than that of the control group (*11.95* ± 1.09). These results indicate that manipulative media made from recycled materials contributed more to young children's numerical thinking than conventional learning.

Table 3. Test results of the effect of educational media based on recycled materials using the phonics method on students' letter literacy

Ranks				
		N	Mean Rank	Sum of Ranks
literacy_letter_posttest_ex - literacy_letter_prettest_ex	Negative Ranks	0[a]	.00	.00
	Positive Ranks	99[b]	50.00	4950.00
	Ties	0[c]		
	Total	99		
a. literacy_letter_posttest_ex < literacy_letter_prettest_ex				
b. literacy_letter_posttest_ex > literacy_letter_prettest_ex				
c. literacy_letter_posttest_ex = literacy_letter_prettest_ex				

Test Statistics[a]	
	literacy_letter_posttest_ex - literacy_letter_prettest_ex
Z	-8.757[b]
Asymp. Sig. (2-tailed)	.000
a. Wilcoxon Signed Ranks Test	
b. Based on negative ranks.	

Table 3 shows *the Wilcoxon test* results for *the* experimental group: Z = -8.757, p = 0.000 (< 0.05). This result indicates a significant effect of educational media based on recycled materials with *the* phonics method on children's letter literacy. The mean letter literacy score rose from *9.59* ± *1.23* at *pre-test* to *13.96* ± *0.81* at *post-test*, and no child's score decreased *(negative ranks* = 0).

Table 4. Test results of the effect of educational media based on recycled materials using the phonics method on students' number numeracy

Ranks				
		N	Mean Rank	Sum of Ranks
numeracy_number_posttest_ex - numeracy_number_prettest_ex	Negative Ranks	0[a]	.00	.00
	Positive Ranks	99[b]	50.00	4950.00
	Ties	0[c]		
	Total	99		
a. numeracy_number_posttest_ex < numeracy_number_prettest_ex				
b. numeracy_number_posttest_ex > numeracy_number_prettest_ex				
c. numeracy_number_posttest_ex = numeracy_number_prettest_ex				

Test Statistics[a]	
	numeracy_number_posttest_ex - numeracy_number_prettest_ex
Z	-8.753[b]
Asymp. Sig. (2-tailed)	.000
a. Wilcoxon Signed Ranks Test	
b. Based on negative ranks.	

Table 4 shows that the *Wilcoxon Signed Ranks Test* on the number numeracy variable produced Z = -8.753 with p = 0.000 (< 0.05). The recycled-media intervention therefore significantly improved number numeracy in the experimental group. The mean score rose from *12.33* ± *0.81* at *pre-test* to *17.96* ± *0.90* at post-*test*, which supports the use of manipulative stimulation with real objects.

Learning Process of Educational Media Based on Recycled Materials Using the Phonics Method in Improving Letter Literacy and Number Numeracy Skills

Learning with educational media based on recycled materials and the phonics method is a form of multisensory learning that combines local environmental wisdom with language and cognitive stimulation for young children. In the opening activities, children are introduced to letters and numbers using picture media and physical cards. The teacher shows the letter and number symbols directly. The children then say the letter sounds (phonemes) and match the symbols with quantities through interactive games. Letter literacy is developed by introducing letter shapes gradually through question and answer and repetition. Number numeracy is developed by asking children to count concrete objects and match them with the appropriate number symbols. This method appeared to increase children's activeness, concentration, and confidence to participate in class.

Learning also combines auditory and visual elements through digital media in the form of an interactive learning video. Children imitate the phonics sounds repeatedly, together and individually, which trains their phonological awareness. The dynamic visuals of the digital media also make children more focused and enthusiastic. At the concrete manipulation stage, children use media made from used materials such as bottle caps and cardboard to match graphemes with phonemes and to manipulate objects when counting from 1 to 10. This hands-on experience stimulates children's kinesthetic abilities through cutting, sticking, and assembling recycled objects. Physical contact with real objects may also strengthen children's long-term memory of early literacy and mathematics concepts.

Field data showed a clear shift in achievement categories in the experimental group. For literacy, most children were in the Starting to Develop (MB) category before the intervention (76 children, 76.77%); after treatment, 95 children (95.96%) reached the Developing According to Expectations (BSH) category. For number numeracy, 95 children (95.96%) were in the Developing According to Expectations (BSH) category before treatment, and after treatment 71 children (71.72%) reached the Very Well Developed (BSB) category. These findings indicate that integrating concrete media with the phonics method supports young children's mastery of symbols.

In-depth interviews indicated that the institutions were ready to sustain this innovation. In the experimental class, teachers actively produced recycled media (bottle caps, cardboard), which appeared to increase children's multisensory attention. In the control class, learning was monotonous because it relied heavily on textbooks and conventional worksheets; children quickly became bored, and letter mastery progressed more slowly. Although there were several technical challenges, such as time management and technological understanding, educators overcame these through individual *scaffolding* strategies and interactive repetition of material to maintain children's focus.

DISCUSSION

The results indicate that children taught with recycled-material media and the phonics method scored higher in both letter literacy and number numeracy than children taught with conventional worksheets. The post-test differences between groups were significant for literacy ($Z = -10.624$) and numeracy ($Z = -11.868$), and the experimental group improved from pre-test to post-test on both measures ($p = 0.000$). Because the groups were intact kindergartens rather than randomly assigned classes, these differences are best read as evidence that the intervention was associated with higher scores, not as proof of a causal effect.

Effectiveness of Recycled Media on Letter Literacy

In letter literacy, the experimental group's post-test mean rank was 137.46, against 54.39 for the control group (Table 1). Its mean score rose from 9.59 to 13.96, and every child scored higher at post-test than at pre-test (Table 3). A likely mechanism is the order of instruction. The phonics stages asked children to link each phoneme with its grapheme before naming letters, and the bottle-cap and cardboard letters gave them something to hold and move while they did so. This matches research that treats sound-symbol knowledge as a basis for early reading (Snowling et al., 2022) and the view that explicit, sequenced phonics helps children understand the alphabetic system (Campbell et al., 2025). The result agrees with Indonesian kindergarten studies in which phonics with letter cards or flash cards improved letter recognition and early reading (Istiqomah et al., 2023; Mayarita et al., 2024). It also agrees with Patrisia et al. (2025), whose phonics-video group outperformed a flashcard group, although that study compared two media within phonics while this study compared phonics with recycled media against worksheet learning. Rianti et al. (2022) showed that children can form letters from loose parts; the present results suggest that such manipulation is more useful when it is tied to letter sounds. For teachers, recycled letter media are worth making when they are used within a planned phonics sequence, not only as free play.

Influence on Number Numeracy Ability

In number numeracy, the gap between the groups was larger. The experimental group's post-test mean rank was 142.59 against 48.99 for the control group (Table 2), and its mean score rose from 12.33 to 17.96, again with no child scoring lower at post-test (Table 4). Counting bottle caps and matching them with number cards gives children repeated practice in one-to-one correspondence. In Bruner's terms, children worked first at the enactive level with objects before moving to pictures and number symbols. Recent Indonesian studies show a similar pattern: early numeracy mastery rose across two action research cycles with recycled-material games (Pujiantie et al., 2026), and a bottle-cap counting activity improved quantity-numeral matching among four children in Pati Regency (Mahmud et al., 2026). Both studies were small and had no control group, so the present comparison with 94 control children adds stronger, though still non-randomized, evidence. A meta-analysis of guided play found a small advantage over direct instruction for early mathematics ($g = 0.24$; Skene et al., 2022). The much larger difference here may reflect the contrast with worksheet teaching, the close match between the test and the activities, or initial group differences that were not reported. One result needs caution: the category data show that 95.96% of the experimental group were already at the Developing According to Expectations level in numeracy before the intervention, which does not fit the low baseline described in the preliminary observations. For teachers, counting with recycled objects is a low-cost way to make number symbols concrete, and it can be built into daily routines such as tidying and sorting.

Psychological Responses and Student Engagement

Observations and interviews suggest how the scores may have changed. Children in the experimental classes handled, cut, stuck and assembled the materials, asked more questions and stayed on task longer, whereas teachers in the control classes described worksheet lessons as monotonous. These are observations, not measured outcomes, but they are consistent with Royani et al. (2025), who reported higher engagement and fine motor practice when children worked with bottle caps, newspapers and cardboard. Teachers also adjusted their support to each child's pace, which fits the idea of scaffolding within the Zone of Proximal Development (Istiqomah et al., 2023). The approach matches the Kurikulum Merdeka for PAUD, in which teachers facilitate exploration (Motimona & Maryatun, 2023), and environmental education that builds habits through practice (Rezeki et al., 2024). For principals and PAUD units in Boyolali, the implication is practical. Teachers need time and shared space to collect and prepare materials, short training in phonics sequencing would help them use the media systematically, and enough sets are needed for every child. The interviews named time management and the use of technology as the main difficulties, which such support could address.

This study has several limitations. First, the groups were intact kindergartens chosen by purposive sampling, and no pre-test comparison between groups is reported, so initial differences cannot be ruled out. Second, the control group's pre-test to post-test change and effect sizes are not reported, so the share of the improvement

attributable to the media is unclear. Third, the means and standard deviations cited in the text do not appear in the tables, and the control group has the same mean (11.95) for both outcomes, which should be checked. Fourth, the intervention combined recycled media, phonics stages and an interactive video, so the contribution of each component cannot be separated. Fifth, the qualitative evidence comes from observations and interviews with the teachers who delivered the programme, and retention after the intervention was not tested. Future studies should assign classes randomly where possible, report descriptive statistics and effect sizes for both groups, add a delayed post-test, and compare recycled media with and without phonics.

CONCLUSION AND RECOMMENDATIONS

Conclusions

Three conclusions can be drawn: (1) educational media based on recycled materials with the phonics method had a significant effect on the literacy and numeracy skills of young children in Boyolali Regency, with non-parametric tests giving p = *0.000* (< *0.05)* for both main variables; (2) a learning process that combines concrete manipulative media (bottle caps, cardboard, plastic) with a coherent phonics method stimulates children's visual, auditory, and kinesthetic senses together, and the observations and interviews suggest that this multisensory model made learning more active and exploratory and sustained children's attention; (3) the experimental group's mean post-test scores (13.96 for literacy and 17.96 for numeracy) were higher than those of the control group (11.95 for both).

Recommendations

Based on these conclusions, the following suggestions are proposed: (1) Teachers should continue to develop creative learning media based on natural materials or loose parts to maintain children's interest in learning. Teachers need to deepen their mastery of phonics methods systematically so that they can provide appropriate stimulation according to the unique characteristics of each child; (2) School principals and educational units should provide support in the form of facilities and space for teachers to share good practices related to the development of creative educational media. Regular training for teachers should be scheduled, especially regarding the latest literacy-numeracy teaching methods and mastery of technology to support the creation of teaching media; (3) Future researchers should conduct studies with a wider area of coverage to strengthen the generalization of research results. Future researchers can focus on developing more durable recycled media innovations so that they can be used repeatedly in the long term. They could also study media logistics in more depth so that the number of teaching aids in a class matches the number of children and all children can participate actively.

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REFERENCES

Adawiyah, R., Kurnia, L., & Khoeriah, A. (2022). Pemanfaatan water bottle recycling pada pembelajaran anak usia dini. *Journal of Early Childhood Education*, 1(1), 1–12.

Cahayani, N. N., Witono, A. H., & Setiawan, H. (2022). Profil kemampuan numerasi siswa kelas III SDN 2 Kuta tahun pelajaran. *Jurnal Ilmiah Profesi Pendidikan*, 7, 534–538.

Campbell, S., Neumann, M. M., & Friend, L. (2025). Teaching phonics and vocabulary through children's literature in early childhood initial teacher education: Trial of the Non-Scripted Intentional Teaching (N-SIT) tool. *Education Sciences*, 15(6), 684. https://doi.org/10.3390/educsci15060684

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). Sage.

Hajar, D., Antika, W., & Setiawan, D. (2025). Pengembangan media pembelajaran smart train PAUD berdasarkan prinsip reuse. *Jurnal Penelitian dalam Bidang Pendidikan Anak Usia Dini*, 14(2), 280–295. https://doi.org/10.26877/paudia.v14i2.1490

Hidayat, Y., & Nurlatifah, L. (2023). Analisis komparasi tingkat pencapaian perkembangan anak usia dini (STPPA) berdasarkan Permendikbud No. 137 Tahun 2014. *Intisabi*, 1(1), 29–40.

Hildayanti, A., Ibrahim, R. D., & Suardi, D. (2023). Pendampingan kemampuan literasi anak melalui pembelajaran fonik (Assisting children's literacy skills through phonics learning). *Jurnal Pengabdian Kepada Masyarakat*, 3(4), 73–78.

Hirsh-Pasek, K., Hadani, H. S., Blinkoff, E., & Golinkoff, R. M. (2020). *A new path to education reform: Playful learning promotes 21st-century skills in schools and beyond*. Brookings Institution.

Istiqomah, R., Sumiharsono, R., & Triwahyuni, E. (2023). Pengaruh penggunaan metode fonik berbantuan flash card terhadap perkembangan bahasa anak dan kemampuan membaca awal anak TK. *Edukasia: Jurnal Pendidikan dan Pembelajaran*, 4(2), 1415–1424. https://doi.org/10.62775/edukasia.v4i2.456

Kementerian Pendidikan dan Kebudayaan. (2014). *Peraturan Menteri Pendidikan dan Kebudayaan Republik Indonesia Nomor 146 Tahun 2014 tentang Kurikulum 2013 Pendidikan Anak Usia Dini*.

Kilat, M. L., & Apas, R., Sr. (2025). Multisensory learning approaches on phonemic awareness among first-grade literacy development. Psychology and Education: A Multidisciplinary Journal, 43(10), 1316–1324. https://doi.org/10.70838/pemj.431004

Maghfiroh, S., & Suryana, D. (2021). Media pembelajaran untuk anak usia dini di pendidikan anak usia dini. *Jurnal Pendidikan Tambusai*, 5(2), 1560–1566.

Mahmud, S., Niswah, K., & Ruiyat, S. A. (2026). Numeracy-on-a-budget: A design-based study of low-cost embodied numeracy using recycled manipulatives in early childhood. The International Journal of Emerging Issues in Early Childhood Education, 8(1), 62–76. https://doi.org/10.33830/ijeiece.v8i1.13738

Mardia, R. (2023). Efektivitas penggunaan media loose parts dalam meningkatkan kemampuan literasi numerasi anak usia dini se-Kecamatan Cipedes Kota Tasikmalaya. Al-Marifah: Journal Pendidikan Islam Anak Usia Dini, 2(1), 1–23.

Marinda, L. (2020). Piaget dan problematikanya pada AUD. *Jurnal Kajian Perempuan & Keislaman*, 13(1), 116–152.

Mayarita, Y., Amelasasih, P., & Yulyanto, Y. (2024). The effectiveness of the Jolly Phonics method on letter recognition ability in 5-year-old children through letter card media. *Jurnal Impresi Indonesia*, 3(2), 176–183. https://doi.org/10.58344/jii.v3i2.4640

Motimona, P. D., & Maryatun, I. B. (2023). Implementasi metode pembelajaran STEAM pada Kurikulum Merdeka untuk PAUD. Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini, 7(6), 6493–6504. https://doi.org/10.31004/obsesi.v7i6.4682

Novitasari, Y., Prastyo, D., Iftitah, S. L., Reswari, A., & Fauziddin, M. (2021). Media daur ulang (recycle system) dalam kemampuan membaca bahasa inggris awal anak usia dini. *Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini*, 6(3), 1323–1330. https://doi.org/10.31004/obsesi.v6i3.1209

Nufus, A., Arianto, F., & Dewi, U. (2024). Pengaruh pendekatan STEAM-loose parts terhadap kemampuan literasi numerasi anak usia dini. *Edukasia: Jurnal Pendidikan dan Pembelajaran*, 5(1), 123–126. https://doi.org/10.62775/edukasia.v5i1.724

Nur Maulida, D., Labiba Kusna, S., & Puspitasari, E. (2023). Pengembangan media pembelajaran koper literasi untuk menstimulasi kemampuan literasi anak usia 5-6 tahun. *Murhum: Jurnal Pendidikan Anak Usia Dini*, 4(2), 568–579. https://doi.org/10.37985/murhum.v4i2.330

Patrisia, W., Widayat, E., & Huda, N. (2025). Application of video phonics media towards pronunciation and cognitive development of English learning children of preschool age Saint Nicholas Kindergarten Pantai Indah Kapuk Jakarta. Jurnal Teknologi Pendidikan: Jurnal Penelitian dan Pengembangan Pembelajaran, 10(1), 154–162. https://doi.org/10.33394/jtp.v10i1.14028

Pujiantie, T., Elnawati, E., & Maulana, R. A. (2026). Peningkatan early numeracy melalui permainan berbasis recycled materials pada anak usia 5–6 tahun. Journal of Education Research, 7(3), 2105–2116. https://doi.org/10.37985/jer.v7i3.4066

Putri, N. A. N., Rahmawati, I. Y., & Kristiana, D. (2022). Implementasi model pembelajaran Cerdas Berbahasa Indonesia Fonik (CBI FONIK) dalam menstimulus kemampuan menyimak anak usia dini. Jurnal Paedagogy, 9(4), 772–781. https://doi.org/10.33394/jp.v9i4.5480

Rezeki, T. I., Irwan, Sagala, R. W., Rabukit, Helman, & Muhajir, M. (2024). Edukasi pengelolaan sampah berbasis kearifan lokal untuk lingkungan berkelanjutan. *Jurnal Abdimas Maduma*, 3(2), 9–19. https://doi.org/10.52622/jam.v3i2.290

Rianti, R., Nurjanah, I., Latifah, D., Alifah, N., & Asyiah, A. (2022). Freedom learning on early childhood education: Implementation of STEAM method with loose parts media. Golden Age: Jurnal Ilmiah Tumbuh Kembang Anak Usia Dini, 7(2), 99–108. https://doi.org/10.14421/jga.2022.72-05

Rohlfing, K. J., Wildt, E., & Tolksdorf, N. F. (2024). Language learning with media and technology in (early) childhood. Dzieciństwo. Literatura i Kultura, 6(1), 35–69.

Royani, I., Suriyani, S., & Tjahyaningsih, R. (2025). Utilizing recycled materials as innovative educational media to enhance early childhood learning. International Journal Education and Computer Studies, 5(2). https://doi.org/10.35870/ijecs.v5i2.5077

Santrock, J. W. (2018). *Educational psychology* (6th ed.). McGraw-Hill Education.

Skene, K., O'Farrelly, C. M., Byrne, E. M., Kirby, N., Stevens, E. C., & Ramchandani, P. G. (2022). Can guidance during play enhance children's learning and development in educational contexts? A systematic review and meta-analysis. Child Development, 93(4), 1162–1180. https://doi.org/10.1111/cdev.13730

Snowling, M. J., Hulme, C., & Nation, K. (Eds.). (2022). *The science of reading: A handbook* (2nd ed.). Wiley-Blackwell.

Sugiyono. (2019). *Metode penelitian kuantitatif, kualitatif, dan R&D*. Alfabeta.

ICISFS-UMK 2026 EDUCATIONAL TECHNOLOGY & MEDIA

Development of Android Media to Enhance Literacy-Numeracy of Kudus Elementary Students

Nur Hasan[1*], Edris Zamroni[1] and Sri Utaminingsih[1]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: hasann243@gmail.com

ABSTRACT

This study analyzed needs and developed a literacy and numeracy learning game for Grade IV elementary students. The media is an Android application that can be used on computers, Android devices, and other gadgets, both online and offline. The study also examined the effectiveness of this "Smart Apps Creator-Based Android" game in improving the basic literacy and numeracy skills of Phase B students in the Adipati Unus Cluster, Dawe Subdistrict, Kudus Regency. The study followed the Borg and Gall Research and Development (R&D) model, and the media were assessed for validity, practicality, and effectiveness. Qualitative data were gathered through interviews and observations, and quantitative data came from questionnaires and tests. The needs analysis showed strong demand for learning media with literacy and numeracy practice questions. The media achieved an average content validity score of 87.5% and a media expert validation score of 85%. Teacher (user) validation reached an average of 80%, placing the media in the “Highly Feasible” category. Student and teacher responses averaged 80.97% and 86.28%, which place teachers in the “Positive” range of the rating scale (81%-100%) and students at the upper limit of the “Fair” range (61%-80%). A t-test showed t-count > t-table (4.822 > 1.674), indicating a significant difference between the experimental and control groups. The Smart Apps Creator-based media therefore appears effective in improving the literacy and numeracy skills of Grade IV students, and teachers may use it as an alternative learning resource.

KEYWORDS development | learning media | Smart Apps Creator | literacy | numeracy

INTRODUCTION

Literacy and numeracy are fundamental competencies that people need in order to meet the demands of modern life. Numeracy goes beyond basic arithmetic skills and includes the ability to interpret, analyze, and apply numerical information in everyday life. Mastery of these skills is an indicator of educational success, especially at the primary level, and is linked to 21st-century learning, which emphasizes critical thinking, creativity, communication, and collaboration.

In Indonesia, many elementary students have not yet reached the minimum standard in literacy and numeracy. Indonesia's PISA 2022 results in reading and mathematics remained well below the OECD average (OECD, 2023), and at the primary level a case study found that a fourth-grade student answered only 17.65% of the AKM numeracy geometry items correctly (Sari et al., 2021). One contributing factor is the continued use of conventional methods that give students few chances to practise actively and make little use of technology. At the same time, most families now own Android devices, which makes interactive digital practice media easier to reach than before.

One such innovation is Smart Apps Creator (SAC), a platform that enables teachers to create interactive Android-based learning media without programming skills. This study develops game-based learning media with SAC to support literacy and numeracy skills in Grade IV students across the Adipati Unus cluster, Dawe District, Kudus Regency.

SAC-based media are expected to offer an engaging and personalized learning experience. By combining educational content with interactive visuals, they may address limited instructional tools and low student enthusiasm and improve understanding and learning outcomes. This research therefore aims to design Android-based media and test their effectiveness in improving students’ literacy and numeracy skills.

LITERATURE REVIEW

Instructional media are the channel through which teachers deliver information to students. Wulandari et al. (2023) describe media as a communication tool between the teacher and the student, which makes media a core part of learning rather than a supplement. For literacy and numeracy in particular, Jayanti et al. (2023) reported that elementary students needed media such as comics to support their practice.

Evidence on game-based and mobile media is generally positive. A meta-analysis of 110 studies found a moderate mean effect (0.523) for integrating mobile devices into teaching and learning (Sung et al., 2016), and a meta-analysis of 18 studies found positive effects of digital game-based learning on primary-school outcomes, especially in mathematics, language and science (Behnamnia et al., 2024). In Indonesia, a meta-analysis of 15 experimental studies reported a mean effect size of 1.146 for interactive multimedia on learning outcomes, with the highest estimate at the elementary level (Khaeruman et al., 2023). Local development studies point the same way. Rahayu et al. (2024) reported that the Math Play Cerbil game increased students' participation and understanding of number concepts, Hidayati and Rezania (2023) found educational games practical in classrooms, and Kirom and Aini (2023) developed an inquiry-based educational game for elementary literacy and numeracy. Hilyana et al. (2024) also argue that Android-based media are needed to improve learning.

Smart Apps Creator (SAC) is a multimedia-based development platform that enables teachers and students to create interactive educational applications without the need for programming skills (Wahyuni et al., 2023). Teachers have used it for integer operations (Arnandi et al., 2022), STEAM-based mathematics (Sirait et al., 2024), project-based mathematics media (Desramaza et al., 2023), contextual IPAS lessons in Grade IV (Edray & Hamimah, 2023) and self-regulated mathematics learning (Nasrullah et al., 2022). Related interactive media have been developed for the water cycle in Grade V science (Fahruji et al., 2022) and for fractions with a contextual approach (Khoirunisa et al., 2023). Its key advantages include a user-friendly interface, multimedia support (text, audio, video, images, animation), and compatibility with platforms such as Windows, Android, and iOS. These features allow teachers to create interactive and attractive instructional media.

To ensure quality, SAC-based media should be developed through a structured process. Sari and Harjono (2021) describe this process as needs analysis, content design, development, implementation, and evaluation. Following these steps helps make the product relevant, engaging, and suited to students' characteristics and learning goals. Visual design (color, layout, animation, and simple navigation) also matters, because multimedia learning depends on how learners combine words and pictures (Mayer, 2014).

Lestari and Hidayati (2023) also argue that SAC's strength is its ability to integrate media elements interactively and in context. Media designed around students' real-world experiences can make literacy and numeracy learning more accessible and relevant. Ningkrum et al. (2024) found that students' interest and enthusiasm in the learning process contribute positively to achieving learning goals.

SAC studies with evaluated outcomes already exist. Rochman et al. (2024) followed the Borg and Gall model and reported validity of 85% and practicality of 86% for SAC multimedia on digital literacy, Rohman et al. (2024) developed SAC media for critical thinking in physics, and Anggraeni et al. (2025) reported a high N-gain (85.11%) for SAC media in Grade 5 Pancasila education against a moderate gain (44.57%) in the control class. Most of these products serve a single subject, and most report expert validity and user practicality without a comparison group. Few combine literacy and numeracy practice in one game for Phase B students, and none of those reviewed was developed with the schools of a single cluster in Kudus Regency. This study therefore develops a SAC-based Android game for literacy and numeracy practice from a needs analysis in the Adipati Unus Cluster and tests it against a control group. The conceptual framework links the identified problem (low literacy and numeracy performance), the solution (interactive game-based practice media) and the expected outcomes (improved skills and learning engagement).

Research Objectives

This study aimed to identify students' needs for Android-based learning media using Smart Apps Creator, to produce valid, practical, and effective media for literacy and numeracy learning, and to evaluate the effectiveness of the media in improving students' literacy and numeracy skills.

RESEARCH METHOD

Research Design

This study used the research and development (R&D) method based on the Borg and Gall model (Gall et al., 2007), which develops and tests educational media systematically for validity, practicality, and effectiveness in improving students' literacy and numeracy skills using Smart Apps Creator.

Respondents of the Study

The population comprised 168 Grade 4 students from six elementary schools in Kudus Regency, Indonesia. Cluster sampling was used because the principals of the selected schools could allow only limited time. Permission to conduct the study was obtained from the respective elementary school principals.

The instruments utilized in this study comprised both qualitative and quantitative research tools. The qualitative instruments consisted of interview protocols and observation sheets for product usage. The quantitative instrument was a product evaluation rating scale designed to measure the quality and effectiveness of the developed media.

Table 1. Score ranges and qualitative descriptions for the rating-scale results

Mean	Qualitative Description
0% – 40%	Negative
41% – 60%	Poor
61% – 80%	Fair
81% – 100%	Positive

RESULTS

The following sections present the results of developing Android-based instructional media with SAC to improve Grade IV students' literacy and numeracy skills.

The questionnaire responses in Table 2 show that most students prefer practice media that are enjoyable and suited to 21st-century learners.

Table 2. Questionnaire results on students' needs analysis for Smart Apps Creator media

No	Evaluated Aspects	Questionnaire Results
1	Interested in educational game media	86%
2	Experiencing difficulties in literacy and numeracy questions	72%
3	In need of interactive practice exercises	90%
4	Having access to Android devices at home	93%

These data indicate a need for Android-based "Smart Apps Creator" practice media to support elementary students' literacy and numeracy skills.

The product developed in this study is an Android-based educational game media designed for literacy and numeracy practice, specifically intended for students in Phase B.

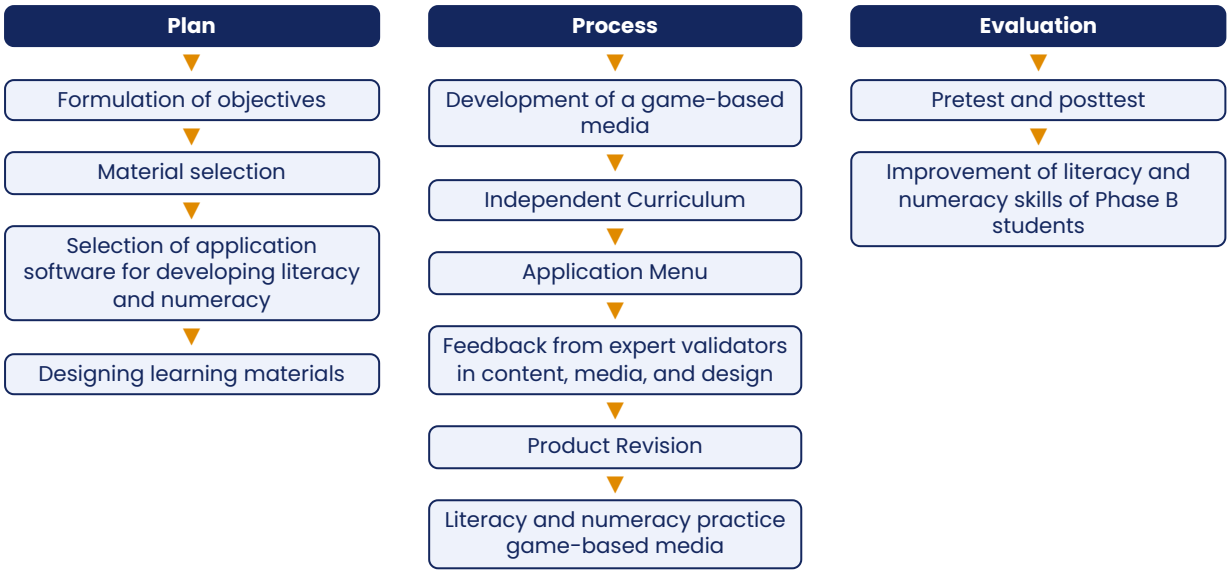

Figure 1. Design of game-based media for literacy and numeracy practice development

The research results indicate a significant difference between the two groups. Students in the experimental group, who used the game-based literacy and numeracy practice media, had higher mean scores than students in the control group, who did not.

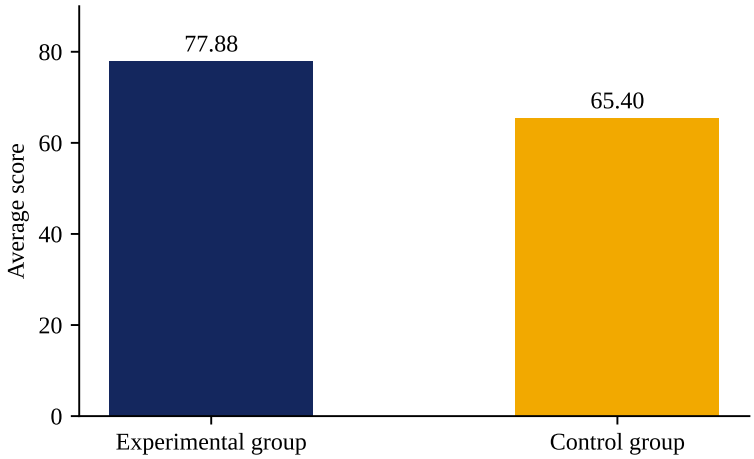

Figure 2. Average score diagram of the experimental and control groups

The experimental group obtained a mean score of 77.88 (highest 92, lowest 60), and the control group a mean of 65.40 (highest 80, lowest 48). These results suggest that the literacy and numeracy game media had a positive effect on students' learning outcomes.

The product was also evaluated through teacher and student response questionnaires distributed during the main field trial. The results are summarized in the following tables.

Table 3. Student response questionnaire results

No	Aspects Assessed	Percentage
1	Appearance	81,25 %
2	Presentation	80,33%
3	Usefulness	81,33%
Overall Average Percentage Score		80,97%

Table 4. Teacher response questionnaire results

No	Aspects Assessed	Percentage
1	Appearance	85,93%
2	Presentation	85,41%
3	Usefulness	87,50 %
Overall Average Percentage Score		86,28%

The questionnaire results show that students and teachers responded positively to the media. Students appeared enthusiastic, active, and interested in using the Smart Apps Creator media as a learning tool. Their enthusiasm was reflected in comments on the ease of use, attractive visual design, and interactive features, which motivated them to complete literacy and numeracy exercises independently and in groups. These responses indicate that the media are practical and can increase students' interest and motivation to learn.

DISCUSSION

The needs analysis showed a clear demand for game-based practice. In Table 2, 86% of students were interested in educational game media, 72% reported difficulties with literacy and numeracy questions, 90% wanted interactive practice exercises, and 93% had access to an Android device at home. High device access matters because a mobile app can extend practice beyond class time, and a meta-analysis found a moderate mean effect for learning with mobile devices (Sung et al., 2016). The same figures show the limit of the approach: the 7% without a device at home would depend on school devices, so the media suit classroom and school-library use as well as homework. The offline mode of the app is useful in this respect, because connectivity in Dawe Subdistrict schools cannot be assumed.

The validation and response data indicate that the product was judged appropriate. Content and media experts gave average scores of 87.5% and 85%, and teacher validation averaged 80%. In the main field trial, students rated the media at 80.97% and teachers at 86.28% (Tables 3 and 4). Teachers gave the highest rating to usefulness (87.50%), and students rated appearance highest (81.25%) and presentation lowest (80.33%). These values are close to those of other SAC products. Rochman et al. (2024) reported 85% validity and 86% practicality, and Anggraeni et al. (2025) reported 91.67% expert feasibility with practicality of 90% from teachers and 96.6% from students. The slightly lower student ratings here may reflect Grade IV students' reading load in text-heavy screens. Multimedia learning theory suggests that pairing short text with images and audio reduces this load (Mayer, 2014), which is a concrete point for revision. These ratings measure perceived quality, not learning, so they support the practicality of the media rather than its effect.

On the learning test, the experimental group obtained a mean of 77.88 (range 60-92) and the control group 65.40 (range 48-80), and the t-test reported in the abstract ($t = 4.822 > 1.674$) indicates that the difference is significant. A likely mechanism is the amount and type of practice. The game gave students many short literacy and numeracy items with immediate feedback, whereas the control group practised with ordinary exercises. Game elements such as scores and levels may also have kept students working for longer; a review of elementary mathematics studies found that regular use of educational games improved engagement and conceptual understanding (Nurhaliza et al., 2025). The response data fit this reading, since students rated usefulness at 81.33% (Table 3), but engagement was not measured directly. This direction agrees with meta-analytic evidence on interactive multimedia in Indonesian classrooms (Khaeruman et al., 2023) and on digital game-based learning in primary schools (Behnamnia et al., 2024). It also agrees with Anggraeni et al. (2025), where the SAC class gained more than the control class, and with Sya'adah et al. (2025), who found a significant gain in IPAS concept understanding with SAC media. Unlike those single-subject studies, the present media combined literacy and numeracy items, but the paper reports one combined score, so it cannot show whether the game helped reading, numeracy or both. The spread of scores also deserves attention. The lowest experimental score (60) was above the lowest control score (48), but the ranges overlap widely, so some students in the experimental group still performed below many control students and will need additional teacher support.

For teachers in the Adipati Unus Cluster, the media can serve as a practice tool after direct teaching, not as a replacement for it. Short sessions with the game can be used for differentiated practice, with students who finish early moving to harder items. Principals can support this by providing shared devices for students without one at home and by using cluster teacher meetings (KKG) to share and revise the app. Because SAC requires no programming, teachers can also adapt the items to local contexts, which other SAC studies have done for mathematics and IPAS (Arnandi et al., 2022; Edray & Hamimah, 2023). At district level, such teacher-made apps could support preparation for the national literacy and numeracy assessment, provided that the items are checked against its framework.

This study has several limitations. The Method does not report how students were assigned to the experimental and control groups, the size of each group, whether a pre-test was given, or which t-test was used, so initial differences between the groups cannot be ruled out. No effect size is reported. The expert validation and t-test results appear only in the abstract, and the student and teacher questionnaires are self-reports of perceived quality. The trial was short and limited to one cluster of schools in Kudus Regency, and retention was not tested. Future studies should report a pre-test and post-test for both groups with group sizes, normality tests and effect sizes, score literacy and numeracy separately, include a delayed post-test, and test the app in schools with lower device access.

CONCLUSION

The development of the media was based on curriculum analysis and the needs of both teachers and students in Phase B. The research findings indicate that the learning media based on Smart Apps Creator for literacy and numeracy practice is considered appropriate for use. Expert validation rated the media as suitable for interactive, enjoyable, and meaningful learning, and the experimental group's higher post-test scores indicate that the media can improve the basic literacy and numeracy skills of Phase B elementary school students.

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REFERENCES

Anggraeni, A., Erita, Y., Nora, D., & Rahmi, U. (2025). Development of Smart Apps Creator-based interactive learning media to support 21st century skills in Pancasila education for elementary schools. Jurnal Kependidikan, 11(2), 702–712. https://doi.org/10.33394/jk.v11i2.15136

Arnandi, F., Siregar, N., & Fitriawan, D. (2022). Media pembelajaran matematika menggunakan Smart Apps Creator pada materi bilangan bulat di sekolah dasar. Plusminus: Jurnal Pendidikan Matematika, 2(3), 345–356. https://doi.org/10.31980/plusminus.v2i3.1110

Behnamnia, N., Kamsin, A., & Hayati, S. (2024). Impact of digital game-based learning on STEM education in primary schools: A meta-analysis of learning approaches. Innoeduca. International Journal of Technology and Educational Innovation, 10(2). https://doi.org/10.24310/ijtei.102.2024.19694

Desramaza, A., Sufri, & Pasaribu, F. T. (2023). Desain media pembelajaran berbasis project based learning berbantuan Smart Apps Creator. Pedagogy: Jurnal Pendidikan Matematika, 8(1), 59–72.

Edray, A. E., & Hamimah. (2023). Pengembangan media pembelajaran berbasis Smart Apps Creator menggunakan pendekatan contextual teaching and learning (CTL) pada pembelajaran IPAS di kelas IV sekolah dasar. Jurnal Ilmu Pendidikan Dan Kearifan Lokal (JIPKL), 3(2), 80–91.

Fahruji, A. N., A.R., S., & Kurnianti, E. M. (2022). Pengembangan media pembelajaran interaktif berbasis Android pada pembelajaran IPA tentang siklus air kelas V SD. OPTIKA: Jurnal Pendidikan Fisika, 6(1), 35–43. https://doi.org/10.37478/optika.v6i1.1086

Gall, M. D., Gall, J. P., & Borg, W. R. (2007). Educational research: An introduction (8th ed.). Pearson.

Hidayati, N., & Rezania, V. (2023). Pengembangan Game Edukasi East Java Culture Pada Pembelajaran Pendidikan Pancasila Di Kelas 4 Sekolah Dasar. *Jurnal Kajian, Penelitian Dan Pengembangan Kependidikan*, *14*(3), 301–312.

Hilyana, F. S., Ermawati, D., Riswari, L. A., Najikhah, F., & Hariyadi, A. (2024). Upaya meningkatkan literasi digital melalui pembuatan media pembelajaran berbasis Android Brain Teaser. *UN PENMAS: Jurnal Pengabdian Masyarakat Untuk Negeri*, *1*(2), 50–56.

Jayanti, P., Safitri, N., Putri, A., & Munfarikha, Zu. (2023). Analisis kebutuhan belajar siswa dengan media komik dalam meningkatkan kemampuan literasi numerasi. *Prosiding Seminar Nasional MIPATI*, *2*(1), 32–39.

Khaeruman, K., Sudiatmika, A. R., Suma, I. K., & Suardana, I. N. (2023). Meta-analisis: Efektivitas multimedia interaktif terhadap peningkatkan hasil belajar siswa. Bioscientist: Jurnal Ilmiah Biologi, 11(2), 1630–1639. https://doi.org/10.33394/bioscientist.v11i2.9497

Khoirunisa, I., Purwoko, R. Y., & Anjarini, T. (2023). Multimedia interaktif berbasis contextual teaching learning pada materi pecahan sederhana di sekolah dasar. Edukasiana: Jurnal Inovasi Pendidikan, 2(3), 186–196.

Kirom, S., & Aini, M. R. (2023). Pengembangan game edukasi berbasis inkuiri terbimbing untuk meningkatkan kemampuan literasi dan numerasi siswa SD. ALFABETA: Jurnal Bahasa, Sastra, Dan Pembelajarannya, 6(2), 50–59. https://doi.org/10.33503/alfabeta.v6i2.3576

Lestari, E., & Hidayati, S. N. (2023). Bahan ajar berbantuan Smart Apps Creator untuk peningkatan hasil belajar peserta didik. *Pensa: E-Jurnal Pendidikan Sains*, *11*(2), 138–142. https://ejournal.unesa.ac.id/index.php/pensa/article/view/53707

Mayer, R. E. (2014). Introduction to multimedia learning. In R. E. Mayer (Ed.), The Cambridge handbook of multimedia learning (2nd ed., pp. 1–24). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369.002

Nasrullah, A. N., Mahuda, I., Putri Mubarika, M., Meilisa, R., & Fajari, L. E. W. (2022). Android-based mathematics learning media assisted by Smart Apps Creator on self-regulated learning. International Journal of Asian Education, 3(3), 160–165. https://doi.org/10.46966/ijae.v3i3.292

Ningkrum, I., Riswari, L. A., & Najikhah, F. (2024). Pengembangan aplikasi Android Guizzer sebagai media pembelajaran matematika untuk siswa kelas V sekolah dasar. *Nusantara: Jurnal Pendidikan Indonesia*, *4*(3), 822–838. https://doi.org/10.14421/njpi.2024.v4i3-15

Nurhaliza, S., Apriza, B., & Dinata, K. B. (2025). The effectiveness of using educational games in learning mathematics to increase students' interest in learning in elementary schools: A systematic literature review. Indonesian Journal of Educational Research and Review, 8(2). https://doi.org/10.23887/ijerr.v8i2.90855

OECD. (2023). PISA 2022 results (Volume I): The state of learning and equity in education. OECD Publishing. https://doi.org/10.1787/53f23881-en

Rahayu, D. R., Murniasih, T. R., Yuwono, T., & Anggraini, L. (2024). Pengembangan media pembelajaran game edukasi Math Play Cerbil pada materi bilangan kelas VII. *Jurnal Kajian Pembelajaran Matematika*, *8*(1), 1–12. http://journal2.um.ac.id/index.php/jkpm

Rochman, F., Hunaifi, A. A., & Santi, N. N. (2024). Development of interactive multimedia in improving students' digital literacy skills. Jurnal Eduscience, 11(1), 102–112. https://doi.org/10.36987/jes.v11i1.5359

Rohman, A. S., Sugianto, S., & Nurbaiti, U. (2024). Development of learning media based on Smart Apps Creator to improve student's critical thinking skills. Physics Communication, 8(2), 60–65. https://doi.org/10.15294/physcomm.v8i2.50232

Sari, D. R., Lukman, E. N., & Muharram, M. R. W. (2021). Analisis kemampuan siswa dalam menyelesaikan soal geometri pada asesmen kompetensi minimum-numerasi sekolah dasar. Fondatia: Jurnal Pendidikan Dasar, 5(2), 153–162. https://doi.org/10.36088/fondatia.v5i2.1387

Sari, R. K., & Harjono, N. (2021). Pengembangan media pembelajaran interaktif berbasis Articulate Storyline tematik terhadap minat belajar siswa kelas 4 SD. *Jurnal Pedagogi Dan Pembelajaran*, *4*(1), 122. https://doi.org/10.23887/jp2.v4i1.33356

Sirait, E., Usman, H., & Angger Wardhani, P. (2024). Pengembangan media pembelajaran Smart Apps Creator 3 berbasis STEAM pada muatan matematika sekolah dasar. Kognitif: Jurnal Riset HOTS Pendidikan Matematika, 4(1), 368–376. https://doi.org/10.51574/kognitif.v4i1.1453

Sung, Y.-T., Chang, K.-E., & Liu, T.-C. (2016). The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. Computers & Education, 94, 252–275. https://doi.org/10.1016/j.compedu.2015.11.008

Sya'adah, A. M. M., Kharisma, A. I., & Huda, M. M. (2025). Media Smart Apps Creator: Development an validation to improve understanding of IPAS concepts in elementary school. Jurnal Tematik, 14(2), 104–113. https://doi.org/10.24114/jt.v14i2.68196

Wahyuni, A., Supratman, S., & Lestari, P. (2023). Smart Apps Creator (SAC) assisted comic media development in optimizing visual spatial intelligence. *AlphaMath : Journal of Mathematics Education*, *9*(1), 1. https://doi.org/10.30595/alphamath.v9i1.15314

Wulandari, A. P., Salsabila, A. A., Cahyani, K., Nurazizah, T. S., & Ulfiah, Z. (2023). Pentingnya media pembelajaran dalam proses belajar mengajar. Journal on Education, 5(2), 3928–3936. https://doi.org/10.31004/joe.v5i2.1074

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

The Influence of Principal Leadership and Self-Efficacy on Teacher Performance in Pati

Muhammad Zankar[1*], Gunawan Setiadi[1] and Ahmad Hariyadi[1]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: muhammadzankar@gmail.com

ABSTRACT

The objectives of this study were (1) to test and analyze the influence of principal leadership on the performance of state elementary school teachers in Pati District, (2) to test and analyze the influence of self-efficacy on the performance of state elementary school teachers in Pati District, (3) to test and analyze the influence of principal leadership and self-efficacy simultaneously on the performance of state elementary school teachers in Pati District. This quantitative study drew a proportional random sample of 159 teachers from a population of 265 contract teachers (government employees with work agreements) at public elementary schools in Pati District. Data were collected in an ex-post facto survey using questionnaires whose validity and reliability had been tested. Data were analyzed using correlation and multiple regression analysis with SPSS version 26. The hypothesis tests showed that (1) principal leadership influenced the performance of public elementary school teachers in Pati District, (2) self-efficacy influenced their performance, and (3) principal leadership and teacher self-efficacy jointly influenced their performance.

KEYWORDS principal leadership | self-efficacy | teacher performance | PLS-SEM | elementary school

INTRODUCTION

Teacher performance is a major determinant of educational quality and student success, including in public primary schools in Pati District. It is shaped by both the organizational environment and teachers' psychological characteristics (Masfufah & Rindaningsih, 2024). On the organizational side, principal leadership helps establish a supportive working climate, motivate staff, and guide instructional improvement. On the individual side, teacher self-efficacy (the belief in one's capability to carry out teaching tasks effectively) is associated with resilience and pedagogical innovation in the classroom.

These questions matter for P3K teachers (government employees with work agreements), a growing group in Indonesian public elementary schools. Their employment rests on fixed-term contracts, which makes performance appraisal a practical concern for them and for the principals who supervise them. Yet the factors behind the performance of this group have received less attention than those of permanent civil-servant teachers.

Reviews of school leadership agree that principals influence learning mainly through teachers. Leithwood et al. (2020) concluded that leaders affect student learning largely through teachers' motivation, capacity and working conditions, and Robinson et al. (2008) found that leadership focused on teaching and on teachers' professional learning had the largest effects on student outcomes. In Asia, a meta-analysis of 65 studies found positive effects of transformational school leadership on teacher job satisfaction, commitment and self-efficacy (Firmansyah et al., 2022). Indonesian surveys report positive effects of principal leadership on teacher performance in elementary schools in Riau (Kamalia et al., 2022), in junior high schools in Aceh Besar (Sariakin et al., 2025), and in public high schools in Pati Regency, where work motivation mediated the effect (Ardliana et al., 2021). Benu (2019) and Kushariyanto et al. (2024) examined the same relationship together with work motivation and workload in Kupang Regency and in Pati junior high schools.

Teacher self-efficacy is the second strand. Bandura (1997) traced self-efficacy to mastery experience, vicarious experience, verbal persuasion and physiological states, and Tschannen-Moran and Hoy (2001) described teacher efficacy in three areas: student engagement, instructional strategies and classroom management. A synthesis of 40 years of research linked higher teacher self-efficacy to better classroom practice, student adjustment, job satisfaction and commitment, and to lower burnout (Zee & Koomen, 2016). The two strands are

connected: a meta-analysis of 24 studies found a moderate positive relationship between principals' instructional leadership and teacher self-efficacy (Alanoglu, 2022).

Most Indonesian studies of teacher performance examine leadership alongside motivation, discipline or culture, and few place leadership and teacher self-efficacy in one model. Those that do, such as Sabila and Jabar (2022) and Maharani (2023), were set in other regions and did not focus on P3K teachers. Evidence for P3K elementary teachers in Pati District is therefore limited. This study tests the separate and joint effects of principal leadership and teacher self-efficacy on the performance of P3K teachers in public elementary schools in Pati District. The results are intended to inform local strategies for teacher management and development.

LITERATURE REVIEW

Principal leadership helps create a conducive work environment and motivates teachers to improve their performance. A principal who uses transformational leadership can set a clear and inspiring vision for the school, support teachers, and develop their potential through appropriate challenges and opportunities for professional development (Leithwood & Jantzi, 2005).

Self-efficacy is an individual's belief in their ability to perform specific tasks. In education, teacher self-efficacy is a teacher's belief in their ability to teach effectively and achieve established educational goals (Tschannen-Moran & Hoy, 2001; Wray et al., 2022).

Problems with teacher performance often stem from low motivation and high work-related stress. Teachers with low self-efficacy tend to report lower commitment and job satisfaction and more burnout (Zee & Koomen, 2016).

The relationships between the variables are formulated as follows. First, principal leadership (X1) influences teacher performance (Y): the principal acts as an instructional leader, and transformational, supportive leadership provides a clear vision, managerial support, and professional development opportunities that improve teacher performance. Second, self-efficacy (X2) influences teacher performance (Y): according to Bandura's social cognitive theory (Bandura, 1997), a teacher's belief in their ability to manage the classroom and adapt to curriculum digitalization motivates them, and high self-efficacy reduces psychological pressure (particularly for teachers with P3K status), which helps keep performance consistent and adaptive. Third, X1 and X2 jointly influence teacher performance (Y): the principal's managerial support (external) and the teacher's self-belief (internal) are expected together to predict sustained teacher performance.

The model treats principal leadership (X1) as an external/managerial factor, teacher self-efficacy (X2) as an internal/psychological factor, and the performance of public elementary school teachers (Y) as the dependent variable, with a focus on P3K (government employees with work agreements) teachers in Pati District.

Research Objectives

The objectives of this study are to: examine and analyze the influence of school principal leadership on the performance of public elementary school teachers in Pati District; examine and analyze the influence of self-efficacy on the performance of public elementary school teachers in Pati District; and examine and analyze the simultaneous influence of school principal leadership and self-efficacy on the performance of public elementary school teachers in Pati District.

RESEARCH METHOD

Research Design

This study used a quantitative method, in which numerical data are collected and analyzed to test hypotheses. Quantitative designs include descriptive designs (describing variables) and experimental/associative designs (seeking cause-and-effect relationships or correlations between variables).

Respondents of the Study

The population comprised all 265 P3K (Government Employees with Work Agreements) teachers at public elementary schools in Pati District. Proportional random sampling was used, and the sample comprised 159 P3K teachers from public elementary schools in Pati District.

A population is a generalization area consisting of subjects or objects possessing specific qualities and characteristics, selected by the researcher for study in order to draw conclusions (Sugiyono, 2018). The population of this study consists of 265 P3K (Government Employees with Employment Agreements) teachers at public elementary schools in Pati District. A sample is a subset of the population, selected by specific procedures, that represents the population (Budiarto, 2024).

Data were collected with a questionnaire, that is, a set of written questions or statements given to respondents to answer. The questionnaire consisted of written items with Likert-scale answer options. The questionnaire measured the three variables of this study: principal leadership, teacher self-efficacy, and teacher performance. A Likert scale is used to measure the attitudes, opinions, and social perceptions of an individual or a group regarding social phenomena.

Table 1. Likert scale scoring rules

Answer Option	Positive Weight (+)	Negative Weight (-)
Strongly agree (SA)	5	1
Agree (A)	4	2
Disagree (D)	3	3
Disagree (DA)	2	4
Strongly disagree (SD)	1	5

Source: Sugiyono (2018)

RESULTS

The significance of each path in the PLS-SEM model was tested to determine whether the relationships between the variables are statistically significant. Bootstrapping was used: the data were resampled to estimate each path coefficient and its standard error. The results are presented in the form of t-statistic values or p-values. A relationship is considered significant if the p-value is lower than the predetermined significance level; this study employs a significance level of 0.05. A significant path coefficient supports the hypothesized relationship between the latent independent and dependent variables, and the hypothesis is then accepted. The bootstrapping results for the direct effects are presented below.

The stage-2 loading factor output for the variables of principal leadership, self-efficacy, and teacher performance shows values exceeding the 0.6 threshold; thus, all are considered valid. This indicates that the indicators correlate adequately with their constructs, which supports the construct validity of the measurement model. The Average Variance Extracted (AVE) values are reported below. The AVE value for each construct must exceed 0.5 (Fornell & Larcker, 1981; Hair et al., 2022). A variable is considered valid if its Average Variance Extracted (AVE) value is greater than 0.5.

The AVE values are 0.615 for the principal leadership variable, 0.672 for the self-efficacy variable, and 0.541 for the teacher performance variable; all three values exceed the 0.50 threshold. These results meet the requirement for convergent validity. Together, the outer loadings and AVE values indicate that the measurement model is valid and that the analysis can proceed to the structural model.

The Cronbach's alpha values were 0.958 for the school principal leadership construct, 0.962 for the self-efficacy variable, and 0.928 for the teacher performance variable. As the Cronbach's alpha values were ≥ 0.70, all three constructs showed good reliability.

The hypothesis test for principal leadership gave a path coefficient of -0.116, a T-statistic of 2.790 and a p-value of 0.005 (< 0.05) (Table 2).

Table 2. Path coefficients and bootstrapping results for the direct effects

Path	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics	P Values
X1 → Y	-0.116	-0.115	0.042	2.790	0.005
X2 → Y	0.989	0.992	0.026	37.784	0.000

Principal leadership has a significant effect on the performance of public elementary school teachers in Pati District (path coefficient -0.116, T-statistic 2.790, P-value 0.005; Table 2). Its effect size ($f^2 = 0.045$) is small, so principal leadership contributes only modestly to differences in teacher performance. Teacher self-efficacy has a significant effect on the performance of public elementary school teachers in Pati District (path coefficient 0.989, T-statistic 37.784, P-value 0.000; Table 2). Its effect size ($f^2 = 3.273$) indicates a large contribution to the variation in teacher performance. The principal's leadership is significantly related to teacher performance, and the self-efficacy variable is significant in explaining variations in teacher performance, with a coefficient of determination (R-square) of 0.837. This means that 69.4% of the variation in teacher performance can be explained by the self-efficacy variable, while the remaining 31.6% is explained by factors outside this research model.

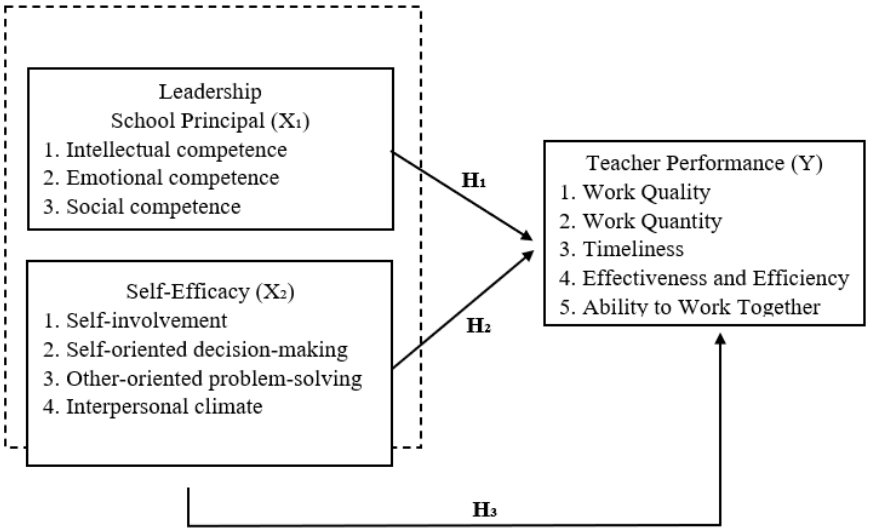

Figure 1. Conceptual framework with two independent variables

DISCUSSION

The first finding concerns principal leadership. Its path to teacher performance was significant (T = 2.790, p = 0.005) but small ($f^2 = 0.045$), and the path coefficient was negative (-0.116; Table 2). By common benchmarks an f^2 of 0.045 is a small effect (Cohen, 1988). The negative sign should not be read as evidence that leadership lowers performance. When a second predictor is very strongly related to the outcome, as self-efficacy is here, the remaining unique contribution of a correlated predictor can become small and change sign. The paper does not report the zero-order correlation between leadership and performance, so this explanation cannot be checked from the data given.

The weak direct path differs from most Indonesian surveys, which report positive direct effects of principal leadership on teacher performance (Ardliana et al., 2021; Kamalia et al., 2022; Sariakin et al., 2025; Tarigan & Sitorus, 2023). One reason is that those models did not include teacher self-efficacy. Reviews of school leadership suggest another reason: principals affect outcomes mainly through teachers' motivation, capacity and working conditions (Leithwood et al., 2020), and transformational leadership works largely through culture, commitment and satisfaction (Leithwood & Jantzi, 2005). Leadership is also positively related to teacher self-efficacy (Alanoglu, 2022; Firmansyah et al., 2022). In this sample, then, the effect of leadership may run mainly through teachers' confidence rather than directly to performance. This is a hypothesis for a mediation test, not a result of the present analysis. In practical terms, principals in Pati District may support P3K teachers most by building their confidence: modelling good practice, mentoring and involving teachers in professional development (Ahsin &

Masfuah, 2022; Utaminingsih & Santoso, 2021), keeping workloads manageable (Kushariyanto et al., 2024), and building a positive school culture (Mujiarti et al., 2024).

The second finding is that teacher self-efficacy had a strong positive path to performance (coefficient 0.989, T = 37.784, p = 0.000, f^2 = 3.273). This direction fits social cognitive theory. Teachers who believe they can engage students, choose instructional strategies and manage the class are more likely to plan carefully, persist with difficult students and adapt to curriculum changes (Bandura, 1997; Tschannen-Moran & Hoy, 2001). It also agrees with the synthesis by Zee and Koomen (2016), which links teacher self-efficacy with classroom quality and commitment, and with Indonesian studies that included self-efficacy among predictors of teacher performance (Maharani, 2023; Sabila & Jabar, 2022). For P3K teachers, whose employment depends on contract renewal, confidence in their own teaching may matter more than for permanent staff, although this study did not compare the two groups.

The size of this effect, however, calls for caution. A path coefficient close to 1 and an f^2 above 3 are far larger than effects usually reported for self-efficacy. Both variables were measured with the same self-report questionnaire, at the same time, from the same teachers, so common method variance may have inflated the relationship (Podsakoff et al., 2003). The two constructs may also overlap: a teacher who rates her teaching ability highly is likely to rate her performance highly as well. Discriminant validity should therefore be checked with the heterotrait-monotrait ratio (Henseler et al., 2015), and collinearity with variance inflation factors (Kock, 2015). Until these checks are reported, the result is best described as a very strong association.

Together, the two predictors accounted for most of the variance in teacher performance (R^2 = 0.837). For the education office and school supervisors in Pati District, the practical message is to combine leadership development with programmes that build teachers' self-efficacy, such as induction for new P3K teachers, peer observation in teacher working groups (KKG), and feedback that gives teachers evidence of their own progress, which is one of the sources of self-efficacy identified by Bandura (1997).

The measurement results support the reliability of the three scales. Cronbach's alpha ranged from 0.928 to 0.962, and the AVE values (0.615 for leadership, 0.672 for self-efficacy and 0.541 for performance) exceeded the 0.50 criterion (Fornell & Larcker, 1981). The study accepted indicator loadings above 0.6, whereas current PLS-SEM guidance recommends 0.708 and retains weaker indicators only when reliability and validity are not harmed (Hair et al., 2022). Several leadership and performance indicators fell between these two values. Very high alpha values close to 0.96 can also signal redundant items, which would fit the overlap between self-efficacy and performance noted above. Reporting the full loading table would let readers judge these points.

This study has limitations. The design was cross-sectional and correlational, so the paths show associations, not causes. All variables were self-reported by teachers; performance ratings from principals or supervisors would give an independent measure. The sample was limited to P3K teachers in one district. The Abstract describes correlation and multiple regression in SPSS while the Results use PLS-SEM, and several values differed across the text before revision, so the analysis should be rechecked and fully reported, including discriminant validity, collinearity and the zero-order correlations. Future studies should test teacher self-efficacy as a mediator between principal leadership and performance, compare P3K and civil-servant teachers, and use multi-source or longitudinal data.

CONCLUSION AND RECOMMENDATIONS

Principal leadership has a significant but small effect on the performance of public elementary school teachers in Pati District (path coefficient -0.116, T-statistic 2.790, P-value 0.005, f^2 = 0.045).

Teacher self-efficacy has a significant and large effect on the performance of public elementary school teachers in Pati District (path coefficient 0.989, T-statistic 37.784, P-value 0.000, f^2 = 3.273).

Together, principal leadership and self-efficacy are significantly related to teacher performance (R-square = 0.837). Of the variation in teacher performance, 69.4% is attributed to self-efficacy and the remaining 31.6% to factors outside this research model.

Because principal leadership was significantly but weakly related to teacher performance in Pati District, principals are encouraged to lead by example and to give teachers emotional support and recognition, using a humanistic approach.

Because teacher self-efficacy was the stronger predictor, schools and the Pati District education office should also build P3K teachers' confidence through mentoring, peer observation in teacher working groups, and planned opportunities for successful teaching experience.

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REFERENCES

Ahsin, M. N., & Masfuah, S. (2022). Principal leadership strategies for enhancing the competence and performance of elementary school teachers. Jurnal Pendidikan Dasar Muria, 6(1), 32–41.

Alanoglu, M. (2022). The role of instructional leadership in increasing teacher self-efficacy: A meta-analytic review. Asia Pacific Education Review, 23, 233–244. https://doi.org/10.1007/s12564-021-09726-5

Ardliana, B., Rusdarti, R., & Suminar, T. (2021). Effect of principal leadership, school culture and pedagogic competence through work motivation on teachers performance. Educational Management, 10(2), 273–283.

Bandura, A. (1997). Self-efficacy: The exercise of control. W. H. Freeman.

Benu, I. (2019). The influence of teacher work motivation and principal leadership on teacher performance in learning at elementary schools across Takari District, Kupang Regency. *Jurnal Dinamika Manajemen Pendidikan*, *2*(2), 82–93. https://doi.org/10.26740/jdmp.v2n2.p82-93

Budiarto, D. S. (2024). Research methodology: A guide to writing articles. Selat Media.

Cohen, J. (1988). Statistical power analysis for the behavioral sciences (2nd ed.). Lawrence Erlbaum Associates.

Firmansyah, F., Prasojo, L. D., Jaedun, A., & Retnawati, H. (2022). Transformational leadership effect on teacher performance in Asia: A meta-analysis. Cypriot Journal of Educational Sciences, 17(6), 2127–2146. https://doi.org/10.18844/cjes.v17i6.7552

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research, 18(1), 39–50. https://doi.org/10.1177/002224378101800104

Hair, J. F., Jr., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2022). A primer on partial least squares structural equation modeling (PLS-SEM) (3rd ed.). Sage.

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. Journal of the Academy of Marketing Science, 43(1), 115–135. https://doi.org/10.1007/s11747-014-0403-8

Kamalia, Ayub, D., & Sumarno, S. (2022). The influence of principal leadership and teacher work discipline on elementary school teacher performance. Journal of Educational Sciences, 6(3), 444–458. https://doi.org/10.31258/jes.6.3.p.444-458

Kock, N. (2015). Common method bias in PLS-SEM: A full collinearity assessment approach. International Journal of e-Collaboration, 11(4), 1–10. https://doi.org/10.4018/ijec.2015100101

Kushariyanto, K., Setiadi, G., & Hariyadi, A. (2024). The influence of principal leadership, work motivation, and workload on the performance of public junior high school teachers in Pati Regency. Lencana: Jurnal Inovasi Ilmu Pendidikan, 3(3), 441–452.

Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven strong claims about successful school leadership revisited. School Leadership & Management, 40(1), 5–22. https://doi.org/10.1080/13632434.2019.1596077

Leithwood, K., & Jantzi, D. (2005). A review of transformational school leadership research 1996–2005. Leadership and Policy in Schools, 4(3), 177–199. https://doi.org/10.1080/15700760500244769

Maharani, S. (2023). The influence of principal's self-efficacy-based transformational leadership in improving teacher performance at MIN 12 Medan. *Jurnal Generasi Ceria Indonesia*, 1(1), 5–10. https://doi.org/10.47709/geci.v1i1.2322

Masfufah, N. F., & Rindaningsih, I. (2024). Factors affecting teacher performance: A literature review. *ELSE (Elementary School Education Journal)*, *8*(1), 244–252.

Mujiarti, S., Hariyadi, A., & Ismaya, E. A. (2024). Analysis of principal leadership in implementing a positive school culture at SD Negeri Gedangan, Welahan, Jepara. Lencana: Jurnal Inovasi Ilmu Pendidikan, 3(4), 515–528.

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal of Applied Psychology, 88(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Robinson, V. M. J., Lloyd, C. A., & Rowe, K. J. (2008). The impact of leadership on student outcomes: An analysis of the differential effects of leadership types. Educational Administration Quarterly, 44(5), 635–674. https://doi.org/10.1177/0013161X08321509

Sabila, H., & Jabar, C. S. A. (2022). The influence of teacher leadership, work motivation, and self-efficacy on teacher performance in the COVID-19 pandemic era. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, *7*(9), 379–387. http://journal.um.ac.id/index.php/jptpp/article/view/15672/6695

Sariakin, S., Yeni, M., Usman, M. B., Mare, A. S., Munzir, M., & Saleh, M. (2025). Fostering a productive educational environment: The roles of leadership, management practices, and teacher motivation. Frontiers in Education, 10, Article 1499064. https://doi.org/10.3389/feduc.2025.1499064

Sugiyono. (2018). Metode penelitian kuantitatif, kualitatif, dan R&D. Alfabeta.

Tarigan, M. A., & Sitorus, J. (2023). The influence of principal leadership and teacher competence on teacher performance. *Journal of Education Research and Social Sciences Review (JERUMI)*, *3*(2), 115–124. https://doi.org/10.59600/jerumi.v3i2.215

Tschannen-Moran, M., & Hoy, A. W. (2001). Teacher efficacy: Capturing an elusive construct. Teaching and Teacher Education, 17(7), 783–805. https://doi.org/10.1016/S0742-051X(01)00036-1

Utaminingsih, S., & Santoso, S. (2021). The influence of principal leadership on teacher performance with work motivation as an intervening variable. Jurnal Magister Manajemen Universitas Muria Kudus, 10(2), 145–154.

Wray, E., Sharma, U., & Subban, P. (2022). Factors influencing teacher self-efficacy for inclusive education: A systematic literature review. *Teaching and Teacher Education*, *117*, 103800. https://doi.org/10.1016/j.tate.2022.103800

Zee, M., & Koomen, H. M. Y. (2016). Teacher self-efficacy and its effects on classroom processes, student academic adjustment, and teacher well-being: A synthesis of 40 years of research. Review of Educational Research, 86(4), 981–1015. https://doi.org/10.3102/0034654315626801

ICISFS-UMK 2026 LEARNING INNOVATION

Effectiveness of Problem Based Learning and Flipped Classroom Models on Fifth Grade Students' Science Learning Outcomes

Mutik Ati Masrifatun[1*], Gunawan Setiadi[1] and Fina Fakhriyah[1]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: mutikmasrifatun67@guru.sd.belajar.id

ABSTRACT

This study analyzed differences in the effectiveness of the Problem Based Learning (PBL) model, the Flipped Classroom model, and direct (conventional) learning on grade V Natural and Social Sciences (IPAS) learning outcomes for the topic "Breathing Helps Me Do Activities" in the Kumbokarno Cluster, Karangtengah District. The design was quasi-experimental, with two experimental groups (PBL and Flipped Classroom) and two control groups (direct learning). Data were collected through a pretest and a posttest, except that experimental group 2 (Flipped Classroom) and control group 2 took only the posttest. The Independent Samples t-test between PBL and direct learning gave a significance value of 0.003 (< 0.05), with a mean N-gain of 0.692 (moderate) in the experimental class and 0.376 (moderate) in the control class, so PBL was more effective than direct learning. Comparing the Flipped Classroom with direct learning gave a significance value of 0.000 (< 0.05) with a mean posttest difference of 22.5 points, indicating that the Flipped Classroom was more effective. The Independent Samples t-test between PBL and the Flipped Classroom gave a reported significance value of 0.048 (< 0.05), which suggests that the Flipped Classroom improved learning outcomes more than PBL. The Two-Way ANOVA showed no significant interaction between pretesting and the learning treatments (sig. 0.0945 > 0.05), so the differences in learning outcomes are attributed to the learning model rather than to the pretest. Post hoc analysis showed that PBL and the Flipped Classroom were both more effective than conventional learning, and that the Flipped Classroom scored higher than PBL, although this last difference needs confirmation.

KEYWORDS problem-based learning | flipped classroom | learning outcomes | science (IPAS) | elementary school

INTRODUCTION

To improve the quality of education, the government introduced the Independent Curriculum in response to social and technological change (Faiz & Purwati, 2021). The curriculum is designed to make learning more flexible and student-centered and to strengthen character and essential competencies through differentiated, project-based, and technology-integrated approaches (Rifai et al., 2024). In addition, this curriculum encourages the development of the Pancasila student profile, so that students become critical, independent, and collaborative individuals (Dayu, Rulviana, & Kurniawati, 2022).

In the context of the Independent Curriculum, science and social studies subjects are combined into IPAS at the elementary school level to encourage students' holistic thinking (Astuti, 2022). However, the results of interviews with teachers in the Kumbokarno Cluster showed that the implementation of this curriculum still faces challenges. Teachers did not fully understand assessment and differentiated learning and still used conventional approaches that do not engage students actively. As a result, students' IPAS learning outcomes remained low. This problem calls for innovative learning models that meet students' learning needs and let them learn actively and independently.

These local observations match national evidence. In PISA 2022, the science performance of Indonesian students remained well below the OECD average (OECD, 2023), which points to the need for teaching that develops understanding rather than recall. In elementary IPAS, this means models in which students work with real phenomena, such as their own breathing, and explain what they observe.

Problem Based Learning (PBL) and the Flipped Classroom are two candidate models. In PBL, students work on an authentic problem, gather information and present a solution, while the teacher guides the inquiry

(Syamsinar, 2024). Evidence from Indonesian elementary schools is consistent. A meta-analysis of 12 studies reported a large mean effect of PBL on critical thinking (effect size 1.065; Setyowati & Sutikno, 2024), and a meta-analysis of 25 studies found a strong effect on the same outcome (Sa'diyah et al., 2024). For science, a meta-analysis of 25 experimental-control studies found a high summary effect of PBL on problem-solving skills (ES = 1.33; Yanto et al., 2026). A literature review of 20 articles concluded that PBL also improves elementary students' academic performance and conceptual understanding (Ningrum, 2025), and a classroom action study in Grade IV IPAS raised classical mastery to at least 85% (Amelia et al., 2026).

The Flipped Classroom moves the first exposure to content out of class, usually through short videos, so that class time can be used for discussion and practice (Walidah et al., 2020). Evidence is more mixed. A meta-analysis of 173 studies found a mean effect of g = 0.37 with high heterogeneity, and only about 3% of the effect sizes came from primary schools (Kapur et al., 2022). A second-order meta-analysis in higher education reported a similar adjusted effect of 0.37 (Hew et al., 2021). Indonesian elementary studies report larger effects: a flipped class in Grade II multiplication outperformed a control class in critical thinking (84.85 vs 70.00; Wardani et al., 2025), and the Flipped Classroom improved Grade V science critical thinking in a factorial quasi-experiment (Riska et al., 2024).

Few studies compare the two models with each other and with conventional teaching in the same elementary science unit. Mardiyah and Sunarsi (2024) examined both models in mathematics, and Yokhebed et al. (2024) proposed combining them, but evidence from IPAS classes in Demak Regency is lacking. This study therefore tests whether PBL and the Flipped Classroom improve Grade V IPAS learning outcomes on the topic "Breathing Helps Me Do Activities" compared with conventional teaching, and which of the two models gives higher outcomes.

LITERATURE REVIEW

In response to these challenges, this study used two learning models: Problem Based Learning (PBL) and the Flipped Classroom. Both models are in line with the Independent Curriculum, such as being student-centered, encouraging critical thinking, increasing learning independence, and utilizing technology as a learning resource. PBL trains students to think critically through solving real problems, while Flipped Classroom reverses the traditional learning pattern by providing material at home before the discussion session in class (Yokhebed et al., 2024). Using media such as learning videos, both models are expected to increase student motivation and active participation in science learning (Walidah et al., 2020).

Based on the problems found in the Kumbokarno Cluster, Karangtengah District, namely low IPAS learning outcomes among grade V students and conventional, teacher-centered learning, the researcher implemented the PBL and Flipped Classroom models. The PBL model provides real experience in solving problems (Syamsinar, 2024), while the Flipped Classroom allows students to be more independent and not passive because they already understand the material before learning (Walidah et al., 2020). The conceptual framework therefore assumes that the two models can accommodate diverse learning needs, increase learning activity, and improve grade V students' IPAS learning outcomes on the topic "Breathing Helps Me Do Activities".

Research Objectives

This study aims to examine the effectiveness of the Problem Based Learning (PBL) and Flipped Classroom learning models on fifth-grade students' science (IPAS) learning outcomes on the topic "Breathing Helps Me Do Activities" in the Kumbokarno Cluster, Karangtengah District, Demak Regency.

RESEARCH METHOD

Research Design

This study used a quantitative experimental method with a true experimental Solomon Four-Group Design. Data were collected through tests and observation, and the sample was selected by simple random sampling. The instrument was a written pretest and posttest whose validity and reliability were tested. The data were analyzed with assumption tests (normality and homogeneity), N-gain, and hypothesis tests (Independent Samples t-tests and two-way ANOVA).

Respondents of the Study

The sample was selected by simple random sampling: all population units were written on slips of paper and drawn by lottery. The selected grade V classes were SD Negeri Karangsari 3 (23 students, experimental class 1), SD Negeri Grogol 2 (20 students, experimental class 2), SD Negeri Karangsari 1 (40 students, control class 1), and SD Negeri Donorejo 2 (20 students, control class 2).

The data collection techniques were: 1) Observation (participatory observation). Observation was conducted to record student activities during the implementation of the Problem Based Learning and Flipped Classroom models. The researchers took part in the learning process to obtain more accurate data. 2) Written test (learning outcome test). The test measured the effectiveness of the learning models and was given twice: (1) a pretest of students' initial abilities before treatment and (2) a posttest of learning outcomes after treatment. The test instrument was tested first to ensure validity, reliability, discriminatory power, and level of difficulty, with trials on students outside the main sample who had similar characteristics. This was done so that the test data would be trustworthy. The trial with 30 respondents at SD Negeri Grogol 1 showed that 10 of the 15 questions were valid, and these 10 questions were used in the pretest and posttest. The item validity results are presented in Table 1.

Table 1. Item validity test results (>0.41)

Validity score	Criteria
0.57	Valid
0.50	Valid
0.59	Valid
0.30	Invalid
0.54	Valid
0.60	Valid
0.52	Valid
0.65	Valid
0.61	Valid
-0.14	Invalid
0.67	Valid
0.56	Valid
0.15	Invalid
0.18	Invalid
0.17	Invalid

RESULTS

The findings are presented according to the four research questions:

Effectiveness of the Problem Based Learning Model on Grade V Science Learning Outcomes

The Problem Based Learning (PBL) model was more effective than conventional learning in improving grade V students' learning outcomes on the topic Breathing Helps Me Do Activities in the Kumbokarno Cluster, Karangtengah District. The hypothesis test showed a significant difference between the PBL group and the control group (significance value 0.003 < 0.05; mean difference 10.60870). This result is consistent with a review of 20 studies concluding that PBL improves elementary students' learning outcomes and conceptual understanding (Ningrum, 2025).

Table 2. Independent samples t-test results: Problem Based Learning

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Problem Based Learning	Equal variances assumed	.576	.451	-3.092	61	.003	-10.60870	3.43055	-17.46851	-3.74888
	Equal variances not assumed			-2.982	41.162	.005	-10.60870	3.55716	-17.79166	-3.42573

Source: learning outcomes of experimental class 1 and control class 1

Effectiveness of the Flipped Classroom Model on Grade V Science Learning Outcomes

The Flipped Classroom model was more effective than conventional learning in improving grade V students' learning outcomes on the topic Breathing Helps Me Do Activities in the Kumbokarno Cluster, Karangtengah District. The hypothesis test showed a significant difference between the Flipped Classroom group and the control group (significance value 0.000 < 0.05; mean difference 22.5 points). This finding is in line with a previous study (Damayanti & Afriansyah, 2024), which showed that the Flipped Classroom improves conceptual understanding, independence, and academic outcomes.

Table 3. Independent samples t-test results: Flipped Classroom

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Flipped Classroom	Equal variances assumed	4.508	.040	-4.793	38	.000	-22.50000	4.69462	-32.00376	-12.99624
	Equal variances not assumed			-4.793	32.143	.000	-22.50000	4.69462	-32.06096	-12.93904

Source: learning outcomes of experimental class 2 and control class 2

Effectiveness of Problem Based Learning and Flipped Classroom Models on Fifth Grade Science Learning Outcomes

The study found a difference between the Problem Based Learning (PBL) and Flipped Classroom (FC) models in improving fifth-grade students' learning outcomes on the topic Breathing Helps Me Do Activities in the Kumbokarno Cluster, Karangtengah District. The hypothesis test gave a reported significance value of 0.048 <0.05, with the Flipped Classroom class scoring 7.39130 points higher on average than the PBL class. The Flipped Classroom model therefore appears more effective than PBL for students' science learning outcomes. Its likely advantages are flexibility, efficient use of class time, and stronger conceptual understanding, although these were not measured directly. PBL remains useful for developing critical thinking and problem solving, and the choice of model depends on the learning objectives and the students' characteristics. The Flipped Classroom may suit topics that require conceptual understanding.

Table 4. Independent samples t-test results: PBL and Flipped Classroom

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Learning Model	Equal variances assumed	1.152	.289	-1.871	41	.048	-7.39130	3.95004	-15.36858	-1.58597
	Equal variances not assumed			-1.902	40.668	.044	-7.39130	3.88553	-15.24025	-1.45764

Source: learning outcomes of the PBL and Flipped Classroom classes

Differences in Effectiveness across All Experimental and Control Classes on Grade V Science Learning Outcomes

This study evaluated differences in effectiveness between conventional learning, Problem Based Learning (PBL), and the Flipped Classroom (FC) for grade V students' science learning outcomes on the topic Breathing Helps Me Do Activities in the Kumbokarno Cluster, Karangtengah District. The results were as follows:

1. The pretest had no significant effect on learning outcomes. The pretest significance value of 0.945 (> 0.05) indicates no difference in learning outcomes between students who took a pretest and those who did not, and there was no interaction between pretesting and the learning models.
2. Comparison of the learning models (Flipped Classroom, Problem Based Learning, and conventional learning). All pairwise comparisons had reported significance values <0.05: a) Flipped classroom with Conventional, significant (0.000). b) Problem Based Learning with Conventional, significant (0.000). c) Flipped Classroom with Problem Based Learning, significant (0.041)

Table 5. Post hoc test of the learning models

Multiple Comparisons						
Dependent Variable: Learning Outcomes						
LSD						
(I) Learning Model	(J) Learning Model	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Problem Based Learning	Conventional	31.7070*	5.22121	.000	21.3470	42.0670
	Flipped Classroom	-12.8450	6.50919	.041	-25.7606	.0707
Conventional	Problem Based Learning	-31.7070*	5.22121	.000	-42.0670	-21.3470
	Flipped Classroom	-44.5520*	5.49700	.000	-55.4592	-33.6448
Flipped Classroom	Problem Based Learning	12.8450	6.50919	.041	-.0707	25.7606
	Conventional	44.5520*	5.49700	.000	33.6448	55.4592
Based on observed means. The error term is Mean Square(Error) = 453.255.						
*. The mean difference is significant at the .05 level.						

Source: learning outcomes of the PBL, Flipped Classroom, and conventional classes

3. On N-gain, the Flipped Classroom had the highest value and therefore the greatest improvement in learning outcomes. Problem Based Learning had an N-gain of 69.20 (moderate category), below the Flipped Classroom. Conventional learning had the lowest N-gain, around 37.6 (moderate category).

Table 6. Mean scores and N-gain of students' IPAS learning outcomes

Group	N (number of students)	Pretest Mean	Posttest Mean	N-Gain	Category
Problem Based Learning	23	62.87	84.35	69.20	Moderate
Flipped Classroom	20	63.04	91.74	82.40	High
Control Class 1	40	62.35	73.74	37.60	Moderate
Control Class 2	20	62.91	69.24	31.80	Low

DISCUSSION

Both models were associated with higher learning outcomes than conventional teaching. The PBL class scored 10.61 points higher than control class 1 at posttest ($t = -3.092$, $df = 61$, $p = 0.003$; Table 2), and its N-gain was 69.20 against 37.60 for the control class (Table 6). The Flipped Classroom class scored 22.50 points higher than control class 2 ($t = -4.793$, $df = 38$, $p = 0.000$; Table 3), with an N-gain of 82.40 against 31.80. By the categories of Hake (1998), the PBL and control gains were moderate and the Flipped Classroom gain was high. The pretest had no significant effect on posttest results ($p = 0.945$), which suggests that taking the pretest did not drive the differences. Pretest means were also similar across the four groups (62.35 to 63.04; Table 6), so the groups appear to have started at a comparable level, although two of these groups were meant to take no pretest under the Solomon design.

The PBL result can be explained by the way the topic was taught. Students started from a problem about their own breathing during activity, collected information in groups and presented explanations, so they processed the content several times in different forms. This agrees with Indonesian meta-analyses that report large effects of PBL in elementary schools (Sa'diyah et al., 2024; Setyowati & Sutikno, 2024) and with the review by Ningrum (2025), which found consistent gains in learning outcomes. The moderate N-gain here is smaller than those effect sizes suggest. One reason is time. Kusasih et al. (2024) noted that PBL needs extra time for students to grasp concepts, and this study covered a single topic over a short period. The meta-analyses also measured critical thinking and problem solving (Yanto et al., 2026), whereas this study measured only a 10-item learning outcome test, so the results say nothing about critical thinking. For teachers in the Kumbokarno Cluster, PBL is a workable option for IPAS topics that can be framed as real problems, provided that enough lessons are planned for the inquiry stage.

The Flipped Classroom gave the largest gain. Students watched videos on the respiratory system before class, so lesson time could go to questions, discussion and teacher feedback. This pattern agrees with Walidah et al. (2020), who reported a positive effect of the Flipped Classroom on learning outcomes, and with recent elementary studies (Riska et al., 2024; Wardani et al., 2025). The size of the gain is larger than the mean effect in the meta-analysis by Kapur et al. (2022), which found g = 0.37 overall and very few primary-school studies. Kapur et al. also concluded that flipped learning works through how class time is used, especially problem solving, rather than through the flipped format itself. The high gain in this study may therefore reflect the active class sessions as much as the videos. It may also reflect the small class (20 students) and differences between schools. The model depends on students being able to watch the videos at home. Teachers who adopt it should check access and provide viewing time at school for students without devices or data. Principals and the cluster can support this by sharing short IPAS videos and lesson plans through teacher working group (KKG) meetings, so that each teacher does not have to produce materials alone.

The comparison between the two models needs more caution. The Flipped Classroom class scored 7.39 points higher than the PBL class, with a reported p of 0.048 (Table 4). However, the reported t value (-1.871, df = 41) is not consistent with $p < 0.05$ for a two-tailed test, and in the post hoc test the confidence interval for this pair includes zero (-25.76 to 0.07; Table 5). The two classes also came from different schools. The difference between the models is therefore best treated as tentative. Mardiyah and Sunarsi (2024) also found that both models can raise achievement, and Yokhebed et al. (2024) proposed combining them. A practical reading is that teachers do not need to choose one model: short videos before class can prepare students for a PBL problem during class.

This study has several limitations. Intact classes from four schools were assigned to the conditions, so the design is quasi-experimental rather than a true experiment, and differences between schools may account for part of the results (Shadish et al., 2002). The groups were small (20 to 40 students), the intervention covered one topic over a short period, and only a written test of 10 items was used, with no reliability coefficient reported. Effect sizes were not reported. Table 6 reports pretest means for the two posttest-only groups, and the mean differences in the post hoc test do not match the posttest means in Table 6; both should be checked. Future studies should randomize classes where possible, run the models for a full semester, report effect sizes, measure critical thinking and learning independence directly, and test a combined PBL and Flipped Classroom model.

CONCLUSION AND RECOMMENDATIONS

Based on the research findings, both the Problem-Based Learning (PBL) and Flipped Classroom models produced significantly higher science learning outcomes among fifth-grade students on the topic "Breathing Helps Me Do Activities" than their respective control groups. In the direct comparison between the two experimental models, the Flipped Classroom produced the highest learning outcomes, followed by PBL. Taking a pretest did not significantly affect students' mean learning outcomes, and there was no interaction between pretesting and the learning model.

Based on these findings, teachers are encouraged to use the Flipped Classroom model to improve fifth-grade science learning outcomes on this topic. Future studies should run over a longer period, and follow-up research on the PBL and Flipped Classroom models should expand its scope to measure different learning aspects by integrating varied assessment tools, such as questionnaires, product assessments, observation sheets, and instructional product development rather than relying solely on written tests.

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REFERENCES

Amelia, C., Zuryanty, Fitria, Y., & Fitri, U. (2026). Peningkatan hasil belajar peserta didik pada pembelajaran IPAS menggunakan model problem based learning (PBL) di kelas IV SDN 21 Bandar Buat Kota Padang. Pendas: Jurnal Ilmiah Pendidikan Dasar, 11(1), 33-44. https://doi.org/10.23969/jp.v11i01.42240

Astuti, E. P. (2022). Pengembangan Kurikulum Merdeka Belajar pada peningkatan pemahaman konsep penyerbukan dengan metode demonstrasi di kelas 4 SDN Sukorejo 2 Kota Blitar. EDUKASIA: Jurnal Pendidikan dan Pembelajaran, 3(3), 671–680.

Damayanti, D., & Afriansyah, E. A. (2024). Kemandirian belajar matematis siswa menengah atas melalui flipped classroom learning. *Jurnal Inovasi Pembelajaran Matematika: PowerMathEdu*, *3*(2), 241–252. https://doi.org/10.31980/pme.v3i2.1780

Dayu, Rulviana, & Kurniawati. (2022). Blended learning: Model case based learning pada implementasi Kurikulum Merdeka. CV. Ae Media Grafika.

Faiz, A., & Purwati, P. (2021). Koherensi program pertukaran pelajar Kurikulum Merdeka Belajar Kampus Merdeka dan general education. Edukatif: Jurnal Ilmu Pendidikan, 3(3), 649–655. https://edukatif.org/index.php/edukatif/article/view/378

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. American Journal of Physics, 66(1), 64–74. https://doi.org/10.1119/1.18809

Hew, K. F., Bai, S., Huang, W., Dawson, P., Du, J., Huang, G., Jia, C., & Thankrit, K. (2021). On the use of flipped classroom across various disciplines: Insights from a second-order meta-analysis. Australasian Journal of Educational Technology, 37(2), 132-151. https://doi.org/10.14742/ajet.6475

Kapur, M., Hattie, J., Grossman, I., & Sinha, T. (2022). Fail, flip, fix, and feed - Rethinking flipped learning: A review of meta-analyses and a subsequent meta-analysis. Frontiers in Education, 7, Article 956416. https://doi.org/10.3389/feduc.2022.956416

Kusasih, I. H., Satria, D., & Gusmaneli. (2024). Strategi pembelajaran berbasis masalah (problem-based learning) dalam meningkatkan kemampuan berpikir kritis peserta didik. Jurnal Teknologi Pendidikan dan Pembelajaran (JTPP), 2(2), 562–568.

Mardiyah, L., & Sunarsi, A. (2024). Problem-based learning dan flipped classroom: Dapatkah meningkatkan prestasi siswa? Edumatica: Jurnal Pendidikan Matematika, 14(1), 25–38. https://doi.org/10.22437/edumatica.v14i01.24948

Ningrum, A. S. (2025). Studi literatur: Efektifitas model problem based learning terhadap hasil belajar siswa SD. Pendas: Jurnal Ilmiah Pendidikan Dasar, 10(4), 610-621. https://doi.org/10.23969/jp.v10i04.31698

OECD. (2023). PISA 2022 results (Volume I): The state of learning and equity in education. OECD Publishing. https://doi.org/10.1787/53f23881-en

Rifai, M. H., dkk. (2024). Kurikulum Merdeka (implementasi dan pengaplikasian). Selat Media Partner.

Riska, R., Marjo, H. K., & Purwantiningsih, A. (2024). The influence of the flipped classroom model and independent learning on the critical thinking capability of science and 5 class students in primary school. Tunas: Jurnal Pendidikan Guru Sekolah Dasar, 10(1), 24-28. https://doi.org/10.33084/tunas.v10i1.8716

Sa'diyah, H., Umalihayati, Hidayah, R., Salimi, M., Fajari, L. E. W., Mashudi, & Aini, S. (2024). The effect of problem based learning model on critical thinking skills in elementary school: A meta analysis study. Jurnal Iqra': Kajian Ilmu Pendidikan, 9(1). https://doi.org/10.25217/ji.v9i1.4456

Setyowati, N., & Sutikno, P. Y. (2024). Meta analisis: Model pembelajaran problem based learning (PBL) terhadap keterampilan berpikir kritis siswa sekolah dasar. Jurnal Inovasi Pendidikan dan Pembelajaran Sekolah Dasar, 8(2), 587-599. https://doi.org/10.24036/jippsd.v8i2.127679

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). Experimental and quasi-experimental designs for generalized causal inference. Houghton Mifflin.

Syamsinar. (2024). Model pembelajaran PBL-4C. CV Ruang Tentor.

Walidah, Z., Wijayanti, R., & Affaf, M. (2020). Pengaruh model pembelajaran flipped classroom (FC) terhadap hasil belajar. Edumatica: Jurnal Pendidikan Matematika, 10(2), 71–77.

Wardani, E., Kurniawan, S., & Sulisti, H. (2025). Anak, layar, dan perkalian: Mencari jalan berpikir kritis melalui flipped classroom di sekolah dasar. Muallimuna: Jurnal Madrasah Ibtidaiyah, 11(1), 55-65. https://doi.org/10.31602/muallimuna.v11i1.20131

Yanto, F., Sulistianingsih, M., Erfani, D., Nisa, K., Aini, N., & Dito. (2026). Effectiveness of problem-based learning on science problem-solving skills: A meta-analysis. Journal of Turkish Science Education, 23(1), 91-108. https://doi.org/10.36681/tused.2026.005

Yokhebed, Sutarno, Maskuri, M., & Prayitno, B. A. (2024). Model socioscientific problem based learning with flipped classroom. PT Nasya Ekspanding Management.

ICISFS-UMK 2026 EARLY CHILDHOOD & INCLUSIVE EDUCATION

Exploration of Techniques and Materials: Creativity Skills in Creating Ecoprint Batik Artwork among Early Childhood Education Students in Sukoharjo Regency

Nurul Rochimah[1*], Nur Fajrie[1] and Sri Utaminingsih[1]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: rochimahnurul878@gmail.com

ABSTRACT

This study aims to (1) identify the ecoprint batik techniques and materials that support the creativity of PAUD (early childhood education) students and (2) determine the effect of these techniques and materials on the creativity of PAUD students. This study employed a mixed-methods approach that combined qualitative and quantitative elements to obtain a broader and deeper understanding (Creswell & Plano Clark, 2018). The research design used was exploratory sequential mixed methods. The study was conducted in RA (Raudhatul Athfal) institutions in Sukoharjo Regency, with a sample of 40 children aged 4–6 years drawn from a population of 704. Data were collected through questionnaires, field notes, interviews, and documentation. Creativity levels were described using descriptive statistics of the questionnaire scores, while the joint effect of the techniques and materials was estimated with multiple linear regression. The results indicate that ecoprint batik activities can support students' creativity through the exploration of ideas, imagination, and problem solving. Children were given the freedom to select natural materials, such as leaves and flowers, and to use the hammering technique with simple tools like wooden hammers, stones, or wooden blocks. The process also appeared to support fine and gross motor skills, self-confidence, responsibility, and appreciation of their own work. The techniques and materials the children chose reflected their aesthetic preferences and made creative activity enjoyable. Based on these findings, the hammering technique, using leaves and flowers on cloth with plastic as a protective layer, is recommended as a practical way to support creativity in PAUD students. The study offers a natural-material approach to art learning in early childhood education.

KEYWORDS ecoprint batik | creativity | early childhood education | natural materials

INTRODUCTION

Education develops knowledge, skills, and human potential through meaningful learning experiences. Schools are the primary institutions where this process takes place, while Early Childhood Education (ECE) provides the foundation for children's lifelong development. According to Aprillia and Wulandari (2023), ECE is the first stage of formal education and is essential for children's overall growth. In accordance with Law No. 20 of 2003, Article 1, Paragraph 14, Early Childhood Education (PAUD) is defined as educational stimulation provided to children from birth to six years of age to support their physical and psychological development and prepare them for subsequent levels of education. Consequently, PAUD emphasizes comprehensive developmental stimulation rather than academic achievement alone.

Early childhood is often called a golden age because physical, cognitive, emotional and social development is rapid during these years. The National Association for the Education of Young Children (NAEYC) defines early childhood as the period from birth to eight years. Stimulation in this period works best when activities are enjoyable, meaningful and suited to the child's level. A meta-analysis of 17 studies with children aged 1 to 8 found that guided play, in which an adult structures a playful activity, produced better early mathematics and shape knowledge than direct instruction (Skene et al., 2022). Art activities that children carry out with their hands and with real materials fit this kind of guided, playful learning.

PAUD in Indonesia is delivered through formal institutions, such as Kindergarten (TK) and Raudhatul Athfal (RA), and through non-formal programmes such as playgroups and childcare centres. The Standards for Children's Development Achievement (STPPA) in Permendikbud No. 137 of 2014 list six developmental domains: religious

and moral values, physical-motor, cognitive, language, social-emotional and art. For RA, the Decree of the Director General of Islamic Education No. 3331 of 2021 expects children aged five to six to explore art activities creatively, produce artworks and express their imagination. Art and creativity are therefore part of the required curriculum in the schools studied here, not an optional extra.

The number of PAUD institutions in Indonesia has grown quickly. Competition among institutions has led many schools to prioritize early reading, writing, and arithmetic (calistung) to meet parental expectations, often at the expense of character development and holistic learning. Early childhood education should instead balance development across all domains, nurturing each according to children's characteristics and needs, rather than focusing on cognitive achievement alone. Excessive emphasis on cognitive skills through reading, writing, and arithmetic may overlook other equally important aspects of development.

Indonesia has abundant plants whose leaves and flowers are usually discarded as waste, although they can be used to make artworks. Ecoprint is a natural printing technique that transfers the shapes and pigments of leaves and flowers onto fabric or paper. It needs no synthetic dyes, which makes it a low-cost and environmentally friendly medium for school art (Faridatun, 2022). In elementary schools, ecoprint artwork has been used to strengthen students' care for the environment (Nugroho et al., 2023). Natural materials from the school surroundings have also been used as art media in early childhood classrooms (Aisyiah & Pamungkas, 2023). Ecoprint thus links art activities with the materials children already see around them.

Sukoharjo Regency possesses rich agricultural biodiversity distributed across various agroecosystems, including rice fields, drylands, mixed gardens, and forests. Plant species such as mango, coconut, banana, teak, clove, cassava, corn, and medicinal plants provide abundant natural materials that can be integrated into PAUD learning activities. This biodiversity is a local resource for ecoprint-based art education. Preliminary observations conducted in Sukoharjo Regency revealed that many children were reluctant to explore new ideas, lacked confidence in producing original work, and tended to imitate existing examples. Classroom activities were dominated by worksheets, magazines, crayons, and colored pencils, while opportunities for creative exploration remained limited. Teachers also relied on less engaging instructional strategies, and children lost interest quickly.

Children's creativity was further constrained by limited learning media, insufficient freedom to explore, and teacher-centered activities. Observations showed that many children still experienced difficulties in classifying shapes, colors, and sizes independently during threading activities and continued to rely heavily on teacher guidance. These findings indicate the need for more interactive learning methods that actively involve children and encourage creative expression. One possible strategy is ecoprint batik, which combines artistic creation with exploration of natural materials. Through this activity, children are encouraged to experiment with leaves and flowers, express original ideas, and produce unique artworks while developing creativity and environmental awareness.

LITERATURE REVIEW

Art education is one way in which a culture passes on its artistic traditions, and every child has some artistic potential. As a means of communication, art education gives children opportunities to explore, express, and develop their creativity (Adhi, Rahmawati, & Rizka, 2023).

This study follows the account of divergent thinking by Guilford (1967), which describes creativity through four indicators: fluency (producing many ideas), flexibility (shifting between kinds of ideas), originality (producing unusual ideas) and elaboration (adding detail). These indicators were used to assess the children's creativity. Seen this way, creativity is a capacity that can be developed in every child through suitable activities, rather than a talent that only a few children possess.

Several studies have examined ecoprint and natural materials in early childhood. Fatmala and Hartati (2020) examined the effect of ecoprint batik on the art creativity of kindergarten children, and Ilyas et al. (2023) examined the effect of the iron-blanket ecoprint technique on early childhood creativity. Fransiska et al. (2023) described how the pounding technique was implemented with children aged 5–6. Two recent experiments found

that ecoprint improved fine motor skills: Bachtiar et al. (2025) reported larger gains in an ecoprint group than in a control group of young children, and Wulandari et al. (2025) reported a significant pretest-posttest gain for 18 children who made ecoprint totebags. Research on natural loose parts points in the same direction. Outdoor exploration with natural materials developed fluency and flexibility in all 16 children observed by Rahmadanti and Sitorus (2026), although originality and elaboration developed less evenly.

Three gaps remain. Most ecoprint studies with young children measure fine motor skills rather than creativity. Most test a single technique chosen by the teacher, so little is known about which techniques and materials children and teachers actually choose when they are free to do so. Few studies combine classroom observation with a quantitative estimate of how techniques and materials relate to creativity, and none that we found was set in RA schools in Sukoharjo Regency, where leaves from rice fields, gardens and forests are easy to collect.

Research Objectives

This study examines ecoprint batik in RA schools in Sukoharjo Regency. It asks which ecoprint techniques and materials children and teachers use, how these relate to children's creative behaviour, and what the joint effect is of ecoprint techniques and materials on children's artistic creativity. The study combines observations and interviews in several schools with a regression analysis of questionnaire data. Its findings are intended as a reference for teachers who design art activities based on local natural materials.

RESEARCH METHOD

This study employed a sequential exploratory mixed methods design, integrating qualitative and quantitative approaches to provide a fuller understanding of the research problem (Creswell & Plano Clark, 2018). The study was conducted in several Raudhatul Athfal (RA) schools in Sukoharjo Regency involving children aged 4–6 years. From a population of 704 children, 40 participants were selected using proportional random sampling.

Qualitative data were collected through classroom observations, teacher interviews, and documentation of ecoprint batik learning activities. The findings were then used to develop a questionnaire, tested for validity and reliability, which was distributed to teachers and parents. Children's creativity was assessed based on the indicators of Guilford (1967): fluency, flexibility, originality, and elaboration.

The independent variables consisted of ecoprint batik techniques (X_1) and materials (X_2), while children's creativity (Y) served as the dependent variable. Qualitative data were analyzed using the interactive model of Miles et al. (2020), whereas quantitative data were analyzed using descriptive statistics and multiple linear regression to examine the effects of technique and material exploration on children's creativity.

RESULTS

The following section presents the results of the data analysis on children's creativity in producing ecoprint batik artwork through the exploration of techniques and materials.

Effective Techniques and Materials for Ecoprint Batik Art to Enhance Early Childhood Creativity

Observations and interviews conducted at RA Baiturahman revealed that children had a good understanding of the techniques and materials used in creating ecoprint batik artwork. Most children identified leaves, white fabric, and wooden pounding tools (mortars or mallets) as the primary materials and equipment. They also expressed personal preferences for leaves with distinctive shapes, such as long or heart-shaped leaves, suggesting that they made aesthetic choices based on their own interests and experiences.

The children's responses consistently showed that they understood the pounding technique, in which leaves are placed on white fabric and gently pounded using a wooden mallet or mortar to transfer their natural pigments and patterns onto the fabric. Green leaves of various shapes, white fabric as the printing medium, and plastic as a protective layer were the materials most frequently mentioned. These findings suggest that simple tools and

natural materials suit early childhood learning: they are easy to use and encourage children to explore, make choices, and express their creativity.

Similar findings were obtained at BA Aisyiyah Waru 03, where the children consistently recognized white fabric, stone mortars, and leaves as the essential tools and materials for ecoprint batik. Several children were able to identify specific plant materials, including papaya and cassava leaves, which showed familiarity with the materials and an understanding that different leaves produce distinctive ecoprint patterns.

Likewise, observations and interviews conducted at BA Aisyiyah Qurrota Ayun showed that the children clearly understood the media, tools, and materials involved in the ecoprint process. Most children identified white fabric as the primary printing medium and stone mortars as the main pounding tools, while leaves of different shapes, sizes, and colors were recognized as the key materials for creating patterns. Some children also mentioned flowers, plastic sheets, and wooden blocks as supporting materials. Their responses reflected both knowledge of the materials and individual preferences; several children favored heart-shaped or colorful leaves because they produced more attractive motifs.

Overall, the findings indicate that children across the three early childhood education institutions understood the tools, materials, and techniques used in ecoprint batik activities. The simple pounding technique, combined with diverse natural materials, appeared to support children's creativity by encouraging experimentation, independent decision-making, aesthetic appreciation, and imaginative expression, as well as sensory and fine motor development.

Interviews and observations at seven early childhood education institutions (RA Baiturahman, BA Aisyiyah Waru 03, BA Aisyiyah Qurrota Ayun, RA Muslimah, RA Zaenab, RA Assakinah, and RA Al-Muhtadin) showed consistent patterns in the techniques and materials used to create ecoprint batik artwork. Most teachers and children preferred the hammering (pounding) technique, using simple tools such as wooden mallets, metal hammers, wooden blocks, or stone mortars. Teachers considered this technique effective because it is developmentally appropriate for young children, easy to perform, and provides an enjoyable learning experience. A teacher at RA Baiturahman explained, “The children are very enthusiastic when pounding leaves onto the fabric. They feel as though they are playing while simultaneously creating beautiful artwork.”

The pounding technique also supports children's motor development. It encourages children to control the force of their strikes, arrange the leaves carefully to prevent movement, and understand basic compositional concepts. The activity thus appears to stimulate creativity and to support fine and gross motor coordination.

Regarding the materials, children primarily used leaves of various shapes, sizes, and colors, including papaya, guava, mango, and cassava leaves, as well as uniquely shaped leaves such as long and heart-shaped leaves. Some children also incorporated flowers to create more colorful and varied patterns. A teacher at BA Aisyiyah Qurrota Ayun explained that the use of natural materials helps children become more familiar with their environment while introducing them to the diversity of natural forms and colors. The primary medium used in the activity was plain white fabric, which clearly displayed the leaf impressions, while plastic sheets were used as protective layers to prevent the leaves from shifting during the pounding process.

The use of simple tools such as wooden mallets, stone mortars, and wooden blocks also represents a form of contextual learning closely connected to children's daily lives. Through these activities, children learn that artistic creations do not require expensive equipment but can be produced using materials and tools readily available in their surroundings. Teachers observed that simple tools make children feel more engaged in the creative process because they can directly understand the relationship between pounding the leaves and the appearance of patterns on the fabric.

Quantitative Analysis: The Effect of Ecoprint Batik Techniques and Materials on the Creativity of Early Childhood Education Students in Sukoharjo Regency

Multiple linear regression analysis was used to estimate the effect of the independent variables on the dependent variable. In this study, regression analysis was used to examine the effects of ecoprint techniques (X_1) and ecoprint materials (X_2) on students' artistic creativity (Y). This analysis tested the research hypothesis and estimated the contribution of ecoprint materials and techniques to the creativity of early childhood education students in Sukoharjo Regency.

Table 1. ANOVA test results

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	210.874	2	105.437	6.248	0.005**
Residual	624.501	37	16.892	–	–
Total	835.375	39	–	–	–

The ANOVA results presented in Table 1 indicate that ecoprint materials and techniques jointly have a significant effect on children's artistic creativity ($F = 6.248$, $p = 0.005 < 0.05$). Therefore, the research hypothesis stating that ecoprint materials and techniques significantly influence the artistic creativity of early childhood education students is accepted.

These findings suggest that the selection of natural materials and the use of varied ecoprint techniques contribute to children's creativity in producing artwork. Early childhood creativity is influenced by internal factors and by learning environments that encourage exploration. A greater variety of natural materials may give children more opportunities to experiment visually, generate original ideas, and express their imagination through artistic creations. Different ecoprint techniques may likewise offer varied artistic experiences and encourage children to explore combinations of colors, patterns, and textures produced by leaf and flower printing.

Table 2. Coefficient of determination (R^2) test results

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.721	0.520	0.505	2.110

In the Model Summary, the R value of 0.721 indicates a strong positive relationship between the independent variables (ecoprint materials and ecoprint techniques) and the dependent variable (children's artistic creativity). The R Square value of 0.520 shows that 52.0% of the variance in children's artistic creativity is explained by the two independent variables, while the remaining 48.0% is attributable to other factors not included in this study. The Adjusted R Square value of 0.505 is close to R Square, so the fit changes little after adjusting for the number of predictors. The Standard Error of the Estimate is 2.110. With $R = 0.721$ and R Square = 0.520, the two predictors explain 52% of the variance in children's creativity; the remaining 48% may reflect factors not included in the model, such as teacher support, the availability of other learning media, and children's prior experiences.

DISCUSSION

The first finding is that the hammering (pounding) technique was the technique most often used in the seven RA and BA schools, with wooden mallets, stone mortars and wooden blocks as tools. Teachers preferred it because it is easy for young children and the result appears at once: a child strikes a leaf and sees its outline and colour on the cloth. This direct link between action and result may explain why children stayed engaged and began to plan where to place leaves and how hard to strike. The finding agrees with Fransiska et al. (2023), who implemented the pounding technique with children aged 5–6. It is also consistent with the motor gains reported for ecoprint by Bachtiar et al. (2025) and Wulandari et al. (2025), since controlling the force of each strike is a fine motor task. This study, however, did not compare pounding with other techniques. Ilyas et al. (2023) studied the iron-blanket technique, so the present data show which technique was most used and most accepted, not which is most effective.

The second finding concerns materials. Children chose leaves from their surroundings, such as papaya, guava, mango and cassava leaves, and often preferred long or heart-shaped leaves because they gave attractive motifs. Choosing a leaf, predicting its print and combining leaves with flowers are small decisions that call on fluency, flexibility and originality as defined by Guilford (1967). This pattern is close to that reported by Rahmadanti and Sitorus (2026), where natural loose parts developed fluency and flexibility in all children, while originality and elaboration developed less evenly. Teachers in other Indonesian studies have also reported that natural loose parts give children freedom to create (Rahardjo, 2019) and support art and motor development (Rianti et al., 2022). Low-cost materials can also build early ecological responsibility (Royani et al., 2025). The teacher's remark that children became more familiar with their environment fits this evidence and the use of ecoprint for environmental care in elementary schools (Nugroho et al., 2023).

The third finding is quantitative. The regression model was significant ($F = 6.248$, $p = 0.005$; Table 1), and Table 2 reports $R = 0.721$ and $R^2 = 0.520$. Read together with the qualitative data, this suggests that children who had richer experiences with techniques and materials were rated as more creative. The result agrees in direction with Fatmala and Hartati (2020), who examined ecoprint batik and art creativity in kindergarten, and with Fajrie et al. (2024), who found that a natural material-based art learning model increased young children's aesthetic experience. Finger painting studies report similar gains in originality and confidence with colour and shape (Bungge et al., 2025). Two cautions apply. First, the paper reports only the joint F-test, so it cannot say whether techniques, materials or both drive the effect. Second, the R^2 in Table 2 does not match the sums of squares in Table 1 (210.874/835.375 = 0.25), so the share of variance explained needs to be checked before it is interpreted.

For teachers in Sukoharjo and similar districts, the findings suggest a practical sequence. Teachers can collect local leaves and flowers with the children, let each child choose and arrange them, and use pounding with simple tools and a plastic cover so that the leaves do not shift. Once children are confident, teachers may introduce other techniques, such as steaming or pressing, so that children move beyond copying a model. The teacher's role is to guide rather than to direct. A meta-analysis found that guided play can produce better learning than direct instruction for some early outcomes (Skene et al., 2022), and Indonesian reviews of STEAM in PAUD describe the teacher as a facilitator under the Kurikulum Merdeka (Motimona & Maryatun, 2023). Ecoprint can also serve as an arts entry point to STEAM activities, which a scoping review found to be especially relevant for young children (Johnston et al., 2022). Principals can support this by allowing time for outdoor collection and by sharing simple tools between classes.

The study has several limitations. The design had no pretest and no comparison group, so the regression shows an association between ecoprint experience and rated creativity, not a causal effect. The sample of 40 children came from a population of 704, but the abstract and findings describe different numbers of schools, which limits generalisation. Creativity was rated by teachers and parents on a questionnaire, not observed in the children's products, so ratings may share method bias (Podsakoff et al., 2003). No validity or reliability statistics and no coefficients table are reported, and Tables 1 and 2 are inconsistent. The qualitative findings come mainly from three schools. Future studies should compare techniques in a quasi-experiment with pretests and a control group, score the children's artworks directly against the four creativity indicators, and follow children over a full semester to see whether gains last.

CONCLUSION AND RECOMMENDATIONS

The study concludes that the hammering technique, using simple tools such as wooden or metal mallets, wooden blocks, and stone mortars, is the most frequently applied ecoprint technique and the one teachers judged most suitable, because it is easy for young children to use and supports enjoyable learning and sensorimotor development. The most commonly used materials are natural leaves, including papaya, guava, mango, and cassava leaves, with flowers occasionally added to enhance color and aesthetic value. White fabric serves as the primary printing medium, while plastic sheets help stabilize the leaves during the printing process.

The regression analysis indicates that ecoprint materials and techniques have a significant joint effect on children's artistic creativity, with a strong relationship ($R = 0.721$) and an explanatory power of 52% ($R^2 = 0.520$).

These findings indicate that the selection of appropriate natural materials and developmentally suitable ecoprint techniques contributes to creativity in early childhood education. Teachers are therefore encouraged to integrate ecoprint activities into art learning using locally available natural resources. Future research should investigate additional factors influencing children's creativity, such as teacher support, parental involvement, and the broader learning environment, to provide a more comprehensive understanding of creativity development.

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REFERENCES

Adhi, B. P., Rahmawati, S. C., & Rizka, A. D. M. (2023). Inovasi pengembangan materi seni untuk anak usia dini di perguruan tinggi. COMSERVA: Jurnal Penelitian dan Pengabdian Masyarakat, 3(5), 1775–1783. https://doi.org/10.59141/comserva.v3i5.974

Aisyiah, N. A., & Pamungkas, J. (2023). Pemanfaatan bahan alam lingkungan sebagai media pembelajaran seni rupa anak usia dini. Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini, 7(6), 6741–6749. https://doi.org/10.31004/obsesi.v7i6.4606

Aprillia, E., & Wulandari, R. (2023). Pengelolan pembelajaran seni rupa melalui kegiatan kolase untuk meningkatkan kreativitas anak usia dini. HYPOTHESIS: Multidisciplinary Journal of Social Sciences, 1(2), 139–147.

Bachtiar, M. Y., Hasmawaty, H., Sultan, J., AM, M. A., & Kassymova, G. K. (2025). Exploring ecoprint-based media: Enhancing fine motor skills in early childhood education. JPUD – Jurnal Pendidikan Usia Dini, 19(1), 1–10. https://doi.org/10.21009/jpud.v19i1.50549

Bungge, S. M., Durrotunnisa, Setianingsih, H. P., & Zuama, S. N. (2025). Finger painting activities and their effects on creativity in early childhood. Indonesian Journal of Early Childhood Educational Research, 4(2). https://doi.org/10.31958/ijecer.v4i2.15964

Creswell, J. W., & Plano Clark, V. L. (2018). Designing and conducting mixed methods research (3rd ed.). SAGE.

Fajrie, N., Kartika, D. D., Utaminingsih, S., & Santoso, D. A. (2024). Natural material-based art learning model increases aesthetic experiences in early childhood. *Jurnal Pendidikan Anak Usia Dini Undiksha*, 12(1), 109–119. https://doi.org/10.23887/paud.v12i1.74612

Faridatun, F. (2022). Ecoprint: Cetak motif alam ramah lingkungan. *Jurnal Prakarsa Paedagogia*, 5(1). https://doi.org/10.24176/jpp.v5i1.9002

Fatmala, Y., & Hartati, S. (2020). Pengaruh membatik ecoprint terhadap perkembangan kreativitas seni anak di taman kanak-kanak. Jurnal Pendidikan Tambusai, 4(2), 1143–1155. https://doi.org/10.31004/jptam.v4i2.577

Fransiska, F., Sudarto, S., & Adpriyadi, A. (2023). Implementasi ecoprint menggunakan teknik pounding pada fase fondasi (5-6 tahun) di TK Santa Maria Sintang. Jurnal Pendidikan Dasar Perkhasa: Jurnal Penelitian Pendidikan Dasar, 9(2), 594–611. https://doi.org/10.31932/jpdp.v9i2.2864

Guilford, J. P. (1967). The nature of human intelligence. McGraw-Hill.

Ilyas, S. N., Kurnia R., R., Dzulfadhilah, F., Amriani H., S. R., & Lismayani, A. (2023). The influence of ecoprint batik iron blanket technique on increasing early childhood creativity. *Edumaspul: Jurnal Pendidikan*, 7(1), 803–810. https://doi.org/10.33487/edumaspul.v7i1.5655

Johnston, K., Kervin, L., & Wyeth, P. (2022). STEM, STEAM and makerspaces in early childhood: A scoping review. Sustainability, 14(20), Article 13533. https://doi.org/10.3390/su142013533

Miles, M. B., Huberman, A. M., & Saldaña, J. (2020). Qualitative data analysis: A methods sourcebook (4th ed.). SAGE.

Motimona, P. D., & Maryatun, I. B. (2023). Implementasi metode pembelajaran STEAM pada Kurikulum Merdeka untuk PAUD. Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini, 7(6), 6493–6504. https://doi.org/10.31004/obsesi.v7i6.4682

Nugroho, A. S., Sumardjoko, B., Desstya, A., Minsih, & Widiyasari, C. (2023). Penguatan karakter peduli lingkungan di sekolah dasar melalui karya seni ecoprint. Jurnal Elementaria Edukasia, 6(2), 762–777. https://doi.org/10.31949/jee.v6i2.5120

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal of Applied Psychology, 88(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Rahardjo, M. M. (2019). How to use loose-parts in STEAM? Early childhood educators focus group discussion in Indonesia. JPUD – Jurnal Pendidikan Usia Dini, 13(2), 310–326. https://doi.org/10.21009/JPUD.132.08

Rahmadanti, L., & Sitorus, A. S. (2026). Efektivitas loose parts berbasis bahan alam dalam mengembangkan kreativitas anak usia 5–6 tahun. Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini, 10(2), 1346–1352. https://doi.org/10.31004/obsesi.v10i2.8264

Rianti, R., Nurjanah, I., Latifah, D., Alifah, N., & Asyiah, A. (2022). Freedom learning on early childhood education: Implementation of STEAM method with loose parts media. Golden Age: Jurnal Ilmiah Tumbuh Kembang Anak Usia Dini, 7(2), 99–108. https://doi.org/10.14421/jga.2022.72-05

Royani, I., Suriyani, S., & Tjahyaningsih, R. (2025). Utilizing recycled materials as innovative educational media to enhance early childhood learning. International Journal Education and Computer Studies, 5(2). https://doi.org/10.35870/ijecs.v5i2.5077

Skene, K., O'Farrelly, C. M., Byrne, E. M., Kirby, N., Stevens, E. C., & Ramchandani, P. G. (2022). Can guidance during play enhance children's learning and development in educational contexts? A systematic review and meta-analysis. Child Development, 93(4), 1162–1180. https://doi.org/10.1111/cdev.13730

Wulandari, I., Sariah, S., Sakilah, S., Wati, I., Nurhayati, N., & Arbi, A. (2025). Children's fine motor development through ecoprint techniques on totebag. Kindergarten: Journal of Islamic Early Childhood Education, 8(1), 1–11. https://doi.org/10.24014/kjiece.v8i1.37464

ICISFS-UMK 2026 LEARNING INNOVATION

The Effect of Problem-Based Learning Assisted by Quizizz-Based Online Game Media in Improving Critical Thinking Skills on Local Wisdom Topics

Milania Dyah Pratiwi[1*], Wawan Shokib Rondli[1] and Khamdun[1]

[1]*Universitas Muria Kudus, Indonesia*

ABSTRACT

This study aims to examine the effect of implementing the PBL model assisted by Quizizz-based online game media on improving students' critical thinking skills regarding local wisdom topics in Natural and Social Sciences (IPAS). Using a quasi-experimental Nonequivalent Pretest-Posttest Control Group Design, the study involved two fifth-grade classes at SDN Weding 1 Bonang: an experimental group (n = 24) taught with PBL and Quizizz and a control group (n = 23) taught conventionally. The instruments were a higher-order thinking skills (HOTS) test covering four Facione dimensions (interpretation, analysis, inference, and evaluation) and learning observation sheets. Data were analyzed with normality and homogeneity tests and an Independent Sample t-test.

Both groups improved, but the experimental class reached a higher posttest mean (85.42) than the control class (71.30), with an average N-Gain of 0.65 compared with 0.32 for the control group (both in the moderate category). The Independent Sample t-test on posttest scores gave t-count = 7.185 > t-table = 2.014 ($p = 0.000 < 0.05$), so the null hypothesis was rejected. PBL assisted by Quizizz therefore had a significant positive effect on the critical thinking skills of these fifth-grade students. The findings offer practical guidance for teachers who design contextual, technology-supported instruction.

KEYWORDS problem-based learning | Quizizz | online games | critical thinking skills | local wisdom

INTRODUCTION

Digital technology has accelerated a shift in formal education from teacher-centered to student-centered learning. This shift reflects 21st-century educational demands, which emphasize higher-order thinking skills (HOTS) such as critical thinking, creativity, collaboration, and communication. Indonesian students still perform below the OECD average in mathematics, reading and science in PISA 2022 (OECD, 2023), and items in these assessments depend on interpreting information and reasoning from evidence. Primary school teachers are therefore expected to adopt models that combine active learning with instructional technology.

Problem-Based Learning (PBL) is one response to these demands. PBL is a learner-centred approach in which students work on ill-structured, authentic problems (Savery, 2006). By anchoring learning in such problems, PBL guides learners to identify challenges, analyze information, formulate hypotheses, and propose evidence-based solutions. PBL engages students in constructing knowledge rather than absorbing it passively, which supports cognitive growth and critical reasoning. In primary education, developing critical thinking early helps students move beyond memorizing facts to evaluating arguments, weighing evidence, and solving contextual problems.

Evidence for PBL in Indonesian primary schools is substantial. A meta-analysis of 12 studies reported a large mean effect of PBL on elementary students' critical thinking (ES = 1.065) (Setyowati & Sutikno, 2024), and a second meta-analysis of 25 SINTA-indexed studies also found a strong effect (Sa'diyah et al., 2024). Across 42 science-learning studies from 2020 to 2024, the pooled effect of PBL on critical thinking and problem solving was 0.798 (Aripin et al., 2025). Anazifa and Djukri (2017) found that both project-based and problem-based learning improved students' thinking skills. Internationally, Abrami et al. (2015) found that critical thinking instruction worked best when it combined dialogue, authentic problems and mentoring (g = 0.57), which are the core features of PBL.

Educational technology has also developed through gamification and game-based learning platforms. Gamification adds game elements such as points, competition and feedback to learning tasks. A meta-analysis found small positive effects of gamification on cognitive (g = .49), motivational (g = .36) and behavioural (g = .25) outcomes (Sailer & Homner, 2020). For K-12 motivation the pooled effect was larger (g = 0.654), but it was smallest for primary school students (g = 0.309) (Kurnaz & Koçtürk, 2025). Platforms such as Quizizz offer interactive, informally competitive quizzes with immediate feedback, leaderboards, visual scoring, and analytics. With HOTS-oriented questions, Quizizz can act as a formative assessment tool and a prompt for reflection (Zhao, 2019). A review of 15 Indonesian studies concluded that Quizizz helps elementary students understand material and become more active and motivated (Arrahim et al., 2022). Most of these studies, however, measured motivation or learning outcomes rather than critical thinking (Puzally et al., 2026).

Combining Problem-Based Learning with Quizizz links problem-centered inquiry with interactive digital technology. In primary school Natural and Social Sciences (IPAS), local wisdom topics, such as traditional practices, cultural values, and environmental preservation, provide real-world problems for this approach. A review of 47 Indonesian studies found that local wisdom-based learning was associated with gains in conceptual understanding, critical thinking and character, although most of the evidence came from development and short-term descriptive studies (Jovanda et al., 2026). Local cultural phenomena allow students to investigate community traditions, weigh social issues from several perspectives, and propose contextual solutions.

Three gaps follow from this literature. First, PBL and Quizizz have mostly been studied separately; studies of Quizizz in Indonesian primary schools often use one-group designs and measure motivation (Saputri et al., 2025; Serli et al., 2026). Second, few studies have used local wisdom topics in IPAS as the problem context for PBL with digital quizzes. Third, little of this evidence comes from rural and semi-rural primary schools, such as those in Bonang, Demak Regency, where device access and internet stability may differ from urban schools.

This study therefore uses a nonequivalent control group design to investigate the effect of the Problem-Based Learning model assisted by Quizizz online game media on improving primary school students' critical thinking skills regarding local wisdom.

LITERATURE REVIEW

The conceptual framework links the intervention to the expected outcome in four steps. The initial condition is conventional, teacher-centred instruction based on lectures and memorisation, low student engagement, limited critical thinking, and abstract delivery of local wisdom topics. The intervention in the experimental class is PBL assisted by Quizizz, in four phases: orientation to an authentic local wisdom problem, group investigation using field or written sources, synthesis and presentation of solutions, and formative assessment and reflection through HOTS quizzes on Quizizz. Two mechanisms are expected to operate: active inquiry and collaborative problem solving (from PBL), and immediate feedback, reflection and motivation (from Quizizz). The expected outcome is higher critical thinking in four dimensions: interpretation, analysis, inference and evaluation (Facione, 2020).

In this framework, conventional learning is assumed to be insufficient for developing higher-order reasoning. The intervention introduces PBL as the overarching pedagogical structure that encourages inquiry and contextual analysis. Quizizz is embedded within the evaluation and reflection phases to supply immediate feedback, reinforce HOTS-level questions, and sustain engagement. Together, these components are expected to improve student performance across the critical thinking dimensions.

Research Objectives

To analyze the effect of applying the Problem-Based Learning model assisted by Quizizz online game media on improving primary school students' critical thinking skills regarding local wisdom topics.

Specific Objectives

1. To measure the difference in critical thinking skill improvement (N-Gain) between students taught with PBL assisted by Quizizz and those taught with conventional methods.

2. To describe how Quizizz was used as supporting media within the PBL syntax.
3. To evaluate student performance gains across specific critical thinking dimensions (interpretation, analysis, inference, and evaluation).
4. To identify contextual and implementation factors that influence the execution of digital game-assisted PBL in elementary schools.

RESEARCH METHOD

Research Design

This study employed a quantitative approach using a quasi-experimental design, specifically the Nonequivalent Pretest-Posttest Control Group Design (Shadish et al., 2002). The research was conducted at SDN Weding 1 Bonang, Demak Regency, Central Java, during the second semester of the 2025/2026 academic year.

The experimental design is structured as follows:

Table 1. Nonequivalent pretest-posttest control group design

Group	Pretest	Treatment	Posttest
Experimental Class (*n* = 24)	O_1	X (PBL + Quizizz)	O_2
Control Class (*n* = 23)	O_3	− (Conventional)	O_4

Where X = PBL assisted by Quizizz; O1 and O3 = pretest measurements; O2 and O4 = posttest measurements.

Population and Sample

The target population comprised all fifth-grade (Class V) students in the Diponegoro Cluster, Bonang District. Using purposive sampling (Sugiyono, 2019), two intact classes from SDN Weding 1 were selected based on equivalent baseline academic ability: Class V-A (n = 24) was the experimental group, and Class V-B (n = 23) was the control group.

Operational Variables

- Independent Variable (X): Problem-Based Learning model integrated with Quizizz online game media.
- Dependent Variable (Y): Critical thinking skills in IPAS local wisdom topics, operationalized across four dimensions (Facione, 2020): *Interpretation*, *Analysis*, *Inference*, and *Evaluation*.

Instruments and Data Collection

1. Critical Thinking Skills Test**:** A validated 15-item HOTS test consisting of essay and reasoned multiple-choice items.
2. Observation Sheets**:** Used to evaluate syntax implementation, student group work, and engagement.

Instrument Testing

- Validity: Evaluated via expert judgment and Pearson Product-Moment correlation (r-count > r-table) (Taherdoost, 2016).
- Reliability: Calculated using Cronbach's Alpha, giving an acceptable reliability index of r11 = 0.71 ≥ 0.70.
- Item Difficulty & Discrimination Index: Item analysis (Arikunto, 2019) showed a balanced proportion of easy-to-medium difficulty items with sufficient discriminating power (D ≥ 0.21).

Data Analysis Techniques

Data were processed using SPSS and Microsoft Excel:

1. **Descriptive Statistics:** Mean, standard deviation, minimum, and maximum scores.
2. **Normalized Gain (N-Gain)** (Hake, 1998), calculated as:

$$N\text{-Gain} = \frac{\text{Posttest Score} - \text{Pretest Score}}{\text{Maximum Possible Score} - \text{Pretest Score}}$$

3. **Prerequisite Tests:** Kolmogorov-Smirnov test for normality ($p > 0.05$) and Levene's test for homogeneity of variance ($p > 0.05$).
4. **Hypothesis Testing:** Independent Sample t-test at $\alpha = 0.05$ significance level.

RESULTS

Pretest and Posttest Results

Descriptive statistics of the pretest and posttest scores of both groups are presented below:

Table 2. Descriptive statistics of pretest, posttest and N-gain scores

Group	n	Pretest Mean ($\bar{X}$)	Pretest SD	Posttest Mean ($\bar{X}$)	Posttest SD	Average N-Gain	Category
Experimental	24	58.50	7.62	85.42	6.28	0.65	Moderate (High-bound)
Control	23	57.83	8.15	71.30	7.14	0.32	Moderate (Low-bound)

Before treatment, baseline critical thinking scores were nearly identical (mean = 58.50 vs. 57.83). After instruction, the experimental group reached a posttest mean of 85.42, compared with 71.30 for the control group. The experimental group also had a higher average N-Gain (0.65 / 65%) than the control group (0.32 / 32%).

Dimension-Wise Critical Thinking Performance

Posttest performance on each critical thinking dimension was higher in the experimental group than in the control group:

Table 3. Posttest performance by critical thinking dimension

Critical Thinking Dimension	Experimental Class (%)	Control Class (%)	Difference (%)
Interpretation (Understanding local wisdom problems)	88.5%	75.0%	+13.5%
Analysis (Identifying cultural connections/causes)	85.0%	71.2%	+13.8%
Inference (Formulating logical solutions/conclusions)	83.2%	68.5%	+14.7%
Evaluation (Assessing cultural arguments and evidence)	84.8%	70.1%	+14.7%

The largest between-group differences were in the Inference (+14.7%) and Evaluation (+14.7%) dimensions, although the differences in all dimensions were of similar size.

Hypothesis Testing

Prerequisite tests indicated normally distributed data (Kolmogorov-Smirnov $p = 0.200 > 0.05$) and homogeneous variances (Levene's test $p = 0.520 > 0.05$). An Independent Sample t-test on pretest scores showed no significant baseline difference ($t = 0.291$, $p = 0.772 > 0.05$).

The Independent Sample t-test on posttest scores yielded:

Table 4. Independent samples t-test results for posttest scores

Variable	t_{count}	t_{table} (α=0.05)	df	p-value (2-tailed)	Decision
Posttest	7.185	2.014	45	0.000	H_0 Rejected, H_1 Accepted

Because t-count (7.185) > t-table (2.014) and $p < 0.05$, H0 was rejected: PBL assisted by Quizizz had a statistically significant positive effect on students' critical thinking skills.

DISCUSSION

Synergy of PBL and Quizizz in Cognitive Growth

The main finding is that students taught with PBL assisted by Quizizz reached a higher posttest mean than students taught conventionally (85.42 vs. 71.30; Table 2). The difference was significant ($t = 7.185 > t\text{-table} = 2.014$, $p < 0.05$; Table 4), while the pretest means were nearly identical (58.50 vs. 57.83; $t = 0.291$, $p = 0.772$). The experimental class also had a higher average N-Gain (0.65 vs. 0.32), although both gains fall in the moderate category. Because the groups started at the same level, the posttest difference is consistent with an effect of the intervention, within the limits of a design with two intact classes.

The control class also improved, with an N-Gain of 0.32, so conventional teaching of the same topics was not ineffective. The contrast between the two gains resembles the pattern Hake (1998) reported when he introduced the normalized gain: courses using interactive engagement averaged 0.48, compared with 0.23 for traditional courses. In both cases, students who actively worked on problems gained more than students who mainly listened. The experimental gain of 0.65 still leaves about a third of the possible improvement unrealised, which suggests that one unit of instruction is not enough to bring most students to a high level of critical thinking.

A likely mechanism is that the PBL syntax required students to work with problems taken from their own community, such as changing customs or environmental preservation in Bonang. To propose a solution, students had to interpret the problem, look for causes and judge which solution was reasonable. These are the same operations that the HOTS test measured. The size and direction of the result agree with Indonesian meta-analyses of PBL in elementary schools (Setyowati & Sutikno, 2024; Sa'diyah et al., 2024) and with the large pooled effect reported for science learning (Aripin et al., 2025). They also fit the finding of Abrami et al. (2015) that authentic problems combined with dialogue are among the most effective ways to teach critical thinking.

Quizizz was used in the evaluation and reflection phases. Its real-time scoring let students see their errors immediately, and the leaderboard and time limits kept attention on HOTS items that students might otherwise avoid. This interpretation agrees with reviews that link Quizizz to more active participation and motivation in primary schools (Arrahim et al., 2022; Puzally et al., 2026), and with the classroom report of Zhao (2019). Two cautions apply. Gamification meta-analyses report only small to moderate effects, and the smallest motivational effects are found among primary school students (Sailer & Homner, 2020; Kurnaz & Koçtürk, 2025). More importantly, this study had no PBL-only group, so the separate contribution of Quizizz cannot be estimated. The result should therefore be read as the effect of the combined package.

Table 3 shows that the experimental class scored higher than the control class on all four dimensions, with differences between 13.5 and 14.7 percentage points. The differences were largest for inference and evaluation, but all four were of similar size and were not tested separately. Table 3 reports posttest percentages only, so it shows where the classes ended, not how much each dimension grew. The pattern is consistent with the review of Jovanda et al. (2026), which found that local wisdom contexts were associated with gains in critical thinking, but our data cannot show that the local wisdom content itself caused the difference.

Practical Implications and Limitations

For teachers in Demak and similar districts, the findings suggest building PBL scenarios from local community issues and writing Quizizz items as short scenarios that require interpretation and evaluation rather than recall. Teachers need to plan time carefully, because open-ended investigation and timed quizzes compete for the same lesson. Students used to passive learning also needed scaffolding when formulating problems. During implementation, the quizzes depended on a stable internet connection and ready devices. Similar constraints, including uneven teacher competence and underused ICT infrastructure, were reported for digital learning under the Kurikulum Merdeka by Afrillia and Dafit (2025). Principals can address these constraints by securing Wi-Fi and devices and by using KKG meetings to let teachers design and share PBL scenarios and HOTS quiz items.

The study has several limitations. It used two intact classes in one school, selected purposively, so the results may not generalise to other schools in the cluster. Without random assignment, differences between the classes

other than the treatment cannot be ruled out (Shadish et al., 2002). The test had 15 items with a reliability of 0.71, which is acceptable but modest. The observation-sheet data on implementation were not reported, and no effect size was reported; an effect size such as Cohen's d would allow comparison with the meta-analyses cited above (Lakens, 2013). Future studies should include a PBL-only group to isolate the role of Quizizz, involve several schools, add a delayed posttest, and report effect sizes and implementation data.

CONCLUSION AND RECOMMENDATIONS

Conclusion

1. Significant effect: Problem-Based Learning assisted by Quizizz online game media significantly improved the critical thinking skills of the fifth-grade students in this study on IPAS local wisdom topics.
2. Statistical evidence: Posttest results (t-count = 7.185 > t-table = 2.014, p = 0.000) show a statistically significant difference favoring the experimental group over conventional instruction.
3. Learning gains: The experimental group achieved a moderate gain (N-Gain = 0.65), compared with a lower moderate gain in the control group (N-Gain = 0.32).
4. Dimension results: The between-group differences were largest for inference and evaluation, although the differences across all dimensions were of similar size.

Recommendations

For Educators

- Incorporate localized, real-world community issues when designing PBL problem scenarios.
- Design Quizizz assessments prioritizing scenario- and visual-based HOTS questions rather than low-level recall items.
- Manage lesson timing systematically to ensure adequate space for both collaborative inquiry and digital reflection.

For School Administrators

- Enhance ICT infrastructure (Wi-Fi stability, device access) to support tech-integrated active learning.
- Facilitate teacher professional development (e.g., KKG workshops) centered on gamified digital learning design.

For Future Researchers

- Expand the sample size across multiple clusters or regions to increase generalizability.
- Investigate the impact of gamified PBL on additional dependent variables, such as self-regulated learning or collaborative skills.
- Employ mixed-method research designs to capture deeper qualitative insights into student cognitive adaptation during digital PBL.

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REFERENCES

Abrami, P. C., Bernard, R. M., Borokhovski, E., Waddington, D. I., Wade, C. A., & Persson, T. (2015). Strategies for teaching students to think critically: A meta-analysis. Review of Educational Research, 85(2), 275-314. https://doi.org/10.3102/0034654314551063

Afrillia, A., & Dafit, F. (2025). Tantangan guru mengimplementasikan pembelajaran berbasis teknologi digital dalam Kurikulum Merdeka di UPT SDN 023 Pandau Jaya. Pendas: Jurnal Ilmiah Pendidikan Dasar, 10(4), 230-242. https://doi.org/10.23969/jp.v10i04.36163

Anazifa, R. D., & Djukri. (2017). Project-based learning and problem-based learning: Are they effective to improve student's thinking skills? *Jurnal Pendidikan IPA Indonesia*, 6(2), 346–355. https://doi.org/10.15294/jpii.v6i2.11100

Arikunto, S. (2019). *Dasar-dasar evaluasi pendidikan* (3rd ed.). Bumi Aksara.

Aripin, N., Festiyed, Yerimadesi, Alberida, H., Ahda, Y., & Mufit, F. (2025). The impact of problem-based learning on science learning to improve students' critical thinking and problem-solving skills: A meta-analysis. Jurnal Penelitian Pendidikan IPA, 11(6), 45-57. https://doi.org/10.29303/jppipa.v11i6.10051

Arrahim, A., Yulianti, H., & Sugiharti, R. E. (2022). Penggunaan media pembelajaran Quizizz untuk meningkatkan hasil belajar siswa sekolah dasar. Jurnal Inovasi Pendidikan dan Pembelajaran Sekolah Dasar, 6(2), 208-218. https://doi.org/10.24036/jippsd.v6i2.120037

Facione, P. A. (2020). *Critical thinking: What it is and why it counts*. Insight Assessment.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. American Journal of Physics, 66(1), 64–74. https://doi.org/10.1119/1.18809

Jovanda, R., Paais, R. L., Manafe, M. P., Sundari, L., Dewi, A. R., Ohodo, M. M. R., Chasanah, I. A. W., Pratama, A. H., & Waluyo, H. (2026). Local wisdom-based learning approaches for strengthening students' conceptual understanding and character in Indonesia: A systematic literature review [Version 1; peer review: 1 approved with reservations]. F1000Research, 15, Article 1384. https://doi.org/10.12688/f1000research.188148.1

Kurnaz, M. F., & Koçtürk, N. (2025). A meta-analysis of gamification's impact on student motivation in K-12 education. Psychology in the Schools, 62(12), 4997-5009. https://doi.org/10.1002/pits.70056

Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for t-tests and ANOVAs. Frontiers in Psychology, 4, Article 863. https://doi.org/10.3389/fpsyg.2013.00863

OECD. (2023). PISA 2022 results (Volume I): The state of learning and equity in education. OECD Publishing. https://doi.org/10.1787/53f23881-en

Puzally, F. N., Nugraha, I. A., Sholehah, P. D., Risawati, N. R., Rofiqoh, J. A., Imaduddin, M., & Indrawati, D. (2026). Peran media pembelajaran digital Quizizz terhadap peningkatan hasil belajar siswa sekolah dasar: Analisis studi pustaka. Pendas: Jurnal Ilmiah Pendidikan Dasar, 11(2), 285-293. https://doi.org/10.23969/jp.v11i02.45833

Sa'diyah, H., Umalihayati, Hidayah, R., Salimi, M., Fajari, L. E. W., Mashudi, & Aini, S. (2024). The effect of problem based learning model on critical thinking skills in elementary school: A meta analysis study. Jurnal Iqra': Kajian Ilmu Pendidikan, 9(1). https://doi.org/10.25217/ji.v9i1.4456

Sailer, M., & Homner, L. (2020). The gamification of learning: A meta-analysis. Educational Psychology Review, 32(1), 77-112. https://doi.org/10.1007/s10648-019-09498-w

Saputri, P., Nazurty, N., & Sulistiyo, U. (2025). Improving learning quality through Quizizz Paper Mode: A quantitative study of elementary school students. Lembaran Ilmu Kependidikan, 54(1), 123-133. https://doi.org/10.15294/lik.v54i1.22230

Savery, J. R. (2006). Overview of problem-based learning: Definitions and distinctions. *Interdisciplinary Journal of Problem-Based Learning*, 1(1), 9–20. https://doi.org/10.7771/1541-5015.1002

Serli, E., Fajar, A., & Martini, E. (2026). The influence of digital learning media "Quizizz Application" on student learning motivation in science learning at SDN 3 Mangkalaya, Sukabumi Regency. EDUKASI, 24(1), 177-191. https://doi.org/10.33387/j.edu.v24i1.11694

Setyowati, N., & Sutikno, P. Y. (2024). Meta analisis: Model pembelajaran problem based learning (PBL) terhadap keterampilan berpikir kritis siswa sekolah dasar. Jurnal Inovasi Pendidikan dan Pembelajaran Sekolah Dasar, 8(2), 587-599. https://doi.org/10.24036/jippsd.v8i2.127679

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). Experimental and quasi-experimental designs for generalized causal inference. Houghton Mifflin.

Sugiyono. (2019). *Metode penelitian pendidikan (pendekatan kuantitatif, kualitatif, dan R&D)*. Alfabeta.

Taherdoost, H. (2016). Validity and reliability of the research instrument; How to test the validation of a questionnaire/survey in a research. SSRN. https://doi.org/10.2139/ssrn.3205040

Zhao, F. (2019). Using Quizizz to integrate fun multiplayer activity in the accounting classroom. *International Journal of Higher Education*, 8(1), 37. https://doi.org/10.5430/ijhe.v8n1p37

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

Management of National and Pesantren-Based Curriculum to Improve Primary School Quality

Hanik Mas Unah[1*], Gunawan Setiadi[1] and Imaniar Purbasari[1]

[1]*Muria Kudus University, Indonesia*

Corresponding author: 202403098@std.umk.ac.id

ABSTRACT

Integrating the National Curriculum with a Pesantren-Based Curriculum is one approach to balancing academic achievement with religious and character education. However, studies on curriculum integration management in public primary schools remain limited, particularly those involving collaboration between public schools and Islamic boarding schools. This study aimed to analyze the management of curriculum integration, identify supporting and inhibiting factors, and examine its contribution to improving school quality at SDN Guyangan, Pati, Indonesia.

Using a qualitative case study design, data were collected through in-depth interviews, observation, and document analysis involving the principal, teachers, school committee, parents, and students. The data were analyzed using an interactive model of data condensation, data display, and conclusion drawing. Trustworthiness was supported through source triangulation, technique triangulation, member checking, and peer debriefing.

The findings show that curriculum integration has been implemented through the four management functions of planning, organizing, actuating, and controlling (POAC). Collaborative planning, clear organizational coordination, integrated instruction, and continuous supervision supported curriculum management. The implementation was supported by visionary leadership, effective communication, competent teachers, stakeholder collaboration, and a strong religious school culture. Limited instructional time, teachers' administrative workload, and varying levels of parental involvement remained challenges. Participants associated the integration with stronger religious competence, character development, institutional identity, and public trust; achievement data were not examined.

The study proposes collaborative curriculum management as a model for combining the National Curriculum and a pesantren-based curriculum to improve primary school quality.

KEYWORDS curriculum integration | curriculum management | pesantren-based curriculum | school quality

INTRODUCTION

Education develops the human resources needed to respond to social, technological, and economic change. The curriculum is a core component of the education system: it organizes learning experiences, develops students' competencies, and supports character formation. Curriculum management therefore affects educational quality because it ensures that curriculum planning, implementation, and evaluation are conducted systematically and continuously (Mulyasa, 2023; Sallis, 2014).

In Indonesia, the implementation of the Merdeka Curriculum encourages schools to design contextual learning based on students' needs and local characteristics while maintaining national education standards, and it is expected to raise education quality (Barlian et al., 2022). This policy also provides opportunities for schools to integrate local content into the curriculum to preserve cultural values and strengthen students' character. Implementing it is demanding: first-grade teachers, for example, struggled with its new terminology, modules and projects (Asmahasanah et al., 2023). A further challenge is the long-standing dichotomy between general education and religious education. General education tends to emphasize academic achievement, whereas religious education focuses on moral and spiritual development. As a result, many educational institutions struggle to balance cognitive, affective, and spiritual competencies within a single educational framework.

Curriculum integration is one strategy for addressing this challenge. It enables schools to connect different areas of knowledge into a coherent learning system that promotes holistic student development. According to Fogarty (1991), curriculum integration creates meaningful relationships among learning experiences and

encourages interdisciplinary understanding. Similarly, Beane (1997) argues that an integrated curriculum facilitates authentic learning by connecting academic content with students' real-life experiences. In pesantren, integrative curriculum management links academic study with daily religious practice, such as congregational prayer and Qur'an reading (Yusuf et al., 2024).

The successful implementation of curriculum integration depends largely on effective educational management. Terry (1977) explains that organizational success is achieved through four fundamental management functions, namely planning, organizing, actuating, and controlling (POAC). These functions ensure that educational programs are systematically designed, appropriately implemented, and continuously evaluated. Edwards III (1980) adds that successful policy implementation is influenced by four major factors: communication, resources, disposition, and bureaucratic structure. Together, these perspectives provide a framework for analyzing curriculum integration management within educational institutions.

Studies of integrated religious and general education in Indonesia report benefits mainly for character. At a pesantren-based madrasah ibtidaiyah in Malang, honesty, discipline, social care, environmental responsibility and love of worship were instilled through curricular integration, religious routines and community programmes (Priatmoko et al., 2025). In four madrasah ibtidaiyah in Kudus, pesantren-based literacy, religious traditions and role modelling strengthened students' religious character where a religious culture was rooted in the school (Zuhri et al., 2025). In public elementary schools in Kudus Regency, principals and teachers reported that the religious dimension of the local Gusjigang tradition was strongly embedded in leadership and character education (Kamal et al., 2025). In a public setting without a pesantren, daily habituation such as prayer and Qur'an reading was also used to build character (Suryaningsih & Desstya, 2023). However, most of these studies were set in madrasah or pesantren, and few examined how the integration itself was managed.

Little research has examined the management of curriculum integration in public primary schools that collaborate with Islamic boarding schools. Most previous studies emphasize curriculum implementation rather than exploring how curriculum integration is managed through planning, organizing, implementation, and supervision. The organizational processes, supporting factors, implementation challenges, and contribution to school quality in public elementary schools have also received little attention.

SD Negeri Guyangan, Pati, Indonesia, is an unusual setting because it has integrated the National Curriculum with a Pesantren-Based Curriculum through collaboration with Pesantren Raudlatul Ulum since 1976. Unlike most public primary schools, students receive both general education and Islamic learning, including *Tauhid*, *Fiqh*, *Nahwu*, *Sharaf*, *Tajwid*, and Arabic, within one integrated educational system. This long-standing collaboration offers a useful case of curriculum integration management in Indonesian public primary education.

This study therefore aims to analyze the management of National and Pesantren-Based Curriculum integration at SD Negeri Guyangan using Terry's (1977) management framework and Edwards III's (1980) implementation theory. Specifically, the study investigates (1) curriculum integration management practices, (2) supporting and inhibiting factors affecting implementation, and (3) the contribution of curriculum integration to improving primary school quality. The study proposes a management model for integrating the National Curriculum and a Pesantren-Based Curriculum in a public primary school. The model may be a practical reference for other schools that seek to strengthen academic achievement, religious competence, and character education together.

LITERATURE REVIEW

The conceptual framework of this study shows the relationship between curriculum integration management and primary school quality. The National Curriculum and the Pesantren-Based Curriculum are integrated through the four management functions proposed by Terry (1977), namely planning, organizing, actuating, and controlling (POAC). The implementation process is shaped by the four factors identified by Edwards III (1980): communication, resources, disposition, and bureaucratic structure. Effective curriculum integration management is expected to improve primary school quality, reflected in academic achievement, religious competence, character development, school management quality, and community trust.

Research Objectives

This study aims to analyze the management of the integration between the National Curriculum and the Pesantren-Based Curriculum at SD Negeri Guyangan, Pati, Indonesia, and to examine its contribution to improving primary school quality. Specifically, the objectives of this study are: 1) To analyze the management of the integration of the National Curriculum and the Pesantren-Based Curriculum through the functions of planning, organizing, actuating, and controlling (POAC). 2) To identify the supporting and inhibiting factors affecting the implementation of curriculum integration based on the dimensions of communication, resources, disposition, and bureaucratic structure. 3) To examine the contribution of curriculum integration management to improving primary school quality, particularly in terms of academic achievement, religious competence, character development, school management quality, and community trust.

RESEARCH METHOD

Research Design

This study employed a qualitative approach using a case study design to explore the management of the integration between the National Curriculum and the Pesantren-Based Curriculum at SD Negeri Guyangan, Pati, Indonesia. A qualitative case study was selected because it enables an in-depth understanding of a contemporary educational phenomenon within its real-life context (Yin, 2018). The research was conducted at SD Negeri Guyangan, Trangkil District, Pati Regency, Central Java, Indonesia. The school was purposively selected because it represents a unique public primary school that has integrated the National Curriculum with a Pesantren-Based Curriculum through collaboration with Pesantren Raudlatul Ulum since 1976.

Respondents of the Study

The participants were selected using purposive sampling based on their direct involvement in curriculum management and implementation. They consisted of the principal, vice principal for curriculum, classroom teachers, Pesantren teachers, representatives of the school committee, parents, and representatives of Pesantren Raudlatul Ulum. These participants were expected to provide detailed information on curriculum planning, implementation, supervision, and evaluation.

Data were collected through semi-structured interviews, participant observations, and document analysis. The interviews explored participants' experiences and perspectives regarding curriculum integration management. Observations focused on classroom instruction, school activities, and curriculum implementation practices. Documentary evidence included curriculum documents, annual programs, lesson plans, supervision reports, meeting minutes, and other school administrative records related to curriculum implementation.

To ensure the trustworthiness of the findings (Lincoln & Guba, 1985), the study employed source triangulation, technique triangulation, member checking, and peer debriefing. These strategies were used to support the credibility, dependability, and confirmability of the findings. The data were analyzed using the interactive model of Miles et al. (2020), which consists of data condensation, data display, and conclusion drawing and verification. The case study analysis also followed Yin's (2018) analytical techniques, including pattern matching and explanation building, to compare empirical findings with the theoretical framework. The analysis was guided by George R. Terry's (1977) management theory, focusing on the four management functions of planning, organizing, actuating, and controlling (POAC), while the supporting and inhibiting factors were interpreted using George C. Edwards III's (1980) implementation framework.

RESULTS

Management of National and Pesantren-Based Curriculum Integration

The findings indicate that the integration of the National Curriculum and the Pesantren-Based Curriculum at SD Negeri Guyangan has been implemented through the four management functions proposed by Terry, namely planning, organizing, actuating, and controlling (POAC). Curriculum integration is carried out through collaboration between the school and Pesantren Raudlatul Ulum to achieve a balance between academic excellence and religious character development.

Table 1. Findings on curriculum integration management

Management Function	Empirical Findings	Contribution
Planning Organizing Actuating Controlling	Joint curriculum planning involving the principal, teachers, curriculum coordinator, and pesantren representatives. Clear distribution of responsibilities between classroom teachers and pesantren teachers National Curriculum implemented in the morning and Pesantren-Based Curriculum in the afternoon (Tuesday–Thursday) Academic supervision, classroom monitoring, semester evaluation meetings, and coordination with the pesantren	Alignment of curriculum objectives with school vision and community needs Improved coordination and instructional effectiveness Balanced development of academic and religious competencies Continuous improvement of curriculum implementation

The planning process reflects Terry's management theory, which emphasizes planning as the foundation for organizational success. The school designed an integrated curriculum through collaborative coordination involving school leaders and pesantren representatives, so that learning objectives matched students' needs and the school's vision.

The implementation follows the connected curriculum model proposed by Fogarty (1991), in which general and religious subjects remain separate but are connected through shared educational goals and values. Students attend general lessons in the morning and religious lessons in the afternoon, which allows time for both academic and spiritual development. Continuous supervision through academic monitoring and evaluation meetings indicates that curriculum integration is managed as an ongoing quality improvement process rather than a one-time initiative.

Supporting and Inhibiting Factors

The study identified several factors influencing curriculum integration. Supporting factors include strong school leadership, collaboration with Pesantren Raudlatul Ulum, competent teachers, community support, and a religious school environment. The implementation also faces challenges related to instructional time, teachers' administrative workload, heterogeneous student abilities, and limited parental involvement.

Table 2. Supporting and inhibiting factors

Supporting Factors	Inhibiting Factors
Principal leadership Teacher competence Collaboration with pesantren Community and parental support Religious school culture	Limited instructional time Heavy administrative workload Diverse student background Limited parental supervision at home Dense academic schedule

These findings are consistent with Edwards III (1980), who argues that communication, resources, disposition, and bureaucratic structure determine implementation effectiveness. Collaboration between the school and pesantren strengthened communication and clarified institutional roles, while the religious environment supported implementation. However, time constraints and administrative demands remained major challenges.

Contribution of Curriculum Integration to Primary School Quality

The findings indicate that curriculum integration contributes to school quality, particularly to religious competence, character development, institutional reputation, and public trust. The integration has become the school's distinctive identity: participants reported that it attracts students from villages beyond Guyangan and increases community confidence in the school.

Table 3. Contribution of curriculum integration

Dimension	Evidence
Academic achievement	Students receive balanced academic instruction
Religious competence	Additional Islamic subjects strengthen religious understanding
Character development	Daily religious practices foster discipline, responsibility, and respect
School quality	Stronger institutional identity and management
Community trust	Increased student enrolment from surrounding villages

The results indicate that curriculum integration contributes to holistic education by combining cognitive, affective, and spiritual development. These findings are consistent with Lickona (1991), who emphasizes that character education should integrate moral knowledge, moral feeling, and moral action. They also align with Sallis (2014), who argues that educational quality improvement requires systematic management, stakeholder participation, and continuous evaluation. The collaboration between SD Negeri Guyangan and Pesantren Raudlatul Ulum shows that a public primary school can integrate national educational standards with pesantren-based learning to improve institutional quality and community trust.

DISCUSSION

The first finding is that SD Negeri Guyangan manages the integration through all four POAC functions (Table 1). The principal, teachers, curriculum coordinator and pesantren representatives plan the curriculum jointly. Responsibilities are divided between classroom teachers and pesantren teachers, the National Curriculum runs in the morning and the pesantren-based curriculum in the afternoon from Tuesday to Thursday, and supervision continues through classroom monitoring and semester evaluation meetings. In the terms used by Fogarty (1991), this is a connected model: the subjects stay separate but share goals and values. It is not yet the deeper integration that Beane (1997) describes, in which knowledge is organised around shared themes and students' real problems. The finding is close to the integrative curriculum management that Yusuf et al. (2024) describe in a pesantren, where academic study is linked to daily religious practice. The difference is that Guyangan is a public school with an external partner. Coordination between two institutions therefore becomes a central management task, and joint planning and shared evaluation meetings are how the school carries it out.

The second finding concerns the factors behind implementation (Table 2). Principal leadership, teacher competence, collaboration with the pesantren, community support and a religious school culture supported the integration. Read through Edwards III (1980), these correspond to communication between the two institutions, human resources, the disposition of staff and parents, and a clear structure of roles. The central place of the principal agrees with reviews that find leadership affects learning mainly through teachers' capacity, motivation and working conditions (Hallinger, 2011; Leithwood et al., 2020). It also agrees with the Jombang case study of Hanik et al. (2025), where supervision, continuous professional development and a collaborative culture made the difference, and with the strong religious dimension of school leadership reported in Kudus (Kamal et al., 2025). The inhibiting factors were limited instructional time, heavy administrative workload, diverse student backgrounds, limited parental supervision at home and a dense schedule. These constraints are likely to grow because teachers are already adapting to the Kurikulum Merdeka (Asmahasanah et al., 2023), and the afternoon pesantren programme adds hours and documents to the same staff.

The third finding is that participants linked the integration with religious competence, character development, a stronger institutional identity and community trust (Table 3). Daily religious practices were described as building discipline, responsibility and respect. This matches the view of Lickona (1991) that character requires moral action as well as moral knowledge, and it parallels the habituation reported at SD Muhammadiyah 22 Surakarta

(Suryaningsih & Desstya, 2023) and in madrasah in Malang and Kudus (Priatmoko et al., 2025; Zuhri et al., 2025). Sallis (2014) treats quality as meeting the expectations of stakeholders through continuous improvement. In this sense, community trust and the reported enrolment of children from surrounding villages are relevant signs of quality, but the study reports them as perceptions and offers no enrolment figures. Table 3 lists only balanced academic instruction as evidence for academic achievement, so the study cannot show that the integration improved achievement. Yasrizal et al. (2022) found that teacher leadership, rather than distributed leadership by the principal alone, was related to school quality; the role of Guyangan's teachers in sustaining quality would be worth examining directly.

The findings have practical implications. Principals in public schools that work with a pesantren can formalise the partnership in a written agreement, hold joint planning meetings at the start of each semester, and include pesantren teachers in supervision and evaluation. Teachers can move from a connected towards a more integrated model by choosing a few shared themes, so that values met in the afternoon lessons are applied in morning subjects. To reduce workload, schools can share administrative tasks between the two staff groups and avoid duplicate documents. District education offices and the Ministry of Religious Affairs can use the flexibility of the Kurikulum Merdeka (Barlian et al., 2022) to recognise pesantren-based content as local content and to provide training in integrated curriculum design. The Guyangan partnership has lasted since 1976, through several national curriculum changes, which suggests that a public school can keep a pesantren programme while national requirements change. Schools starting a new partnership may need more time to agree on goals, schedules and roles than Guyangan needs today.

This study has limitations. It is a single case chosen because it is unusual, so its findings transfer only to similar public schools with a long-standing pesantren partner. The number of participants and the length of fieldwork are not reported, and the evidence on quality rests on the accounts of staff, parents and committee members, who may present the school favourably. Students were not interviewed. No achievement data or enrolment records were analysed. Future research should compare several public school-pesantren partnerships, add student perspectives, and combine interviews with achievement and enrolment trends over several years.

CONCLUSION AND RECOMMENDATIONS

This study shows that the integration of the National Curriculum and the Pesantren-Based Curriculum at SD Negeri Guyangan has been managed through the four management functions of planning, organizing, actuating, and controlling (POAC). The collaborative partnership between the school and Pesantren Raudlatul Ulum has enabled the alignment of national educational standards with pesantren-based learning, which has produced a balanced educational model that integrates academic achievement, religious competence, and character development.

The implementation of curriculum integration is supported by school leadership, stakeholder collaboration, adequate human resources, and a strong religious school culture. However, several challenges remain, including limited instructional time, teachers' administrative workload, varying student learning abilities, and the need for stronger parental involvement. Despite these constraints, participants and documents associate the integrated curriculum with stronger Islamic values and character, better institutional management, and greater community trust in the school; its effect on academic performance was not measured.

This study contributes to the field of educational management by proposing a practical model of curriculum integration for public primary schools that combines the National Curriculum with a Pesantren-Based Curriculum through collaborative management. The findings suggest that curriculum integration can be a useful strategy for holistic education and school quality in similar Indonesian public schools.

Based on the findings of this study, several recommendations are proposed. For school leaders, curriculum integration should be continuously strengthened through systematic planning, regular monitoring, and sustainable collaboration with pesantren institutions to ensure the effective implementation of integrated learning. For teachers, professional development programs should focus on integrated curriculum design, interdisciplinary teaching strategies, and innovative learning approaches that combine academic content with religious values while

reducing unnecessary administrative burdens. Educational authorities are encouraged to formulate policies that provide greater flexibility for public schools implementing local curriculum innovations, particularly those integrating national and pesantren-based curricula. Policy support should also include teacher training, curriculum development, and institutional collaboration. For future researchers, further studies are recommended to investigate curriculum integration in different educational settings using comparative case studies or mixed-methods approaches. Future research may also examine the long-term effects of curriculum integration on students' academic achievement, character development, and school performance to develop a more comprehensive model of integrated curriculum management.

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REFERENCES

Asmahasanah, S., Chairunnissa, I. C., & Hakim, N. (2023). Navigating Merdeka curriculum in first grade: Teacher challenges and strategies. Journal of Integrated Elementary Education, 3(2), 137-149. https://doi.org/10.21580/jieed.v3i2.17592

Barlian, U. C., Solekah, S., & Rahayu, P. (2022). Implementasi kurikulum merdeka dalam meningkatkan mutu pendidikan. Journal of Educational and Language Research, 1(12), 2105–2118.

Beane, J. A. (1997). Curriculum integration: Designing the core of democratic education. Teachers College Press.

Edwards, G. C., III. (1980). Implementing public policy. Congressional Quarterly Press.

Fogarty, R. (1991). How to integrate the curricula. IRI/Skylight Publishing.

Hallinger, P. (2011). Leadership for learning: Lessons from 40 years of empirical research. Journal of Educational Administration, 49(2), 125–142. https://doi.org/10.1108/09578231111116699

Hanik, H., Nuphanudin, N., Khamidi, A., Roesminingsih, E., Kristanto, A., Trihantoyo, S., & Haq, M. S. (2025). Kepala sekolah sebagai instructional leader: Penguatan kompetensi pedagogik guru untuk pembelajaran mendalam di sekolah dasar. Didaktika, 5(3). https://doi.org/10.17509/didaktika.v5i3.93269

Kamal, J., In'am, A., & Khozin, K. (2025). Culturally-rooted school leadership: The role of Gusjigang values in enhancing character education at the primary level. Elmidad, 17(2). https://doi.org/10.20414/elmidad.v17i2.14134

Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven strong claims about successful school leadership revisited. School Leadership & Management, 40(1), 5–22. https://doi.org/10.1080/13632434.2019.1596077

Lickona, T. (1991). Educating for character: How our schools can teach respect and responsibility. Bantam Books.

Lincoln, Y. S., & Guba, E. G. (1985). Naturalistic inquiry. Sage.

Miles, M. B., Huberman, A. M., & Saldaña, J. (2020). Qualitative data analysis: A methods sourcebook (4th ed.). SAGE.

Mulyasa, E. (2023). Manajemen berbasis sekolah (Revised ed.). PT Remaja Rosdakarya.

Priatmoko, S., Rahman, S. A., Inayah, S. R., Ekawati, R., & Mustakim, S. S. (2025). Exploration of religious character education in pesantren-based madrasah ibtidaiyah. Mudarrisa: Jurnal Kajian Pendidikan Islam, 17(1), 1–28. https://doi.org/10.18326/mudarrisa.v17i1.3329

Sallis, E. (2014). Total quality management in education (3rd ed.). Routledge.

Suryaningsih, M. R., & Desstya, A. (2023). Implementasi nilai-nilai profil pelajar Pancasila dalam Kurikulum Merdeka di sekolah dasar. Muallimuna: Jurnal Madrasah Ibtidaiyah, 9(1), 12–26. https://doi.org/10.31602/muallimuna.v9i1.10961

Terry, G. R. (1977). Principles of management. Richard D. Irwin.

Yasrizal, Y., Dahlan, J. A., & Chandrawati, T. (2022). Pengaruh kepemimpinan distribusi kepala sekolah dan kepemimpinan guru terhadap mutu pendidikan sekolah dasar. Lentera: Jurnal Ilmiah Kependidikan, 15(1), 23–38.

Yin, R. K. (2018). Case study research and applications: Design and methods (6th ed.). SAGE.

Yusuf, M., Ali, N., & Nur, M. A. (2024). Integrative curriculum management in shaping Muslim character in pesantren. Ta'dib, 28(2), 136–149. https://doi.org/10.19109/td.v28i2.20122

Zuhri, A., Mas'ud, A., & Syukur, F. (2025). Strengthening religious character in madrasah: Integrating pesantren values as an educational strategy. Al-Tarbawi Al-Haditsah: Jurnal Pendidikan Islam, 10(1), 71–92. https://doi.org/10.24235/tarbawi.v10i1.19819

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

The Effect of Principals' Academic Supervision, Teacher Competence, and Organizational Commitment on Elementary Teacher Performance

Sarmi[1*], Nur Fajrie[1] and Ahmad Hariyadi[1]

[1]*Master of Basic Education, Universitas Muria Kudus, Indonesia*

Corresponding author: 202403125@std.umk.ac.id

ABSTRACT

Teacher performance in elementary schools depends on school leadership, teachers' pedagogical competence, and their commitment to the workplace. This study examines the effect of principals' academic supervision, teacher competence, and organizational commitment on teacher performance among public elementary school teachers in Grobogan Regency, Central Java, Indonesia, both partially and simultaneously. An explanatory quantitative design with a cross-sectional survey was used. The population comprised 3,706 state elementary school teachers with civil servant status (PNS and ASN PPPK) distributed across public schools in 19 sub-districts in Grobogan Regency. Using the Slovin formula and proportionate stratified random sampling, a sample of 361 teachers was drawn.

Data were collected through a self-administered five-point Likert questionnaire adapted from validated instruments: a clinical instruction scale for academic supervision, the national teacher competence framework for teacher competence, the Allen and Meyer framework for organizational commitment, and the PKG evaluation standards for teacher performance. Data were analyzed using multiple linear regression in SPSS 29, preceded by validity, reliability, and classical assumption testing. The study hypothesized that academic supervision, teacher competence, and organizational commitment each have a significant positive effect on teacher performance and that together they explain a significant share of its variance. This version reports descriptive results; the regression estimates are not yet included. The findings are intended to inform principals, school supervisors, and regional education authorities about human resource management in elementary schools.

KEYWORDS academic supervision | organizational commitment | teacher competence | teacher performance

INTRODUCTION

Primary education is a foundation for human capital development and long-term regional progress. In public schools, classroom teachers are the main operational force: their teaching affects student mastery, learning experiences, and institutional accountability. Teacher performance is the quality and quantity of work a teacher achieves in carrying out assigned duties (Mangkunegara, 2017). Evaluating and improving it has therefore become a priority for regional and national education policymakers. High-performing teachers plan, deliver, and evaluate classroom instruction systematically, which shapes the quality of classroom practice. Teachers' own professionalism depends on both internal factors, such as motivation and competence, and external factors, such as leadership and working conditions (Aulia et al., 2025).

However, initial assessment reports indicate that primary school teacher performance across local districts has not yet reached the expected standard. In Grobogan Regency, performance varies widely. Initial data compiled from Teacher Performance Assessment (PKG) summaries, school supervisor observations, and regional Dapodik records indicate that approximately 41% to 46% of state elementary teachers remain categorized in the "sufficient" performance range, while an additional 8% to 11% fall into the "poor" category. Weaknesses are most visible in creative instructional planning, the use of innovative teaching methods, and continuous classroom evaluation with authentic assessment.

Several institutional factors may contribute to these gaps. The first is principals' academic supervision, which remains limited. Initial field surveys show that the frequency of structured academic supervision across multiple sub-districts averages only one to two sessions per teacher per year. Existing supervision procedures also tend to

be administrative rather than offering continuous professional development or structured post-observation feedback. Second, teacher professional competence varies considerably. Regional education report cards show that student-centered learning environments, differentiated instruction, and digital technological integration still fall below target averages. Third, organizational commitment varies: low participation in long-term school development programs, limited collaborative initiative, and little voluntary professional training tend to weaken the effect of administrative interventions at school level.

Prior research supports each of these factors. A meta-analysis of 27 studies found that instructional leadership had an average effect on student outcomes three to four times larger than transformational leadership, and that promoting and participating in teacher learning had the largest effect (Robinson et al., 2008). Coaching, the core of clinical supervision, improved instruction by 0.49 SD across 60 causal studies (Kraft et al., 2018). In Indonesian elementary schools, principal leadership and academic supervision were each related to teacher performance among 64 teachers in Lebak Regency (Starlinsky et al., 2022), and Hardono et al. (2017) examined academic supervision together with leadership and work motivation. For competence, a path analysis of 114 teachers in Pati Regency found that pedagogic competence directly affected teacher performance, partly through work motivation (Ardliana et al., 2021), and Amalia and Saraswati (2018) examined how certification moderates the effect of competence on performance. For commitment, Allen and Meyer (1990) distinguished affective, continuance and normative commitment, and a meta-analysis of 65 Asian studies linked transformational leadership with teachers' commitment and self-efficacy (Firmansyah et al., 2022). Local studies have examined commitment and school culture (Isnawati et al., 2023) and instructional leadership, self-efficacy and performance (Elfira et al., 2024).

Most of these studies tested one or two predictors, often in a single district with a small sample, and few covered elementary teachers in Grobogan Regency. It is therefore unclear how supervision, competence and commitment relate to performance when they are examined together in a regency-wide sample. This study addresses that gap with a stratified sample of 361 public elementary teachers from all 19 sub-districts. It aims to estimate the partial and joint effects of the three factors on teacher performance and to describe how teachers perceive each factor.

LITERATURE REVIEW

Teacher Performance (Y)

Teacher performance is the teaching, rule compliance, and pedagogical work that teachers carry out in fulfilling their professional duties within a given period. It cannot be judged only by attendance or routine administrative indicators; it also includes creative planning, differentiated instruction, authentic evaluation, and active collaborative contribution toward institutional development (Hasibuan, 2019; Mangkunegara, 2017).

Academic Supervision (X1)

Academic supervision is the guidance, feedback, and clinical observation that principals carry out systematically to improve teachers' pedagogical capacity. As instructional leaders, principals use structured supervision to build reflective practice, clarify performance targets, and establish a professional learning culture (Hallinger & Murphy, 1985). Supervision can also support teachers' professional identity, for example in inclusive classrooms (Alila et al., 2016). Korthagen (2017) argues that professional development changes practice only when it connects with how teachers themselves learn.

Teacher Competence (X2)

Teacher competence is the combination of professional knowledge, classroom skills, and attitudes required by national education policy, covering the pedagogical, professional, social, and personality domains (Febriana, 2021). Competence is the basis of teaching: it shapes how well a teacher plans lessons, uses instructional technology, manages classroom behavior, and designs diagnostic assessments.

Organizational Commitment (X3)

Organizational commitment is the psychological variable in the model. It reflects a teacher's emotional attachment, moral alignment, and long-term loyalty to the school. Following the three-component model of Allen and Meyer (1990), commitment is measured on affective, continuance, and normative dimensions. Highly committed teachers tend to work beyond routine requirements, take part in extra-curricular activities, and support school development goals (Luthans, 2015). Commitment is also linked with organizational citizenship behaviour in both public and private organisations (Grego-Planer, 2019).

Based on this framework, four hypotheses are proposed:

- **H1:** Academic supervision has a significant positive effect on elementary teacher performance.
- **H2:** Teacher competence has a significant positive effect on elementary teacher performance.
- **H3:** Organizational commitment has a significant positive effect on elementary teacher performance.
- **H4:** Academic supervision, teacher competence, and organizational commitment jointly have a significant positive effect on elementary teacher performance in Grobogan Regency.

RESEARCH METHOD

Research Design

This study used a quantitative approach with an explanatory cross-sectional survey design (Creswell & Creswell, 2018). This design allows the relationships between several independent variables and the dependent variable to be measured and tested statistically without experimental manipulation.

Population and Sample Stratification

The population comprised all 3,706 active state elementary school teachers with civil servant status (PNS and ASN PPPK) in public schools in the 19 sub-districts of Grobogan Regency. The Slovin formula with a margin of error of e = 0.05 gave a required sample of 361 respondents. Proportional stratified random sampling was used across all 19 sub-districts to keep the sample representative.

Table 1. Target population and sample stratification across 19 sub-districts

No	Sub-District Location	Teacher Population (N_i)	Percentage (%)	Proportional Sample (n_i)
1	Purwodadi	358	9.66%	35
2	Karangrayung	287	7.74%	28
3	Toroh	257	6.94%	25
4	Gubug	252	6.80%	24
5	Pulokulon	239	6.45%	23
6	Wirosari	226	6.10%	22
7	Kradenan	205	5.53%	20
8	Grobogan	200	5.40%	19
9	Godong	215	5.80%	21
10	Tegowanu	172	4.64%	17
11	Ngaringan	188	5.07%	18
12	Penawangan	162	4.37%	16
13	Gabus	179	4.83%	17
14	Geyer	173	4.67%	17
15	Tawangharjo	132	3.56%	13
16	Tanggungharjo	128	3.45%	12
17	Brati	117	3.16%	11
18	Kedungjati	117	3.16%	11
19	Klambu	107	2.89%	12
-	**Total Regional Context**	**3,706**	**100.00%**	**361**

Measurement Instruments

Each variable was measured with indicators translated into items on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree).

Table 2. Instrument domains and total items

Latent Constructs	Dimensions / Operational Focus	Total Items	Reference Scale Source
Academic Supervision (X_1)	Clinical Planning, Execution, Audit Data Capture, Restorative Feedback	12	Clinical Instruction Scale
Teacher Competence (X_2)	Pedagogical, Professional Knowledge, Social Interaction, Psychological Maturity	10	National Capabilities Matrix
Org. Commitment (X_3)	Affective Loyalty, Continuance Analysis, Normative Values	10	Allen & Meyer Framework
Teacher Performance (Y)	Planning Quality, Technology Adaptation, Lesson Delivery, Diagnostic Loop	10	PKG Evaluation Standards

Data Analysis Techniques

Data were processed using SPSS version 29. The analysis involved item screening through corrected item-total correlations, reliability testing using Cronbach's alpha (Cronbach, 1951; $\alpha \geq 0.70$), classical assumption tests (normality, linearity, homoscedasticity, and multicollinearity via VIF and tolerance), and multiple linear regression.

RESULTS

Descriptive Analysis of Demographic Profiles

The gender, age, and academic qualifications of the 361 respondents are summarized below.

Table 3. Gender distribution of respondents

Classification	Sample Frequency (*f*)	Empirical Percentage (%)
Male Instructors	114	31.60%
Female Instructors	247	68.40%
Total Sample Grid	**361**	**100.00%**

Most respondents were female. Professional development and collaborative networks in the regency should be planned with this composition in mind.

Table 4. Age distribution of respondents

Age Cohort Categories	Sample Frequency (*f*)	Empirical Percentage (%)
36 - 41 Years Old	43	12.00%
42 - 47 Years Old	87	24.10%
48 - 53 Years Old	130	36.10%
54 - 59 Years Old	101	27.80%
Total Sample Grid	**361**	**100.00%**

Over 63% of the respondents are aged 48 or older. This suggests extensive teaching experience but may also pose challenges for technological adaptation. Older educators may require targeted professional development to build confidence in using modern digital platforms.

Table 5. Educational qualifications of respondents

Degree Tier Classification	Sample Frequency (*f*)	Empirical Percentage (%)
Undergraduate Degree (S-1)	271	75.18%
Master's Degree (S-2)	49	13.53%
Undergraduate Diploma (D-1 to D-3)	41	11.27%
Total Sample Grid	**361**	**100.00%**

About three-quarters of the respondents hold the standard undergraduate qualification, and 13.53% hold a Master's degree, which may reflect interest in advanced professional development.

Analysis of Respondent Perceptions

The distribution of responses across the four survey domains shows how teachers perceive their professional environment.

Table 6. Frequency percentages for academic supervision (X1)

No	Measured Items / Indicators	SS (%)	S (%)	N (%)	TS (%)	STS (%)
1	Supervision Focus Communication	38.30%	45.90%	12.00%	3.00%	0.80%
2	Routine Classroom Observation	41.40%	47.40%	7.50%	2.20%	1.50%
3	Constructive Data Feedback Loops	35.30%	50.40%	10.50%	3.00%	0.80%
4	Instructional Coaching Support	35.30%	50.40%	10.50%	3.00%	0.80%
5	Post-Observation Progress Audits	32.30%	46.60%	15.00%	4.60%	1.50%

Most teachers agreed with the items on classroom observation and coaching support. The higher share of neutral responses for post-observation progress audits suggests that principals' busy schedules may limit the continuity of post-observation feedback.

Table 7. Frequency percentages for teacher competence (X2)

No	Measured Items / Indicators	SS (%)	S (%)	N (%)	TS (%)	STS (%)
1	Conceptual Core Subject Mastery	42.10%	45.90%	9.00%	2.30%	0.70%
2	Differentiated Lesson Design	37.60%	50.40%	7.50%	3.00%	1.50%
3	Classroom Dialogue Management	39.10%	47.40%	9.80%	3.00%	0.70%
4	Professional Development Track	34.60%	44.40%	13.50%	6.00%	1.50%
5	Technology Software Integration	28.60%	46.60%	16.50%	6.80%	1.50%

Teachers rated their subject mastery and classroom dialogue management highly. Lower agreement on technology integration suggests gaps in the use of digital learning tools.

Table 8. Frequency percentages for organizational commitment (X3)

No	Measured Items / Indicators	SS (%)	S (%)	N (%)	TS (%)	STS (%)
1	School Identity Internalization	38.30%	46.60%	12.80%	2.30%	0.00%
2	Normative Regulatory Adherence	41.40%	48.10%	8.30%	2.20%	0.00%
3	Proactive Collaborative Support	35.30%	51.11%	11.30%	2.30%	0.00%
4	Professional Capacity Initiative	32.30%	47.40%	15.80%	4.50%	0.00%
5	Long-Term Workplace Retention	29.30%	50.40%	15.00%	4.50%	0.80%

Agreement was highest for rule compliance and identification with the school. The neutral responses on professional initiative and retention may indicate that reporting workloads limit teachers' voluntary involvement in school improvement activities.

Table 9. Frequency percentages for teacher performance (Y)

No	Measured Items / Indicators	SS (%)	S (%)	N (%)	TS (%)	STS (%)
1	Pedagogical Classroom Delivery	43.60%	48.10%	6.00%	1.50%	0.80%
2	Proactive Capability Upgrading	36.10%	43.60%	13.50%	5.30%	1.50%
3	Curricular Adaptability Adjustments	33.10%	50.40%	12.00%	3.70%	0.80%
4	Workplace Professional Ethics	48.10%	43.60%	5.30%	2.20%	0.80%
5	Output Performance Reflection	39.10%	46.60%	9.00%	4.50%	0.80%

Teachers rated their professional ethics and classroom delivery highly. Lower agreement on capability upgrading may reflect time constraints, suggesting that teachers need support to balance administrative work with skill development.

DISCUSSION

The paper reports demographic and item-level descriptive results only. Hypotheses H1 to H4 therefore cannot yet be accepted or rejected, and the discussion below interprets the descriptive patterns and states what the regression analysis would need to show.

For academic supervision, most teachers agreed or strongly agreed with the items on classroom observation and coaching support (Table 6). Neutral responses were most common for post-observation progress follow-up. This pattern is consistent with the field reports in the Introduction that teachers receive only one or two supervision sessions a year and that supervision is often administrative. It matters because the strongest leadership effect in the meta-analysis of Robinson et al. (2008) came from principals promoting and taking part in teacher learning, and coaching that includes feedback improved instruction substantially (Kraft et al., 2018). Indonesian surveys also link academic supervision with teacher performance (Hardono et al., 2017; Starlinsky et al., 2022). If the regression confirms H1, the practical message for Grobogan principals is to add structured follow-up conferences to each observation, possibly shared with school supervisors and KKG groups, rather than to observe more often.

For teacher competence, teachers rated their subject mastery and classroom dialogue management highly, and agreement was lowest for technology integration (Table 7). Over 63% of respondents were aged 48 or older (Table 4), which may partly explain the lower ratings for digital tools. Age alone is not a barrier, however: in a survey of 153 elementary teachers in Yogyakarta, teachers aged 40 and above also used technology in distance learning, and the authors recommended school-provided training (Suwarjo et al., 2022). The pattern agrees with the finding of Ardliana et al. (2021) that pedagogic competence is directly related to performance. For the Education Office, the implication is to schedule practical, school-based training in digital lesson design and to spread it across rural sub-districts.

For organizational commitment, agreement was highest for compliance with rules and identification with the school, and neutral responses were more frequent for professional initiative and long-term retention (Table 8). In terms of Allen and Meyer (1990), this suggests that normative commitment may be stronger than the affective commitment that leads teachers to volunteer for school development. Commitment is associated with citizenship behaviour beyond formal duties (Grego-Planer, 2019), and leadership that supports teachers is linked with higher commitment and self-efficacy (Firmansyah et al., 2022; Alanoglu, 2022). Reducing reporting workloads and involving teachers in school planning may therefore help convert compliance into initiative, but this remains to be tested.

For teacher performance, teachers rated their professional ethics and classroom delivery highly and their capability upgrading lower (Table 9). These self-ratings are noticeably more positive than the PKG data cited in the Introduction, where 41% to 46% of teachers were rated only "sufficient". The difference suggests that self-reported performance may be inflated. Because all four variables were measured with the same self-report questionnaire, common method variance may also inflate the relationships among them (Podsakoff et al., 2003). Leadership is thought to affect performance mainly through teachers' capacity, motivation and working conditions (Leithwood et al., 2020), so the three predictors may also be related to one another.

The demographic profile also matters for interpreting H4, the joint effect. Most respondents were women (68.40%; Table 3), most held an undergraduate degree, and 13.53% held a Master's degree (Table 5). Diploma holders (11.27%) may differ from graduates in both competence ratings and performance, so qualification and age should be entered as control variables when the regression is reported. If the three predictors together explain a substantial share of the variance, the policy implication for the Grobogan Regency Education Office is to treat supervision, training and teachers' working conditions as one programme rather than as separate initiatives. If only one or two predictors remain significant after the others are controlled, resources can be directed to those. Either way, the decision should rest on the regression estimates, not on the descriptive percentages reported here.

The study has several limitations. The validity and reliability results, the classical assumption tests and the regression table are not reported. The Likert percentages in Tables 6 to 9 do not correspond to whole numbers of respondents out of 361. The design is cross-sectional, so even significant coefficients would show associations, not causal effects. Future work should report the regression with standardised coefficients and R^2, use PKG scores or supervisor ratings for performance, account for the clustering of teachers within schools, and test whether self-efficacy mediates the effect of supervision on performance, as suggested by Elfira et al. (2024) and by the link between instructional leadership and self-efficacy (Alanoglu, 2022).

CONCLUSION AND RECOMMENDATIONS

The descriptive results suggest that principals' academic supervision, teacher competence, and organizational commitment are relevant to teacher performance in public elementary schools in Grobogan Regency; the hypothesized effects remain to be confirmed by the regression analysis. Efforts to improve educational quality should look beyond administrative metrics to supportive supervisory practices, balanced skills development, and collaborative school environments.

The following guidelines are put forward for local school networks:

1. **Transition to Clinical Coaching:** Principals should move from checklist inspections to clinical coaching that gives teachers detailed instructional feedback.
2. **Optimize Professional Trainings:** The Grobogan Regency Education Office is advised to schedule practical professional training programs evenly across rural areas, with an emphasis on digital lesson-design tools.
3. **Reduce Administrative Load:** Education authorities should reduce unnecessary paperwork so that teachers have more time for student-centered instructional planning.

REFERENCES

Alanoglu, M. (2022). The role of instructional leadership in increasing teacher self-efficacy: A meta-analytic review. Asia Pacific Education Review, 23, 233–244. https://doi.org/10.1007/s12564-021-09726-5

Alila, R., Määttä, K., & Uusiautti, S. (2016). How does supervision support inclusive teacherhood? International Electronic Journal of Elementary Education, 8(3), 351–362.

Allen, N. J., & Meyer, J. P. (1990). The measurement and antecedents of affective, continuance and normative commitment to the organization. *Journal of Occupational Psychology*, 63(1), 1–18.

Amalia, R., & Saraswati, E. (2018). The impact of competencies toward teacher's performance moderated by the certification in Indonesia. KnE Social Sciences, 3(10). https://doi.org/10.18502/kss.v3i10.3363

Ardliana, B., Rusdarti, R., & Suminar, T. (2021). Effect of principal leadership, school culture and pedagogic competence through work motivation on teachers performance. Educational Management, 10(2), 273–283.

Aulia, N., Utaminingsih, S., & Fajrie, N. (2025). Analisis unsur internal dan eksternal yang mempengaruhi profesionalisme pendidik sekolah dasar. *Jurnal Pendidikan Dasar Kudus*, 6(1), 45–58.

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. Psychometrika, 16(3), 297–334. https://doi.org/10.1007/BF02310555

Elfira, N., Fajrie, N., & Hariyadi, A. (2024). Hubungan kepemimpinan instruksional kepala sekolah terhadap efikasi diri dan kinerja guru sekolah dasar. *Jurnal Studi Manajemen Pendidikan*, 8(2), 143–157.

Febriana, R. (2021). *Kompetensi guru*. Bumi Aksara.

Firmansyah, F., Prasojo, L. D., Jaedun, A., & Retnawati, H. (2022). Transformational leadership effect on teacher performance in Asia: A meta-analysis. Cypriot Journal of Educational Sciences, 17(6), 2127–2146. https://doi.org/10.18844/cjes.v17i6.7552

Grego-Planer, D. (2019). The relationship between organizational commitment and organizational citizenship behavior in the public and private sectors. *Sustainability*, 11(22), Article 6395. https://doi.org/10.3390/su11226395

Hallinger, P., & Murphy, J. (1985). Assessing the instructional management performance of principals. *Elementary School Journal*, 86(2), 217–247.

Hardono, H., Haryono, H., & Yusuf, A. (2017). Kepemimpinan kepala sekolah, supervisi akademik, dan motivasi kerja dalam meningkatkan kinerja guru. *Educational Management*, 6(1), 26–33.

Hasibuan, M. S. P. (2019). *Manajemen sumber daya manusia*. Bumi Aksara.

Isnawati, L., Rondli, W. S., & Utaminingsih, S. (2023). Pengaruh komitmen organisasi dan budaya sekolah terhadap kinerja guru sekolah dasar di Koordinator Wilayah Kecamatan. *Jurnal Pendidikan Muria*, 7(2), 98–111.

Korthagen, F. (2017). Inconvenient truths about teacher learning: Towards professional development 3.0. Teachers and Teaching: Theory and Practice. https://doi.org/10.1080/13540602.2017.1287221

Kraft, M. A., Blazar, D., & Hogan, D. (2018). The effect of teacher coaching on instruction and achievement: A meta-analysis of the causal evidence. Review of Educational Research, 88(4), 547–588. https://doi.org/10.3102/0034654318759268

Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven strong claims about successful school leadership revisited. School Leadership & Management, 40(1), 5–22. https://doi.org/10.1080/13632434.2019.1596077

Luthans, F. (2015). *Organizational behavior: An evidence-based approach*. McGraw-Hill.

Mangkunegara, A. A. A. P. (2017). *Manajemen sumber daya manusia perusahaan*. Remaja Rosdakarya.

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal of Applied Psychology, 88(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Robinson, V. M. J., Lloyd, C. A., & Rowe, K. J. (2008). The impact of leadership on student outcomes: An analysis of the differential effects of leadership types. Educational Administration Quarterly, 44(5), 635–674.

https://doi.org/10.1177/0013161X08321509

Starlinsky, L., Belawati, T., & Rosita, T. (2022). Korelasi antara kepemimpinan kepala sekolah dan supervisi akademik terhadap kinerja guru sekolah dasar di Kecamatan Lebakgedong Kabupaten Lebak. Indonesian Journal of Educational Counseling, 6(1), 26–33. https://doi.org/10.30653/001.202261.190

Suwarjo, S., Haryanto, H., Wuryandani, W., Mahfuzah, A., Hidayah, R., & Erviana, V. Y. (2022). Digital literacy analysis of elementary school teachers on distance learning instructional process in Yogyakarta. Al-Ishlah: Jurnal Pendidikan, 14(2), 1145-1156. https://doi.org/10.35445/alishlah.v14i2.1233

ICISFS-UMK 2026 CURRICULUM, CULTURE & CHARACTER

Implementation Strategies of Syekh Jangkung Values for Character Education in Primary Schools

Agus Supriyanto[1*], Gunawan Setiadi[1] and Santoso[1]

[1]*Department of Primary Education, Universitas Muria Kudus, Indonesia*

Corresponding author: supriyantoa928@gmail.com

ABSTRACT

Purpose: Although local wisdom is widely used as a foundation for character education, existing studies focus mainly on identifying cultural values and on instructional innovation. They explain little about how local wisdom is transformed into school-wide character education. This study investigated how Syekh Jangkung values were translated into character education through the interaction between policy content and implementation context.

Method: A qualitative case study was conducted at SD Negeri Sembaturagung 02, Pati Regency, Indonesia. Data were collected through semi-structured interviews with the principal, teachers, parents, school committee representatives, and community leaders, supported by classroom observations and document analysis. Thematic analysis, guided by Grindle's implementation framework, integrated evidence across data sources.

Findings: The analysis identified an integrated implementation process. The school adapted Syekh Jangkung values by prioritizing honesty, responsibility, mutual cooperation, and respect according to students' developmental needs. These values were institutionalized through curriculum integration, daily habituation, teacher role modelling, and school culture, which indicates that character education operated as a school-wide practice. Participants linked implementation to the interaction between policy content and implementation context. They described leadership commitment, teacher collaboration, stakeholder participation, and cultural legitimacy as supporting implementation, and limited instructional resources, teachers' administrative workload, inconsistent instructional practices, and weak monitoring as constraining it.

Research Implications: The study proposes a context-sensitive implementation framework that emphasizes organizational alignment among curriculum, leadership, school culture, and stakeholder collaboration in culturally responsive character education.

Originality: This study treats local wisdom as an implementation process and uses Grindle's implementation framework to explain how cultural values are institutionalized into school-wide character education.

KEYWORDS character education | Grindle's implementation framework | local wisdom | primary school | Syekh Jangkung

INTRODUCTION

Indonesian primary schools are expected to develop students' moral responsibility, social competence, and cultural awareness alongside academic achievement. Rapid digital change has made this task more pressing, because children now meet values and behaviours that neither families nor schools fully control. Studies in Indonesia suggest that character education works better when it is embedded in learners' sociocultural contexts, where students meet ethical values through familiar cultural practices rather than through decontextualized moral instruction (Tohri et al., 2022; Sakti et al., 2024). The need is visible in Central Java. A case study of 21 fifth graders with a Javanese cultural background found that their polite language use was very low and was shifting negatively under family and environmental influences (Mirmanto et al., 2021). Pati Regency has its own resource for this work. Syekh Jangkung, also known as Saridin, is a revered local figure in Pati, and the values attached to his story remain part of community tradition. How a primary school turns such values into everyday practice is the question this study takes up.

Research on local wisdom-based learning has grown quickly. A meta-analysis examined the influence of local wisdom-based learning media on the character of Indonesian students (Yusuf, 2023), and a systematic review of 47 studies published between 2021 and 2026 identified five implementation patterns, from integrating values into

subject content to drawing on local community resources (Jovanda et al., 2026). The same review noted that most of this evidence comes from development and short-term descriptive studies. Work on history learning (Ramadani & Fitrisia, 2023) and on project-based learning grounded in Kudus local wisdom for critical thinking (Hikmawati et al., 2023) points the same way: culturally grounded learning can support character and higher-order thinking. Most of these studies, however, evaluate a learning product or a classroom intervention. They say little about the school as the unit that selects, adapts, and sustains cultural values.

Previous research reports that local wisdom contributes to character education by strengthening students' ethical values, cultural identity, and contextual learning. Empirical studies indicate that local wisdom-based teaching materials, authentic assessment, and folklore-integrated instruction promote students' peace-loving character, critical thinking, learning motivation, and engagement with cultural values (Asrial et al., 2023; Andriani & Aulia, 2023; Sukma et al., 2022). Research from Universitas Muria Kudus reports that a local wisdom-based character education module offers a practical way to integrate cultural values into upper-class elementary learning in Pati (Komariah et al., 2022). In neighbouring Kudus Regency, a survey of 15 principals and 85 teachers found that the religious dimension of the Gusjigang tradition was strongly embedded in school leadership and character education, while its literacy and entrepreneurship dimensions were only moderately implemented (Kamal et al., 2025). Local values, in other words, are taken up unevenly even where schools endorse them. Most of these studies treat local wisdom as instructional content, and they give limited evidence on how a school selects, adapts, and institutionalizes cultural values.

Understanding how local wisdom is institutionalized into sustainable character education requires an implementation perspective that goes beyond instructional effectiveness. Grindle's implementation framework was adopted because it explains implementation as the interaction between policy content (objectives, resources, and target groups) and implementation context (leadership, institutional capacity, stakeholder support, and sociocultural conditions). Together, these determine implementation outcomes (Grindle, 1980). Recent educational studies similarly report that successful character education depends on organizational commitment, collaborative governance, and contextual adaptation rather than curriculum design alone (Badeni & Saparahayuningsih, 2023; Supriyadi et al., 2024). Grindle's framework therefore provides an appropriate analytical lens for explaining how Syekh Jangkung values are selected, adapted, and institutionalized into sustainable school-wide character education.

The gap this study addresses is therefore organizational. A case study of character education in Indonesian elementary schools described how programmes are run (Aningsih et al., 2022), teachers' strategies for internalizing local values have been documented (Qudwatullathifah et al., 2025), and other work reports the constraints schools face when they implement local wisdom values (Annissabrina et al., 2023). Studies rarely follow one local tradition from the choice of values to their place in the curriculum, school routines, and community relations, and few use an implementation framework to explain that process. This study applies Grindle's framework to the institutionalization of Syekh Jangkung values in one primary school. Theoretically, it extends policy implementation analysis to culturally responsive character education. Practically, it describes the steps one school took, which school leaders in Pati and similar districts can examine and adapt.

LITERATURE REVIEW

Character education grounded in local wisdom is increasingly recognized as a culturally responsive approach that strengthens students' ethical development while preserving cultural identity. Local wisdom is more than instructional content: it provides a contextual foundation for internalizing cultural values through school culture, authentic learning experiences, and community engagement. Recent studies indicate that sustainable character education requires systematic integration of cultural values into curriculum, school routines, and educational practices rather than isolated classroom activities (Hidayat et al., 2022; Aulia et al., 2022).

This study adopts Grindle's implementation framework because the institutionalization of character education depends both on the values introduced and on how schools implement them. Grindle (1980) argues that implementation outcomes are shaped by the interaction between policy content and implementation context,

including leadership, institutional capacity, stakeholder participation, and sociocultural conditions. Accordingly, this study conceptualizes the institutionalization of Syekh Jangkung values as a dynamic interaction among cultural values, organizational practices, and implementation context. This lens is used to explain how local wisdom is translated into sustainable school-wide character education.

Research Objectives

This study therefore asks how Syekh Jangkung values were selected, adapted, and institutionalized in one primary school, and how the interaction between policy content and implementation context shaped that process. It examines the organizational mechanisms through which local wisdom entered the curriculum, school culture, teacher practice, and stakeholder collaboration. The findings are intended to inform school leaders and policymakers who design local wisdom-based character education programmes in primary schools (Hafina et al., 2022; Zakiah et al., 2022).

RESEARCH METHOD

Research Design

A qualitative case study was employed to examine how Syekh Jangkung values are strategically selected, adapted, and institutionalized into sustainable school-wide character education. The design was chosen because the research sought to explain organizational processes, contextual interactions, and participants' experiences in a real educational setting. It allowed an in-depth understanding of how local wisdom is translated into everyday educational practice. A qualitative case study is appropriate for investigating complex educational phenomena in their natural context through multiple sources of evidence (Creswell & Poth, 2023).

SD Negeri Sembaturagung 02, Pati Regency, Central Java, Indonesia, was selected through purposive case sampling because the school has implemented character education initiatives grounded in Syekh Jangkung values through curriculum integration, daily habituation, teacher role modelling, and community participation. These characteristics made it an information-rich case for examining how local wisdom is institutionalized in primary education and how implementation unfolds in its natural context (Tisdell et al., 2025).

Respondents of the Study

Purposive sampling was employed to recruit information-rich participants who were directly involved in planning, implementing, supporting, and experiencing Syekh Jangkung values in school-based character education. Selection prioritized individuals who could provide detailed insight into the organizational processes through which local wisdom was selected, adapted, and institutionalized. Recruitment continued until information saturation was reached, that is, until further interviews produced no substantially new themes or categories (Ahmad & Wilkins, 2025; Tight, 2024).

Table 1. Research participants

Participants	Number	Selection criteria
Principal	1	Responsible for school leadership and character education policy
Classroom teachers	4	Implemented Syekh Jangkung values in classroom learning
Islamic Religious Education teacher	1	Integrated local wisdom into religious and character education
Parents	3	Observed students' character development beyond school
School committee representatives	2	Supported school character education programmes
Community leader	1	Represented local cultural perspectives
Total	12	

Participation was entirely voluntary, and written informed consent was obtained from all participants before data collection. Ethical procedures included explaining the research objectives, participants' right to withdraw at any stage without consequence, and measures to ensure anonymity and confidentiality. Personal identifiers were

replaced with participant codes throughout transcription, analysis, and reporting to protect participants' privacy and maintain research integrity, in line with current qualitative research guidelines (Tisdell et al., 2025).

Research Instruments

Three complementary qualitative instruments were used to address the research objectives and to allow methodological triangulation. A semi-structured interview guide explored five analytical domains, namely the strategic selection, adaptation, and institutionalization of Syekh Jangkung values, together with enabling factors and implementation constraints. A non-participant observation sheet examined curriculum integration, daily habituation, teacher role modelling, and school culture, whereas a document analysis sheet verified implementation evidence through lesson plans, school policies, character education programmes, and supporting records. Together, these instruments generated evidence for the three analytical themes developed during thematic analysis (Flick, 2022).

Table 2. Research instruments

Instrument	Data source	Purpose
Semi-structured interview guide	Principal, teachers, parents, school committee, community leader	Explore the strategic selection, adaptation, and institutionalization of Syekh Jangkung values, together with enabling factors and implementation constraints
Non-participant observation sheet	Classroom learning, school routines, and character education activities	Examine curriculum integration, daily habituation, teacher role modelling, and school culture
Document analysis sheet	Lesson plans, school programmes, policy documents, and activity reports	Verify implementation evidence and triangulate findings across data sources

Instrument quality was established through expert review by two specialists in qualitative research and character education to evaluate content relevance, question clarity, and alignment with the research objectives. Pilot interviews involving two participants outside the study subsequently assessed question relevance, sequencing, clarity, and procedural feasibility before field implementation. Revisions from both stages improved the credibility and applicability of the instruments.

Data Collection Procedures

Semi-structured interviews explored the selection, adaptation, and institutionalization of *Syekh Jangkung* values, while non-participant observations and document analysis verified their implementation across curriculum, school practices, and institutional records. Evidence from the three sources was then compared to identify convergence and divergence (Flick, 2022). The procedure ran from research preparation and participant recruitment through data collection, methodological triangulation, and thematic analysis to interpretation within Grindle's implementation framework.

Data Analysis

Data were analyzed using Braun and Clarke's (2022) six-phase thematic analysis: familiarization with the data, coding, generating initial themes, developing and reviewing themes, refining, defining, and naming themes, and writing up. The analysis integrated evidence from interviews, observations, and documents to identify implementation patterns while maintaining alignment with the research objectives. Grindle's implementation framework served as an analytical lens for organizing and interpreting the codes; it did not predetermine the findings.

Table 3. Analytical framework

Analytical construct	Coding focus
Policy content	Value selection, value adaptation, implementation objectives, expected benefits, instructional strategies
Implementation context	School leadership, teacher collaboration, stakeholder participation, school culture, institutional support, implementation constraints
Implementation outcomes	Curriculum integration, daily habituation, teacher role modelling, sustainability of character education

Initial codes generated from interview transcripts, observation field notes, and school documents were consolidated into related categories before being synthesized into overarching themes. The resulting themes were then interpreted through the interaction between policy content and implementation context to explain the institutionalization of Syekh Jangkung values within sustainable school-wide character education.

Trustworthiness

Trustworthiness was addressed using Lincoln and Guba's criteria through methodological triangulation and member checking (credibility), contextual description (transferability), an audit trail (dependability), and continuous verification across interview, observation, and documentary evidence (confirmability) (Lincoln & Guba, 1985).

RESULTS

Thematic analysis generated three interconnected themes that explain the institutionalization of *Syekh Jangkung* values in school-wide character education. The findings show the organizational processes through which local wisdom was strategically selected, adapted, and implemented within the school context. This section reports the first theme, strategic selection and adaptation of the values, with its supporting evidence (Tables 4 and 5).

Strategic selection and adaptation of Syekh Jangkung values formed the foundation of school-wide character education. Four core values (honesty, responsibility, mutual cooperation, and respect) were consistently prioritized because they aligned with students' developmental needs and the school's character education objectives. These values were systematically adapted into curriculum implementation, daily habituation, and classroom practices to support sustainable character education.

Table 4. Strategic selection and adaptation of Syekh Jangkung values

Analytical aspect	Findings	Evidence sources
Strategic value selection	Honesty, responsibility, mutual cooperation, and respect were prioritized as core values.	Principal, teachers, school documents
Value adaptation	Cultural values were adapted into age-appropriate learning experiences and daily school practices.	Teachers, observations
Curriculum integration	Values were embedded in classroom learning, habituation programmes, and school activities.	Lesson plans, observations
Educational rationale	Value selection reflected students' developmental needs and school character education goals.	Principal, teachers

Table 4 shows that Syekh Jangkung values were strategically selected and adapted to support school-wide character education. Interview evidence showed that the principal positioned local wisdom as the moral foundation of school programmes, stating that *"the values of Syekh Jangkung are integrated into school activities, classroom learning, and daily interactions."* Classroom teachers consistently embedded honesty, responsibility, mutual cooperation, and respect into collaborative learning and classroom routines, while the Islamic Religious Education teacher reinforced these values through religious instruction and moral reflection. Parents also reported improvements in students' respectful behaviour, responsibility, and cooperation at home, which suggests that value internalization extended beyond the school environment.

Observation data documented how Syekh Jangkung values were enacted during classroom learning and school routines. Teachers introduced and reinforced character values during learning activities, modelled respectful communication and responsible behaviour, and facilitated collaborative tasks that encouraged mutual cooperation. Students displayed these values in classroom participation, routine responsibilities, and interactions with peers and teachers, which indicates consistent implementation across daily school practices.

Document analysis identified explicit integration of Syekh Jangkung values within learning objectives, instructional activities, assessment indicators, annual character education programmes, and school regulations. Lesson plans and institutional documents consistently reflected the school's commitment to embedding local wisdom in curriculum implementation and routine educational practices. These documents gave formal support to school-wide character education.

Table 5. Triangulation matrix for Theme 1

Data source	Evidence	Analytical conclusion
Principal interview	Character education policy prioritized honesty, responsibility, mutual cooperation, and respect.	Strategic value selection aligned with the school's vision and character education policy.
Teacher interviews	Values were integrated into lesson planning, classroom instruction, and daily learning routines.	Cultural values were systematically adapted into instructional practices.
Islamic Religious Education teacher interview	Religious instruction reinforced Syekh Jangkung values through moral reflection and daily practice.	Cross-curricular implementation strengthened value internalization.
Parent interviews	Students increasingly practiced honesty, responsibility, cooperation, and respect at home.	Character development extended beyond the school environment.
Classroom observations	Teachers modelled character values and students practiced them during learning and school routines.	Daily habituation reinforced value internalization.
Lesson plans and school programmes	Character values were embedded in learning objectives, activities, and school programmes.	Curriculum integration supported sustainable implementation.

Triangulated evidence indicated that strategic value selection was the initial stage of institutionalizing Syekh Jangkung values within school-wide character education. Alignment across interviews, observations, and documentary evidence indicated that local wisdom was systematically translated into curriculum implementation, daily habituation, and organizational practices. This translation formed the operational foundation for sustainable character education.

DISCUSSION

The first finding is that the school did not adopt Syekh Jangkung values wholesale. It selected four of them (honesty, responsibility, mutual cooperation, and respect) and justified the choice by students' developmental needs and the school's character education goals (Table 4). In the terms used by Grindle (1980), this selection is the policy content of the programme: the school decided which values to pursue and in what form. Reducing a broad cultural tradition to a short list of age-appropriate values gave teachers concrete targets that could be written into lesson plans and observed in classrooms. Studies of local wisdom-based learning report that contextual integration supports students' moral development and cultural identity (Yusuf, 2023; Asrial et al., 2023; Andriani & Aulia, 2023). A pesantren-based madrasah ibtidaiyah in Malang likewise instilled a small set of values, including honesty, through curricular integration and religious routines (Priatmoko et al., 2025). Those studies mostly treat the values as given. The present case suggests that value selection is itself an organizational decision that shapes what follows.

The second finding concerns how the selected values were institutionalized. Interviews, observations, and documents agreed that the values were embedded in learning objectives, assessment indicators, annual programmes, and school regulations, practised in daily routines, and modelled by teachers (Table 5). The Islamic Religious Education teacher reinforced the same values through religious instruction and moral reflection, so students met them in more than one subject. Repetition across settings is a plausible mechanism. A value that appears in the lesson plan, the daily routine, and the teacher's own conduct is harder for students to treat as

classroom content only. This pattern is consistent with a Surakarta primary school where Pancasila student profile values were instilled through daily habituation such as polite greetings, class duty, and food sharing (Suryaningsih & Desstya, 2023). It also matches four Kudus madrasah where religious character grew through role modelling and flourished where a religious culture was rooted in the school (Zuhri et al., 2025), and reports that character education depends on curriculum integration and organizational commitment rather than on isolated activities (Supriyadi et al., 2024; Badeni & Saparahayuningsih, 2023).

Third, the three parents interviewed reported more respectful, responsible, and cooperative behaviour at home (Tables 1 and 5). This suggests that the values may have carried beyond school, but the evidence rests on a few self-reports and was not checked by observation at home. The point matters because home settings can work against school efforts. In a primary school in Sukoharjo, students' polite language was shifting negatively under family and environmental influences (Mirmanto et al., 2021). Involving parents, the school committee, and a community leader may therefore be part of what made the programme coherent, since the values students met at school were also recognized in the community.

The interviews also show the principal positioning local wisdom as the moral foundation of school programmes. School leaders are thought to influence learning mainly indirectly, through teachers' motivation, capacity, and working conditions (Leithwood et al., 2020), and in Grindle's framework this belongs to the implementation context. Regional evidence shows that such context varies. In Kudus Regency, the religious dimension of the Gusjigang tradition was strongly embedded in principals' leadership and character education, while its literacy and entrepreneurship dimensions were only moderately implemented (Kamal et al., 2025). Among pre-service teachers at Universitas Muria Kudus, Gusjigang values worked as a character ecosystem supported by course-plan integration and lecturer modelling but were constrained by cultural dissonance (Santoso et al., 2026). Elementary schools elsewhere also report constraints when implementing local wisdom values (Annissabrina et al., 2023). This paper does not yet present comparable evidence on the enabling and constraining conditions in the case school, so the role of leadership and stakeholder support remains an interpretation.

Several practical implications follow for the case school and for other schools in Pati Regency. Principals who wish to draw on a local figure such as Syekh Jangkung can begin by choosing a few values and stating why they suit their students, rather than presenting the whole tradition. Teachers need those values written into learning objectives and assessment indicators so that they appear in planning and not only in assemblies. Religious education teachers can carry the same values across subjects, and schools can involve parents and community leaders so that the values are recognized outside school. District education offices could support this work with locally developed materials, such as the character education module developed for upper primary classes in Pati (Komariah et al., 2022), and with monitoring that checks whether values are practised rather than only documented.

This study has several limitations. It examined one school with 12 participants, so its findings describe one case and cannot be generalized without further evidence. The Findings report only the first of the three themes, and the evidence on the enabling and constraining factors summarized in the abstract still needs to be presented. Parents' reports of behaviour at home are self-reports from three people, and students were observed but not interviewed. The study did not measure students' character outcomes, so it cannot show whether the programme changed behaviour. A recent review notes the same weakness across local wisdom research in Indonesia, which relies mostly on development and short-term descriptive studies (Jovanda et al., 2026). Future research could compare several Pati schools that draw on Syekh Jangkung values, follow students over time with observed or validated measures of character, and examine how leadership, workload, and monitoring support or constrain implementation.

CONCLUSION AND RECOMMENDATIONS

In the case school, strategic selection, contextual adaptation, and school-wide institutionalization of Syekh Jangkung values shaped how character education was organized. Character education was implemented through the interaction of curriculum integration, daily habituation, teacher role modelling, school leadership, and stakeholder participation rather than through isolated instructional activities. These findings extend Grindle's implementation framework by suggesting that the implementation of local wisdom-based character education depends on the reciprocal interaction between policy content and implementation context within school organizations. School leaders and policymakers should therefore institutionalize local wisdom through curriculum development, continuous teacher professional learning, and collaborative partnerships with families and local communities to support sustainable character education. Future studies could examine local wisdom-based character education at other educational levels and in other cultural contexts to test the transferability of these findings.

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REFERENCES

Ahmad, M., & Wilkins, S. (2025). Purposive sampling in qualitative research: A framework for the entire journey. *Quality & Quantity, 59*(3), 1461–1479. doi:10.1007/s11135-024-02022-5

Andriani, M., & Aulia, F. (2023). The reinforcement of character education through the values of local wisdom in folktales. *Indonesian Research Journal in Education, 7*(2), 420–429. https://doi.org/10.22437/irje.v7i2.27609

Aningsih, Zulela, M., Neolaka, A., Iasha, V., & Setiawan, B. (2022). How is the education character implemented? The case study in Indonesian elementary school. *Journal of Educational and Social Research,* 12(1), 371–384. https://doi.org/10.36941/jesr-2022-0029

Annissabrina, I., Nasrul, H. S., Ifliadi, I., Abimanyu, D. S., MS, A., & Nebres, A. J. (2023). Characteristic of elementary school learning: Constraints in implementing local wisdom values in elementary schools. *Jurnal Gentala Pendidikan Dasar,* 8(2), 262–275. https://doi.org/10.22437/gentala.v8i2.30350

Asrial, A., Syahrial, Kurniawan, D. A., Perdana, R., & Nugroho, P. (2023). Peace-loving character, critical thinking, and learning motivation through local wisdom-based teaching materials. *Indonesian Journal on Learning and Advanced Education, 5*(2), 151–167. https://doi.org/10.23917/ijolae.v5i2.17068

Aulia, S. S., Arif, D. B., & Amalia, R. (2022). Implementasi gerakan penguatan pendidikan karakter sebagai wahana pendidikan nilai [Implementation of the character education strengthening movement as a medium for values education]. *Jurnal Pendidikan Karakter,* 13(2), 234–243. https://doi.org/10.21831/jpka.v13i2.53207

Badeni, B., & Saparahayuningsih, S. (2023). The implementation of local wisdom-based character education in elementary school. *Journal of Educational Issues*, 9(2), 1–14. https://doi.org/10.5296/jei.v9i2.20768

Braun, V., & Clarke, V. (2022). *Thematic analysis: A practical guide*. SAGE.

Creswell, J. W., & Poth, C. N. (2023). Qualitative inquiry and r*esearch* design: Choosing among five approaches (5th ed.). SAGE Publications.

Flick, U. (2022). *An introduction to qualitative research* (7th ed.). SAGE.

Grindle, M. S. (1980). *Politics and policy implementation in the Third World*. Princeton University Press.

Hafina, A., Nur, L., & Malik, A. A. (2022). The development and validation of a character education model through traditional games based on the Socratic method in an elementary school. *Jurnal Cakrawala Pendidikan*, 41(2), 404–415. https://doi.org/10.21831/cp.v41i2.46125

Hidayat, M., Rozak, R. W. A., Hakam, K. A., Kembara, M. D., & Parhan, M. (2022). Character education in Indonesia: How is it internalized and implemented in virtual learning? *Jurnal Cakrawala Pendidikan*, 41(1), 186–198. https://doi.org/10.21831/cp.v41i1.45920

Hikmawati, F., Santoso, & Khamdun. (2023). Development of a project-based learning model based on Kudus local wisdom for students critical thinking. *ICCCM Journal of Social Sciences and Humanities*, 2(6), 28–33.

https://doi.org/10.53797/icccmjssh.v2i6.5.2023

Jovanda, R., Paais, R. L., Manafe, M. P., Sundari, L., Dewi, A. R., Ohodo, M. M. R., Chasanah, I. A. W., Pratama, A. H., & Waluyo, H. (2026). Local wisdom-based learning approaches for strengthening students' conceptual understanding and character in Indonesia: A systematic literature review [Version 1; peer review: 1 approved with reservations]. F1000Research, 15, Article 1384. https://doi.org/10.12688/f1000research.188148.1

Kamal, J., In'am, A., & Khozin, K. (2025). Culturally-rooted school leadership: The role of Gusjigang values in enhancing character education at the primary level. Elmidad, 17(2). https://doi.org/10.20414/elmidad.v17i2.14134

Komariah, S., Murtono, & Kanzunuddin, M. (2022). Development of local wisdom-based character education module in Pati District for upper-class elementary schools. *ANP Journal of Social Science and Humanities*, *3*(2), 16–22. https://doi.org/10.53797/anp.jssh.v3i2.4.2022

Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven strong claims about successful school leadership revisited. School Leadership & Management, 40(1), 5–22. https://doi.org/10.1080/13632434.2019.1596077

Lincoln, Y. S., & Guba, E. G. (1985). Naturalistic inquiry. Sage.

Mirmanto, N., Prayitno, H. J., Sutopo, A., Rahmawati, L. E., & Widyasari, C. (2021). Pergeseran tindak kesantunan peserta didik kelas 5 sekolah dasar dengan berlatar belakang budaya Jawa [A shift in the politeness actions of grade 5 elementary school students with a Javanese cultural background]. Pedagogia: Jurnal Pendidikan, 10(2), 89–94. https://doi.org/10.21070/pedagogia.v10vi2i.1006

Priatmoko, S., Rahman, S. A., Inayah, S. R., Ekawati, R., & Mustakim, S. S. (2025). Exploration of religious character education in pesantren-based madrasah ibtidaiyah. Mudarrisa: Jurnal Kajian Pendidikan Islam, 17(1), 1–28. https://doi.org/10.18326/mudarrisa.v17i1.3329

Qudwatullathifah, R. N., Nugraha, T. A., & Miftahurrohmah, C. (2025). Strategi guru dalam menginternalisasi nilai-nilai kearifan lokal untuk penguatan karakter siswa sekolah dasar [Teachers' strategies for internalizing local wisdom values to strengthen elementary school students' character]. *Prima Magistra: Jurnal Ilmiah Kependidikan*, 6(1), 20–28. https://doi.org/10.37478/jpm.v6i1.5235

Ramadani, D. R., & Fitrisia, A. (2023). The character education implementation and local wisdom values in learning history: The Islamic development in Indonesia. *Indonesian Research Journal in Education*, 7(1), 196–206. https://doi.org/10.22437/irje.v7i1.26308

Sakti, S. A., Endraswara, S., & Rohman, A. (2024). Revitalizing local wisdom within character education through ethnopedagogy approach: A case study on a preschool in Yogyakarta. *Heliyon*, 10(10), e31370. https://doi.org/10.1016/j.heliyon.2024.e31370

Santoso, Suyahmo, & Lestari, P. (2026). Strengthening pre-service teachers' characters through Gusjigang local wisdom: A phenomenological study in Indonesian higher education. Indonesian Journal of Educational Development, 7(2), 703–716. https://doi.org/10.59672/ijed.v7i2.7036

Sukma, E., Abbas, A., Asriani, A., Nurhayati, N., Kaharuddin, K., & Gheisari, A. (2022). Development of authentic assessment in local wisdom-based reading learning. *Education Research International*, 2022, Article 4905583. https://doi.org/10.1155/2022/4905583

Supriyadi, S., Febriyanti, B. K., & Tirtoni, F. (2024). Implementation of integral character education based on school curriculum integration. *Mimbar PGSD Undiksha*, 12(1), 141–151. https://doi.org/10.23887/jjpgsd.v12i1.65942

Suryaningsih, M. R., & Desstya, A. (2023). Implementasi nilai-nilai profil pelajar Pancasila dalam Kurikulum Merdeka di sekolah dasar [Implementation of Pancasila student profile values in the Merdeka Curriculum in elementary school]. Muallimuna: Jurnal Madrasah Ibtidaiyah, 9(1), 12–26. https://doi.org/10.31602/muallimuna.v9i1.10961

Tight, M. (2024). Saturation: An overworked and misunderstood concept? *Qualitative* I*nquiry*, 30(7), 577–583. https://doi.org/10.1177/10778004231183948

Tisdell, E. J., Merriam, S. B., & Stuckey-Peyrot, H. L. (2025). Qualitative research: A guide to design and implementation (5th ed.). John Wiley & Sons.

Tohri, A., Rasyad, A., Sururuddin, M., & Istiqlal, L. M. (2022). The urgency of Sasak local wisdom-based character education for elementary school in East Lombok, Indonesia. *International Journal of Evaluation and Research in Education, 11*(1), 333–344. https://doi.org/10.11591/ijere.v11i1.21869

Yusuf, F. A. (2023). Meta-analysis: The influence of local wisdom-based learning media on the character of students in Indonesia. *International Journal of Educational Methodology, 9*(1), 237–248. https://doi.org/10.12973/ijem.9.1.237

Zakiah, L., Marini, A., & Nafiah, M. (2022). Implementation of character education policies on online learning in elementary schools. *Jurnal Ad'ministrare*, 9(1). https://doi.org/10.26858/ja.v9i1.32703

Zuhri, A., Mas'ud, A., & Syukur, F. (2025). Strengthening religious character in madrasah: Integrating pesantren values as an educational strategy. Al-Tarbawi Al-Haditsah: Jurnal Pendidikan Islam, 10(1), 71–92. https://doi.org/10.24235/tarbawi.v10i1.19819

ICISFS-UMK 2026 EDUCATIONAL TECHNOLOGY & MEDIA

Development of E-Modules (SI E-PAL) on Critical Thinking Skills for Grade 4 Elementary School Students

Nevananda Arica Lungdiansari[1*], Fina Fakhriyah[1] and Imaniar Purbasari[1]

[1]*Muria Kudus University, Indonesia*

Corresponding author: 202403127@std.umk.ac.id

ABSTRACT

Technological development and the implementation of the Independent Curriculum call for student-centered learning and for 21st-century skills, especially critical thinking. This study aimed to develop an interactive e-module on environmental heroes (SI E-PAL) to help teachers deliver Natural and Social Sciences (IPAS) material. The study used the Research and Development (R&D) method with the ADDIE development model. The subjects were fourth-grade students in 3 elementary schools in the Hadipolo cluster in the even semester of the 2025/2026 academic year. Material experts, teaching material experts, and linguists validated the product for feasibility. Practicality was measured through teacher and student responses, and the gain in critical thinking skills was tested with N-Gain. Feasibility ratings were 86% from the material validation, 86.3% from teaching material experts, and 90% from linguists ("very feasible"). Teacher responses averaged 93.8% and student responses 85.3% ("very practical"). Pretest-posttest scores increased, with an N-Gain of $0.30 \leq 0.57 < 0.7$ in the "moderate" category. These results suggest that the SI E-PAL e-module can help improve the critical thinking skills of fourth-grade elementary school students.

KEYWORDS critical thinking skills | IPAS | SI E-PAL | teaching materials | science

INTRODUCTION

Technological development affects teaching and learning, and its pace needs to be matched by the quality of education in elementary schools. Effective learning requires interaction between educators and students. When the components of learning are integrated, this interaction can achieve the intended goals (Halid, 2024).

The Independent Curriculum promotes 21st-century skills, so learning must be designed around the 4C skills: critical thinking, creativity, communication, and collaboration (Rosnaeni, 2021). Implementing the curriculum requires commitment and collaboration among school stakeholders, especially educators, so that students receive quality learning that is innovative and adapted to their competencies (Asri et al., 2024). Starting in the 2025/2026 academic year, the government has introduced a deep learning approach, including in elementary schools. The deep learning approach integrates the concepts of mindful learning, meaningful learning, and joyful learning (Syafi'i & Darnaningsih, 2025). As a learning approach, deep learning encourages students to relate existing knowledge to new information, think critically, and apply knowledge in real life (Nabila et al., 2025).

This approach aligns with science learning, which emphasizes inquiry, problem-solving, and connection to the environment. Implementing the Independent Curriculum through a deep learning approach provides opportunities for meaningful, active, and challenging learning. However, its implementation still requires the support of learning design and media that can facilitate optimal exploration and student interaction. Educators are expected to innovate so that learning goes beyond delivering material, and teaching materials, media, and methods should be tailored to student characteristics.

However, the researchers' observations and interviews showed that teachers still relied on lectures. Teaching materials were limited to worksheets (LKS) and did not use technology. When students only listen, they become bored, and their engagement and thinking decline. In the science subject, 62% of students' grades in the science subject were still below the learning objective achievement criteria (KKTP), which indicates that educators need to design more varied learning (Najwa & Radiansyah, 2024). Combining media or learning models can involve students actively and encourage them to learn concepts independently. Interactive media are one way to support this interaction. A meta-analysis of 15 Indonesian experimental studies found a mean effect size of 1.146 for

interactive multimedia on learning outcomes, with the highest estimate at elementary level (Khaeruman et al., 2023). Educators should integrate technology into the delivery of learning materials so that learning is more interactive and creative, which attracts students' interest and supports real understanding (Agustian & Salsabila, 2021).

Mardliyah et al. (2023) identified monotonous learning strategies, especially reliance on lectures, as one factor that limits students' critical thinking. Based on the observations above, the researchers concluded that teachers needed teaching materials that help them explain content and let students work with it actively. The researchers therefore developed an interactive e-module on preserving natural resources to prevent environmental damage, for the Natural and Social Sciences (IPAS) subject in grade IV of elementary school.

Several development studies in Indonesian elementary schools have tested digital teaching materials of this kind. A problem-solving-oriented digital e-module for grade 5 science produced a mean N-gain of 0.77 on an essay test with 26 students (Firman et al., 2024). A contextual electronic worksheet on fractions was rated 86-90% feasible by experts and produced a moderate N-gain of 0.61 with 32 fifth graders (Sakinah et al., 2023), and Articulate Storyline media on the Earth, Sun, and Moon reached a medium N-gain of 0.69 in science literacy with 20 students (Ramadhani & Asrul, 2024). Digital science modules developed with ADDIE have also been rated valid and practical by experts and users (Pratiwi & Jayanta, 2023). Most of these products target conceptual understanding or literacy rather than critical thinking, and most were tried without a comparison group. We found few e-modules for grade 4 IPAS that link the topic of preserving natural resources with explicit critical thinking indicators. SI E-PAL was designed to fill that gap.

LITERATURE REVIEW

Teaching materials are systematically arranged resources that contain content, methods, and evaluation tools designed to help students reach intended competencies (Magdalena et al., 2020). They assist teachers in carrying out teaching and learning activities. According to Magdalena et al. (2020), teaching materials save teachers time, change the teacher's role from instructor to facilitator, and improve the learning process, while students can learn independently anytime and anywhere. Good materials can also present things that cannot be observed directly in class, which gives students room to analyse and reason.

One such teaching material is the electronic module (e-module), a digitally packaged teaching material. E-modules can combine text, images, video, animation, and audio, and students can open them on computers or mobile phones. The cognitive theory of multimedia learning, which treats multimedia learning as learning from words and pictures, provides the rationale for these features (Mayer, 2014).

Interactive teaching materials present information and also let students explore, reflect, and interact with content through multimedia features such as text, images, animations, videos, quizzes, and automated feedback. A meta-analysis of 110 experimental and quasi-experimental studies found a moderate mean effect of 0.523 for integrating mobile devices into teaching and learning (Sung et al., 2016). One possible e-module links science content to the topic "Becoming an Environmental Hero". Such a module can place students in familiar environmental problems, ask them to weigh evidence and decide what to do, and connect science learning with social responsibility towards the environment. The value of an e-module therefore lies both in its multimedia features and in its ability to connect contextual learning with the needs and characteristics of elementary school students.

Ennis (2011) defines critical thinking as reasonable reflective thinking focused on deciding what to believe or do. His outline groups critical thinking abilities into basic clarification, two bases for a decision (judging the credibility of sources and of observation reports), inference, advanced clarification, and supposition and integration, together with auxiliary abilities (Ennis, 2011). This study uses the first five groups as indicators of critical thinking. Critical thinking can be taught. A meta-analysis of 341 studies found a small positive effect of instruction on generic critical thinking ($g = 0.30$) and larger gains when dialogue, authentic problems, and mentoring were combined (Abrami et al., 2015).

Research Objectives

This study aimed to develop the interactive environmental-hero e-module (SI E-PAL) for grade IV IPAS and to answer three questions: how feasible SI E-PAL is according to material, teaching material, and language experts; how practical it is according to teachers and students; and how much students' critical thinking scores change from pretest to posttest after using it.

RESEARCH METHOD

Research Design

This research used the Research and Development (R&D) method, which develops a product and tests its feasibility through defined procedures. Effectiveness tests are conducted to check that the product works for its intended users (Gall et al., 2007). The product developed is an interactive e-module for environmental heroes (SI E-PAL) to improve the critical thinking skills of fourth-grade elementary school students. The study used the ADDIE (Analysis, Design, Development, Implementation, Evaluation) development model (Branch, 2009).

Respondents of the Study

The subjects were fourth-grade students in three elementary schools in the Hadipolo cluster in the even semester of the 2025/2026 academic year. The product was validated by material experts, teaching material experts, and linguists, and teachers and students completed response questionnaires.

Research Instruments and Data Analysis

The instruments were expert validation sheets for material, teaching material, and language; teacher and student response questionnaires; and a critical thinking test based on the indicators of Ennis (2011), given as a pretest and a posttest. Validation and response scores were converted to percentages and categorized (for example, "very feasible" and "very practical"). The gain in critical thinking was calculated with the normalized gain (N-Gain), where $g < 0.3$ is low, $0.3 \leq g < 0.7$ is moderate, and $g \geq 0.7$ is high (Hake, 1998).

RESULTS

Product feasibility. The material validation gave a score of 86%, the teaching material experts 86.3%, and the linguists 90%. All three ratings fall in the "very feasible" category.

Practicality. Teacher responses averaged 93.8% and student responses 85.3%, both in the "very practical" category.

Critical thinking. Students' critical thinking scores increased from pretest to posttest, with an N-Gain of 0.57 in the moderate category ($0.30 \leq g < 0.7$).

DISCUSSION

The first finding is that experts rated SI E-PAL as very feasible: 86% for material, 86.3% for teaching material design, and 90% for language. These ratings indicate that the experts judged the content accurate, the design suitable for fourth graders, and the language readable. They are close to the ratings reported for similar products. A contextual electronic worksheet on fractions was rated 86-90% feasible (Sakinah et al., 2023), a digital science practicum module was rated 91.3-96.6% valid (Pratiwi & Jayanta, 2023), and Smart Apps Creator media for Pancasila education were rated 91.67% feasible (Anggraeni et al., 2025). The material rating was the lowest of the three, which suggests that the content, rather than the language, is where revision would help most. Percentage ratings also have a limit. They show how far a few experts agreed with a checklist but do not indicate whether the agreement is statistically reliable. A coefficient such as Aiken's V would allow that check (Aiken, 1985). Reporting each expert's comments and the revisions made after validation would also show how the product changed during the development stage of ADDIE.

The second finding concerns practicality. Teachers rated SI E-PAL higher (93.8%) than students did (85.3%), although both ratings were in the very practical category. One likely reason is that the teachers had relied on lectures and printed worksheets, so a ready-made structured module met a need they had already felt. Students may have found reading and navigating a digital module more demanding than the teachers expected, but the paper does not report item-level responses that would confirm this. The pattern differs from Anggraeni et al. (2025), where students rated their interactive media higher than teachers did (96.6% versus 90%), and it is close to the student responses of 83-89% for an electronic worksheet (Sakinah et al., 2023). For teachers, the result points to practical steps: introduce the navigation of the e-module before the first lesson, and read the denser pages together with students.

The third finding is that students' critical thinking scores rose from pretest to posttest with an N-Gain of 0.57, in the moderate category. For comparison, interactive-engagement physics courses averaged a normalized gain of 0.48 and traditional courses 0.23 (Hake, 1998). The SI E-PAL gain is lower than the high gain of 0.77 reported for a problem-solving-oriented digital e-module (Firman et al., 2024) and close to the 0.61 for a contextual electronic worksheet (Sakinah et al., 2023) and the 0.69 for Articulate Storyline media (Ramadhani & Asrul, 2024). It is higher than the 0.38 reported for discovery learning on critical thinking in grade 6 (Putri et al., 2026). A plausible mechanism is the module's environmental theme. Problems about preserving natural resources ask students to judge sources, draw inferences, and decide what to do, which are abilities listed in the outline by Ennis (2011). Instruction in critical thinking works best when dialogue, authentic problems, and mentoring are combined (Abrami et al., 2015). The moderate rather than high gain suggests that the e-module may need to be paired with class discussion of the problems it poses.

These findings have practical value for schools in the Hadipolo cluster and for IPAS teachers more widely. Teachers who still rely on lectures and worksheets can use SI E-PAL to give students structured, contextual tasks without building materials from scratch. The deep learning approach introduced in 2025/2026 asks for mindful, meaningful, and joyful learning (Syafi'i & Darnaningsih, 2025), and a module that connects science content with students' own environment is one way to meet that aim (Nabila et al., 2025). Schools need enough devices and a stable connection for students to use the module, and the teacher working group in the cluster could share the module and adapt it to other IPAS topics. The baseline problem reported in the Introduction, with 62% of students' science grades below the KKTP, also gives schools a concrete target. They could track whether the share of students reaching the KKTP rises after a semester of using the module, which would be more informative than a single pretest and posttest.

This study has several limitations. The trial used a one-group pretest-posttest design without a control group, so the gain cannot be separated from the effects of testing, maturation, or ordinary teaching (Shadish et al., 2002), and it does not show that SI E-PAL is more effective than other materials. The trial took place in three schools in one cluster, and the number of students is not reported. The validation and response data are percentages without inter-rater statistics, and the validity and reliability of the critical thinking test are not reported. The gain was also measured immediately after use, so retention is unknown. Future research should compare SI E-PAL with ordinary teaching in a quasi-experimental design, report gains for each critical thinking indicator, and test whether the effect lasts.

CONCLUSION AND RECOMMENDATIONS

SI E-PAL was rated very feasible by material experts, teaching material experts, and linguists, and very practical by teachers and students. Students' critical thinking scores rose from pretest to posttest with a moderate N-Gain. Because the trial had no comparison group, this gain indicates the module's potential rather than demonstrated effectiveness. Teachers can use SI E-PAL to replace lecture-based IPAS lessons on preserving natural resources, ideally combined with class discussion. Future studies should test the module against ordinary teaching and with more schools.

REFERENCES

Abrami, P. C., Bernard, R. M., Borokhovski, E., Waddington, D. I., Wade, C. A., & Persson, T. (2015). Strategies for teaching students to think critically: A meta-analysis. Review of Educational Research, 85(2), 275–314. https://doi.org/10.3102/0034654314551063

Agustian, N., & Salsabila, U. H. (2021). Peran Teknologi Pendidikan dalam Pembelajaran. *Islamika*, *3*(1), 123–133. https://doi.org/10.36088/islamika.v3i1.1047

Aiken, L. R. (1985). Three coefficients for analyzing the reliability and validity of ratings. Educational and Psychological Measurement, 45(1), 131–142. https://doi.org/10.1177/0013164485451012

Anggraeni, A., Erita, Y., Nora, D., & Rahmi, U. (2025). Development of Smart Apps Creator-based interactive learning media to support 21st century skills in Pancasila education for elementary schools. Jurnal Kependidikan, 11(2), 702–712. https://doi.org/10.33394/jk.v11i2.15136

Asri, D., Daulay, N. K., Hasibuan, A. S., Lukman, P., Daulay, A., Pane, T. I. L., & Tahara, A. (2024). Implementasi Kurikulum Merdeka Belajar dalam mewujudkan sekolah unggul di SD. *Jurnal Pendidikan Tambusai*, *8*(2), 23854–23862.

Branch, R. M. (2009). Instructional design: The ADDIE approach. Springer. https://doi.org/10.1007/978-0-387-09506-6

Ennis, R. H. (2011). The nature of critical thinking: An outline of critical thinking dispositions and abilities [Unpublished manuscript]. University of Illinois. https://education.illinois.edu/docs/default-source/faculty-documents/robert-ennis/thenatureofcriticalthinking_51711_000.pdf

Firman, S., Nurlina, Rahmawati, Ma'ruf, & Imran, M. E. (2024). The effectiveness of developing problem-solving oriented digital e-modules on Theme 7: Events in life for grade V elementary school. Didaktika: Jurnal Kependidikan, 13(4). https://doi.org/10.58230/27454312.1045

Gall, M. D., Gall, J. P., & Borg, W. R. (2007). Educational research: An introduction (8th ed.). Pearson.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. American Journal of Physics, 66(1), 64–74. https://doi.org/10.1119/1.18809

Halid, A. (2024). Model guru yang ideal dalam perspektif pembelajaran. *Al-Ashr*, *9*(2), 119–129.

Khaeruman, K., Sudiatmika, A. R., Suma, I. K., & Suardana, I. N. (2023). Meta-analisis: Efektivitas multimedia interaktif terhadap peningkatkan hasil belajar siswa [Meta-analysis: The effectiveness of interactive multimedia in improving student learning outcomes]. Bioscientist: Jurnal Ilmiah Biologi, 11(2), 1630–1639. https://doi.org/10.33394/bioscientist.v11i2.9497

Magdalena, I., Prabandani, R. O., Rini, E. S., Fitriani, M. A., & Putri, A. A. (2020). Analisis pengembangan bahan ajar [Analysis of teaching material development]. Nusantara: Jurnal Pendidikan dan Ilmu Sosial, 2(2), 170–187. https://ejournal.stitpn.ac.id/index.php/nusantara

Mardliyah, S. Z., Salsabilla, A. P., & Herianingtyas, N. L. R. (2023). Strategi peningkatan kemampuan berpikir kritis siswa melalui learning community. *Awwaliyah: Jurnal PGMI*, 6(2), 102–109. https://doi.org/10.58518/awwaliyah.v6i2.1747

Mayer, R. E. (2014). Introduction to multimedia learning. In R. E. Mayer (Ed.), The Cambridge handbook of multimedia learning (2nd ed., pp. 1–24). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369.002

Nabila, S. M., Septiani, M., Fitriani, & Asrin. (2025). Pendekatan deep learning untuk pembelajaran IPA yang bermakna di sekolah dasar. *Primera Educatia Mandalika: Elementary Education Journal*, *2*(1), 9–20.

Najwa, U., & Radiansyah. (2024). Meningkatkan aktivitas, keterampilan berpikir kritis, dan hasil belajar melalui model PBL, NHT, picture and picture. *Jurnal Pendidikan Tambusai*, *8*(2), 34797–34806.

Pratiwi, N. K. A., & Jayanta, I. N. L. (2023). Elementary school science skills practical digital teaching module. Jurnal Edutech Undiksha, 11(2). https://doi.org/10.23887/jeu.v11i2.61524

Putri, M. Y., Miftakhuddin, & Adiyan, F. (2026). Pengaruh model discovery learning terhadap kemampuan berpikir kritis di sekolah dasar [The effect of the discovery learning model on critical thinking skills in elementary school]. Jurnal Tunas Pendidikan, 9(1), 209–217. https://doi.org/10.52060/pgsd.v9i1.4422

Ramadhani, I. A., & Asrul, A. (2024). Development of interactive learning media based on Articulate Storyline to improve student' science literacy. Lectura: Jurnal Pendidikan, 15(2), 533–545. https://doi.org/10.31849/lectura.v15i2.20974

Rosnaeni. (2021). Karakteristik dan asesmen pembelajaran abad 21. *Jurnal Basicedu*, *5*(5), 4334–4339.

Sakinah, S., Dewi, R. S., & Hakim, Z. R. (2023). Development of contextual-based E-LKPD to improve the ability to understand fraction concepts. EduBasic Journal: Jurnal Pendidikan Dasar, 5(1), 71–82. https://doi.org/10.17509/ebj.v5i1.51576

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). Experimental and quasi-experimental designs for generalized causal inference. Houghton Mifflin.

Sung, Y.-T., Chang, K.-E., & Liu, T.-C. (2016). The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. Computers & Education, 94, 252–275. https://doi.org/10.1016/j.compedu.2015.11.008

Syafi'i, A., & Darnaningsih. (2025). Pendekatan pembelajaran berbasis deep learning: Mindful learning, meaningful learning, dan joyful learning. *Al-Mumtaz: Jurnal Manajemen Pendidikan Islam*, *2*(1), 45–57.

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

Principals' Professional Competence, CARE Leadership, and Teacher Performance in Indonesian Schools

Yeni Eka Dyah Pratiwi[1*], Ahmad Hariyadi[1] and Yuni Ratnasari[1]

[1]*Muria Kudus University, Indonesia*

ABSTRACT

Teacher performance in the digital era is a key determinant of educational quality, and school principals need both professional competence and leadership that emphasizes character development and interpersonal relationships. However, empirical evidence regarding the combined influence of principals' professional competence and CARE leadership (character, adaptability, relationship, and empowerment) on teacher performance remains limited, particularly in Indonesian elementary schools. This study aimed to examine the effects of principals' professional competence and CARE leadership on teacher performance in the digital era. A quantitative survey was conducted with 184 elementary school teachers, selected with the Slovin formula from a population of 340 teachers in Kradenan District, Indonesia. Data were collected through validated and reliable questionnaires and analyzed using descriptive statistics, multiple linear regression, t-tests, F-tests, and the coefficient of determination (R^2). Principals' professional competence had a positive and significant effect on teacher performance ($\beta = 0.534$; $t = 6.621$; $p < 0.001$). CARE leadership also had a positive and significant effect on teacher performance ($\beta = 0.523$; $t = 6.279$; $p < 0.001$). Together, both independent variables significantly predicted teacher performance ($F = 99.927$; $p < 0.001$), explaining 52.5% of the variance ($R^2 = 0.525$). These findings suggest that strengthening principals' professional competence together with CARE leadership may improve teacher performance in digital learning environments. The study adds to the educational leadership literature by showing that professional competence and caring leadership are jointly associated with teacher performance during digital transformation in elementary education.

KEYWORDS principal professional competence | CARE leadership | teacher performance | digital learning | elementary schools | educational leadership

INTRODUCTION

Digital technology has changed how schools teach, and teachers are now expected to combine sound pedagogy with the use of digital tools in class. Readiness for this shift is uneven. In Surabaya, teachers' mental and personal readiness for digital transformation was good, but low adaptability limited their use of virtual media, web-based platforms, and IoT tools (Turrohmah & Suryanto, 2023). Under the Merdeka Curriculum, elementary teachers also face uneven competence, underused ICT infrastructure, and varying school support for digital learning (Afrillia & Dafit, 2025). Teacher performance in the digital era therefore depends partly on conditions that school principals can influence.

In Indonesia, the implementation of the Merdeka Curriculum and digital transformation policies has raised expectations that school principals act as instructional leaders who encourage innovation, facilitate professional development, and strengthen teachers' digital competencies (Kemendikbudristek, 2023). Principals' work now goes beyond administration. In three elementary schools in Jombang, principals' instructional leadership (setting the school mission, managing the instructional programme, and building a learning climate) strengthened teachers' pedagogical competence and deep-learning practice under the Merdeka Curriculum (Hanik et al., 2025).

Professional competence is one of the core competencies of school principals because it enables them to manage educational programs, supervise instruction, develop school improvement strategies, and respond to technological change. Indonesian studies report that principal leadership and academic supervision are each related to teacher performance (Starlinsky et al., 2022). A path analysis of 114 teachers in Pati Regency found that principal leadership, school culture, pedagogic competence, and work motivation each directly affected teacher

performance (Ardliana et al., 2021). Principals with strong professional competence are better placed to support teachers' professional growth, encourage instructional innovation, and build supportive learning environments.

Recent leadership research also gives attention to caring leadership, in which principals build caring school cultures through their relationships with staff and students (Ryu et al., 2022). This study uses the CARE leadership model, which has four dimensions: character, adaptability, relationship, and empowerment. It stresses ethical decision-making, trust-building, collaborative relationships, adaptability to educational change, and teacher empowerment. Related relational approaches have similar correlates: a review of 20 quantitative studies associated servant leadership in education with staff engagement, commitment, job satisfaction, psychological empowerment, positive school climate, and performance (Hossain et al., 2026). In digitally transformed schools, caring leadership may help teachers adapt to technological innovation while maintaining positive professional relationships.

Empirical studies have examined leadership and teacher outcomes, but usually one leadership dimension at a time. A survey of 1,200 Indonesian teachers found that principals' leadership and the learning organization each directly affected teachers' innovative work behaviour (Hidayat & Patras, 2022). A PLS-SEM study of 119 teachers and principals in Aceh Besar found that principal leadership affected teacher motivation (0.422) and teacher performance (0.388) (Sariakin et al., 2025). A qualitative case study linked a school culture of innovation and support for professional growth, built by school leaders, to teachers' work motivation (Imawati et al., 2025). These studies rarely combine principals' professional competence with a relational model such as CARE in one analysis.

Meta-analytic evidence suggests why such a combination matters. Instructional leadership has a larger average effect on student outcomes than transformational leadership, and promoting and participating in teacher learning has the largest effect among leadership dimensions (Robinson et al., 2008). Transformational leadership, in turn, affects teachers' motivation, work settings, and classroom practices (Leithwood & Jantzi, 2006). Professional competence and relational leadership may therefore work through different routes. Evidence on their joint relationship with teacher performance is limited, particularly in Indonesian elementary schools, where digital transformation remains uneven across regions. This is the gap the present study addresses.

This study therefore examines how principals' professional competence and CARE leadership, separately and jointly, relate to the performance of elementary school teachers in Kradenan District, Indonesia, in the digital era. The findings are intended to inform school leadership practice in digital learning environments.

LITERATURE REVIEW

Principal professional competence refers to the ability of school principals to perform instructional leadership, strategic management, academic supervision, and continuous school improvement. In the context of digital transformation, professional competence extends beyond administrative responsibilities to include the capacity to facilitate technology integration, support teachers' professional development, and promote innovation in teaching and learning (Kemendikbudristek, 2023).

Professionally competent principals are expected to create conditions that support teachers' instructional work. Through academic supervision, mentoring, and evidence-based decision-making, principals can encourage teachers to adopt new instructional practices, and leadership affects learning mainly indirectly through such school conditions (Hallinger, 2011). A meta-analysis of 24 studies with 9,178 teachers found a moderate positive relationship between principals' instructional leadership and teacher self-efficacy (Alanoglu, 2022). Principal professional competence is therefore seen as a strategic factor in school effectiveness in the digital era.

CARE leadership is a leadership approach that emphasizes four interrelated dimensions: Character, Relationship, Adaptability, and Empowerment. The model treats ethical leadership, collaborative relationships, responsiveness to educational change, and teacher empowerment as components of effective school leadership. The character dimension focuses on integrity, responsibility, and ethical decision-making. Relationship emphasizes trust, communication, and collaboration between principals and teachers. Adaptability reflects leaders'

ability to respond to technological and organizational change. Empowerment encourages teachers to participate actively in decision-making and professional learning.

In digital learning environments, CARE leadership can help principals build organizational cultures in which teachers feel supported when implementing technological innovations. Transformational leadership has been found to have strong effects on organizational conditions such as school culture and planning (Leithwood & Jantzi, 2000), and among 163 elementary teachers in Sukabumi, principals' transformational leadership (r = 0.694) and school culture (r = 0.620) were each correlated with teacher job satisfaction (Nurhadidjah et al., 2023). Teacher performance, the third variable, refers to teachers' effectiveness in planning, implementing, and evaluating learning activities to achieve educational objectives. In the digital era, teacher performance also encompasses digital literacy, technology integration, online classroom management, digital assessment, and continuous professional learning.

Digital transformation requires teachers to use educational technologies while maintaining pedagogical quality and student engagement. Principals can support this through digital leadership. In 24 elementary schools, visionary leadership, a digital-age learning culture, and related digital leadership constructs directly affected teacher performance and students' 21st-century competence (Timan et al., 2022).

Research Objectives

The relationship between principal professional competence and teacher performance can be explained through instructional leadership theory, which argues that principals influence teaching quality by providing supervision, professional guidance, and strategic direction. Professionally competent principals encourage continuous teacher development, which improves instructional practices and student learning outcomes (Leithwood, Harris, & Hopkins, 2020).

CARE leadership complements this perspective by emphasizing supportive interpersonal relationships, ethical leadership, adaptability, and teacher empowerment. Teachers who perceive supportive leadership tend to report higher motivation, organizational commitment, and performance (Hossain et al., 2026; Leithwood & Jantzi, 2006).

Combining principal professional competence and CARE leadership may therefore give a fuller explanation of teacher performance during digital transformation. Based on this review, the study tests three hypotheses. H1: Principals' professional competence has a positive effect on teacher performance. H2: CARE leadership has a positive effect on teacher performance. H3: Principals' professional competence and CARE leadership jointly have a positive effect on teacher performance.

RESEARCH METHOD

Research Design

This study employed a quantitative research approach using an explanatory survey design to examine the influence of principals' professional competence and CARE leadership on teacher performance in the digital era. The research was conducted in public elementary schools in Kradenan District, Central Java, Indonesia. The explanatory design was selected because it allows hypothesized relationships among variables to be tested statistically (Creswell & Creswell, 2018).

The population consisted of 340 elementary school teachers working in public schools in Kradenan District. The sample comprised 184 teachers selected using proportional random sampling based on the Slovin formula with a 5% margin of error, so that each teacher had an equal chance of selection.

Data were collected using structured questionnaires developed from relevant theoretical constructs. The questionnaire consisted of three sections corresponding to the research variables: principals' professional competence, CARE leadership, and teacher performance in the digital era. All items were measured using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Before data collection, the instrument was tested for validity and reliability. Item validity was assessed using Pearson's Product Moment correlation,

while internal consistency reliability was evaluated using Cronbach's Alpha. All questionnaire items met the validity criteria, and reliability coefficients were satisfactory.

Data collection was carried out after obtaining permission from the participating schools. Respondents completed the questionnaires voluntarily and anonymously to protect confidentiality and reduce response bias. Ethical principles, including informed consent, voluntary participation, and confidentiality of respondents' identities, were maintained throughout the research process.

Data analysis was conducted using IBM SPSS Statistics. Descriptive statistics were first used to summarize respondents' characteristics and describe the distribution of each research variable. Before hypothesis testing, classical assumption tests were performed, including normality, multicollinearity, heteroscedasticity, and linearity tests, to ensure that the regression model met the assumptions required for multiple linear regression analysis.

The research hypotheses were tested using multiple linear regression analysis. Partial effects of the independent variables were examined using the t-test, while the simultaneous effect of principals' professional competence and CARE leadership on teacher performance was analyzed using the F-test. The coefficient of determination (R^2) was calculated to determine the proportion of variance in teacher performance explained by the independent variables. Statistical significance was determined at the 0.05 significance level.

Table 1. Summary of hypothesis testing

Hypothesis	Statistical Test	Result	Decision
H1: Principal professional competence → Teacher performance	$\beta = 0.534$; $t = 6.621$; $p < 0.001$	Positive and significant	Accepted
H2: CARE leadership → Teacher performance	$\beta = 0.523$; $t = 6.279$; $p < 0.001$	Positive and significant	Accepted
H3: Principal professional competence and CARE leadership → Teacher performance	$F = 99.927$; $p < 0.001$	Positive and significant	Accepted
Coefficient of Determination	$R^2 = 0.525$	52.5% explained variance	Moderate explanatory power

RESULTS

Table 1 summarizes the hypothesis tests. Principals' professional competence had a positive and significant effect on teacher performance ($\beta = 0.534$; $t = 6.621$; $p < 0.001$), and so did CARE leadership ($\beta = 0.523$; $t = 6.279$; $p < 0.001$). Together, the two variables significantly predicted teacher performance ($F = 99.927$; $p < 0.001$) and explained 52.5% of its variance ($R^2 = 0.525$). The remaining 47.5% is attributable to variables not included in the study. All three hypotheses were therefore supported.

DISCUSSION

The first finding is that principals' professional competence was positively associated with teacher performance ($\beta = 0.534$; $t = 6.621$; $p < 0.001$; Table 1). Teachers who rated their principal as more competent in supervision, management, and school improvement also rated their own performance higher. A plausible mechanism is academic supervision. Competent principals give teachers specific feedback and direction, which may help them integrate digital tools into planning, instruction, and assessment. Because both variables were reported by the same teachers at one point in time, the association cannot be read as a causal effect of competence on performance.

This result agrees with research on instructional leadership. Leithwood et al. (2020) conclude that school leadership influences learning largely through teachers' motivation, capacity, and working conditions, and Robinson et al. (2008) found that promoting and participating in teacher learning had the largest effect among leadership dimensions. Indonesian surveys point the same way. Principal leadership and academic supervision were each related to teacher performance among 64 elementary teachers in Lebak (Starlinsky et al., 2022), and

principal leadership affected teacher performance in Aceh Besar (Sariakin et al., 2025). Also in Central Java, a path analysis of high school teachers in Pati Regency found direct effects of principal leadership on teacher performance, with work motivation as a mediator (Ardliana et al., 2021). The present study did not measure motivation, so whether competence works through motivation in Kradenan remains open.

The second finding is that CARE leadership was also positively associated with teacher performance ($\beta = 0.523$; $t = 6.279$; $p < 0.001$). Leadership that emphasizes character, relationships, adaptability, and empowerment may create a climate in which teachers feel supported when they try new practices. During digital transformation, trust and open communication may lower the perceived risk of using unfamiliar technology in class, and empowerment gives teachers room to decide how to use it.

The result is consistent with research on caring and relational leadership. Ryu et al. (2022) describe how principals' caring leadership produces caring school cultures, and a review of 20 quantitative studies associated servant leadership with staff engagement, commitment, psychological empowerment, and performance (Hossain et al., 2026). Studies of transformational leadership report similar links with teachers' motivation and classroom practices (Leithwood & Jantzi, 2006) and with job satisfaction (Nurhadidjah et al., 2023). One difference deserves attention. Leithwood and Jantzi (2006) found effects on teachers' practices but not on student achievement gains, a reminder that teacher-rated performance is not the same as student learning.

Together, the two variables explained 52.5% of the variance in teacher performance ($R^2 = 0.525$; $F = 99.927$; $p < 0.001$). Teachers' views of their own performance were therefore closely tied to how they saw their principal's leadership. The size of the coefficients needs care. If the reported β values are standardized, an R^2 of 0.525 implies that the two predictors are almost uncorrelated, which is unusual for two leadership scales rated by the same teachers. Reporting the correlation between the predictors and the multicollinearity statistics would show whether the two constructs are distinct. The study also did not test an interaction term, so it cannot show that competence and CARE leadership strengthen each other. It shows only that both are associated with performance when entered together.

The remaining 47.5% of the variance points to other factors. Earlier studies identify school culture, work motivation, and job satisfaction as correlates of teacher performance (Ardliana et al., 2021; Imawati et al., 2025; Nurhadidjah et al., 2023), and teachers' uneven digital competence and school infrastructure constrain digital learning (Afrillia & Dafit, 2025). Future models of teacher performance in the digital era could include these variables.

The study's contribution is to place principals' professional competence and CARE leadership in one regression model for elementary teachers in Kradenan District. Earlier studies mostly examined instructional, transformational, or digital leadership separately. The results suggest that both technical competence and relational leadership matter for teacher performance as teachers perceive it.

For practice, the results suggest that the district education office and school supervisors in Kradenan should develop both sides of principals' work. Training in academic supervision and digital leadership can build professional competence, while mentoring in ethical decision-making, communication, and teacher empowerment can build CARE leadership. Principals can start with regular supervision cycles that include feedback on teachers' use of digital tools, and with teacher learning communities in which teachers share digital practices. Such programmes should be evaluated with measures other than teacher self-ratings.

This study has several limitations. Its cross-sectional survey design cannot establish causal effects, and all three variables were rated by the same teachers, so common method variance may have inflated the associations (Podsakoff et al., 2003). Teacher performance was self-reported rather than assessed by supervisors or through classroom observation. The paper does not report descriptive statistics, assumption tests, or validity and reliability coefficients, and whether the β values are standardized needs to be confirmed. The sample came from public elementary schools in one district. Future research could use supervisor ratings or observation of teacher performance, test mediators such as motivation and digital competence with structural equation modelling, and compare districts with different levels of digital infrastructure.

CONCLUSION AND RECOMMENDATIONS

This study examined the influence of principals' professional competence and CARE leadership on teacher performance in the digital era among elementary school teachers in Kradenan District, Central Java, Indonesia. Principals' professional competence had a positive and significant effect on teacher performance, which suggests that principals with strong professional competencies are better able to support instructional improvement, academic supervision, and teachers' professional development. CARE leadership also had a significant positive effect on teacher performance, plausibly through ethical leadership, collaborative relationships, adaptability, and teacher empowerment.

Jointly, principals' professional competence and CARE leadership had a significant effect on teacher performance and explained 52.5% of the observed variance. These findings indicate that effective school leadership in the digital era involves both professional expertise and caring, relationship-oriented leadership practices. The integration of these two leadership dimensions provides a more comprehensive explanation of teacher performance than examining either dimension independently.

The findings add to the educational leadership literature on the complementary roles of principals' professional competence and CARE leadership in improving teacher performance during digital transformation. This perspective offers a broader framework for understanding teacher performance in elementary education.

From a practical perspective, educational policymakers, school supervisors, and principals should prioritize leadership development programs that strengthen both professional competence and CARE leadership capacities. Leadership training should emphasize instructional supervision, digital leadership, ethical decision-making, collaborative communication, adaptability to technological change, and teacher empowerment. Such integrated professional development initiatives are expected to improve teacher performance and support the sustainable implementation of digital learning in elementary schools.

This study is limited to public elementary schools in Kradenan District and focuses on two leadership-related variables. Future research could investigate additional factors influencing teacher performance, such as teachers' digital competence, organizational culture, job satisfaction, work motivation, school climate, and institutional support. Expanding the research to different educational levels and geographical contexts may also enhance the generalizability of the findings.

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REFERENCES

Afrillia, A., & Dafit, F. (2025). Tantangan guru mengimplementasikan pembelajaran berbasis teknologi digital dalam Kurikulum Merdeka di UPT SDN 023 Pandau Jaya [Teachers' challenges in implementing digital technology-based learning in the Merdeka Curriculum at UPT SDN 023 Pandau Jaya]. Pendas: Jurnal Ilmiah Pendidikan Dasar, 10(4), 230–242. https://doi.org/10.23969/jp.v10i04.36163

Alanoglu, M. (2022). The role of instructional leadership in increasing teacher self-efficacy: A meta-analytic review. Asia Pacific Education Review, 23, 233–244. https://doi.org/10.1007/s12564-021-09726-5

Ardliana, B., Rusdarti, R., & Suminar, T. (2021). Effect of principal leadership, school culture and pedagogic competence through work motivation on teachers performance. Educational Management, 10(2), 273–283.

Creswell, J. W., & Creswell, J. D. (2018). Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.). SAGE Publications.

Hallinger, P. (2011). Leadership for learning: Lessons from 40 years of empirical research. Journal of Educational Administration, 49(2), 125–142. https://doi.org/10.1108/09578231111116699

Hanik, H., Nuphanudin, N., Khamidi, A., Roesminingsih, E., Kristanto, A., Trihantoyo, S., & Haq, M. S. (2025). Kepala sekolah sebagai instructional leader: Penguatan kompetensi pedagogik guru untuk pembelajaran mendalam di sekolah dasar [The

principal as instructional leader: Strengthening teachers' pedagogical competence for deep learning in elementary schools]. Didaktika, 5(3). https://doi.org/10.17509/didaktika.v5i3.93269

Hidayat, R., & Patras, Y. E. (2022). The effect of principals' leadership and learning organization on teachers' innovative work behavior during the COVID-19 pandemic. Tadris: Jurnal Keguruan dan Ilmu Tarbiyah, 7(1), 161–175. https://doi.org/10.24042/tadris.v7i1.11355

Hossain, M. F., Uddin, M. S., Rana, M. S., & Siddique, M. N.-E.-A. (2026). A systematic literature review of servant leadership in education. Journal of Ethnic and Cultural Studies, 13(1), 1–28. https://doi.org/10.29333/ejecs/2562

Imawati, Maryani, I., & Zuhaery, M. (2025). School culture in fostering teachers' work motivation. JMKSP (Jurnal Manajemen, Kepemimpinan, dan Supervisi Pendidikan), 10(1), 778–801. https://doi.org/10.31851/jmksp.v10i1.19207

Kemendikbudristek. (2023). Panduan implementasi Kurikulum Merdeka. Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi.

Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven strong claims about successful school leadership revisited. School Leadership & Management, 40(1), 5–22. https://doi.org/10.1080/13632434.2019.1596077

Leithwood, K., & Jantzi, D. (2000). The effects of transformational leadership on organizational conditions and student engagement with school. Journal of Educational Administration, 38(2), 112–129. https://doi.org/10.1108/09578230010320064

Leithwood, K., & Jantzi, D. (2006). Transformational school leadership for large-scale reform: Effects on students, teachers, and their classroom practices. School Effectiveness and School Improvement, 17(2), 201–227. https://doi.org/10.1080/09243450600565829

Nurhadidjah, A., Rusti, E. R., & Hidayat, Z. (2023). Hubungan gaya kepemimpinan transformasional kepala sekolah dan budaya organisasi sekolah dengan kepuasan kerja guru SD di Kecamatan Cidahu [The relationship of principals' transformational leadership style and school organizational culture with elementary teachers' job satisfaction in Cidahu District]. Journal of Contemporary Issue in Elementary Education, 1(1), 62–71. https://doi.org/10.33830/jciee.v1i1.5111

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal of Applied Psychology, 88(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Robinson, V. M. J., Lloyd, C. A., & Rowe, K. J. (2008). The impact of leadership on student outcomes: An analysis of the differential effects of leadership types. Educational Administration Quarterly, 44(5), 635–674. https://doi.org/10.1177/0013161X08321509

Ryu, J., Walls, J., & Seashore Louis, K. (2022). Caring leadership: The role of principals in producing caring school cultures. Leadership and Policy in Schools, 21(3), 585–602. https://doi.org/10.1080/15700763.2020.1811877

Sariakin, S., Yeni, M., Usman, M. B., Mare, A. S., Munzir, M., & Saleh, M. (2025). Fostering a productive educational environment: The roles of leadership, management practices, and teacher motivation. Frontiers in Education, 10, Article 1499064. https://doi.org/10.3389/feduc.2025.1499064

Starlinsky, L., Belawati, T., & Rosita, T. (2022). Korelasi antara kepemimpinan kepala sekolah dan supervisi akademik terhadap kinerja guru sekolah dasar di Kecamatan Lebakgedong Kabupaten Lebak [The correlation of principal leadership and academic supervision with elementary teacher performance in Lebakgedong District, Lebak Regency]. Indonesian Journal of Educational Counseling, 6(1), 26–33. https://doi.org/10.30653/001.202261.190

Timan, A., Mustiningsih, M., & Imron, A. (2022). Digital leadership kepala sekolah hubungannya dengan kinerja guru dan kompetensi siswa era abad 21 [Principals' digital leadership and its relationship with teacher performance and student competence in the 21st century]. Jurnal Administrasi dan Manajemen Pendidikan, 5(4).

Turrohmah, H., & Suryanto, S. (2023). Teacher readiness for digital transformation. Jurnal Educatio: Jurnal Pendidikan Indonesia.

ICISFS-UMK 2026 EDUCATIONAL TECHNOLOGY & MEDIA

Development of Batik-Themed Media on Animal Generative Reproduction to Improve Student Learning Outcomes

Abdul Majid[1*], Slamet Utomo[1] and Khamdun[1]

[1]*Muria Kudus University, Indonesia*

ABSTRACT

This study aimed (1) to analyze teacher and student needs for the development of Bakaran Batik learning media; (2) to develop Bakaran Batik learning media; (3) to determine the feasibility of Bakaran Batik learning media; (4) to measure the effectiveness of Bakaran Batik learning media. The study used the research and development (R&D) method, following Sugiyono's steps up to the ninth step: (1) potential and problems, (2) data collection, (3) product design, (4) design validation, (5) design revision, (6) product trial, (7) product revision, (8) usage trial, and (9) product revision. The tenth step, mass production, was not carried out. The results indicate that (1) Bakaran Batik learning media can attract students' curiosity and is needed for teaching generative animal reproduction in grade IV of elementary school; (2) Bakaran Batik learning media is suitable for use: the material expert assessment scored 3.25 (good), the media expert validation 4.52 (very good), and the practitioner assessment 3.67 (very good). The teacher response was 89.29% (good) and the student response 93.75% (very good); (3) the Batik Bakaran learning media increased pretest-posttest scores, with moderate n-gain scores in two limited trials.

KEYWORDS learning media development | Bakaran batik | animal generative reproduction

INTRODUCTION

Observations of teachers and interviews with teachers and fourth-grade students in two elementary schools, including SDN Karanglegi 01, Trangkil District, in the first week of July 2025 showed that the science topic "Generative Reproduction" for grade IV was taught only through reading material, which made it less interesting for students. Students appeared passive, and learning was not student-centered. Teachers made limited use of varied methods, models, and learning media. Teachers used videos downloaded from the internet, but some students were inattentive while the videos played because the media did not involve them actively. This affected students' cognitive scores: some students had not reached the KKM (Minimum Completion Criteria) of 75, and the average completion rate was 55%.

One way to address this problem is to develop learning media that involve students actively. Learning media serve several functions in carrying the learning message to students (Aghni, 2018), and their role in improving learning outcomes is widely discussed in Indonesian education (Audie, 2019). Interactive media have shown positive effects in meta-analysis. Across 15 Indonesian experimental studies, interactive multimedia had a mean effect size of 1.146 on learning outcomes, with the highest estimate at elementary level (Khaeruman et al., 2023). Media of this kind have also been developed for elementary science and for madrasah ibtidaiyah students, for example a gamification-oriented medium on energy sources for grade 4 (Purniasih et al., 2020) and Articulate Storyline as interactive media (Juhaeni et al., 2021).

Learning media can also draw on local culture, which lets students meet new content through objects they already recognize and helps preserve that culture. A systematic review of 47 Indonesian studies identified five ways of using local wisdom in learning, including integration into teaching materials and media. It reported gains in conceptual understanding, literacy, critical thinking, and character, but most of the evidence came from development and short-term descriptive studies (Jovanda et al., 2026). Batik in particular has been used as a learning context. Yogyakarta batik motifs contain geometric concepts and cultural values that can serve as a context for learning geometry (Prahmana & D'Ambrosio, 2020), and a Javanese-batik worksheet on symmetry for

fifth graders was rated highly feasible and produced a moderate gain in mathematical literacy, with an N-gain of 0.58 (Katon & Sukmawarti, 2026).

Batik Bakaran is the traditional batik of Bakaran village in Juwana, Pati Regency, close to the study schools in Trangkil District. Existing batik-based learning studies concern mathematics, and we found no learning media that use Batik Bakaran, or batik more generally, to teach science content such as generative reproduction in animals. Learning that uses local culture can also prepare students for the Industrial Revolution 4.0 era, which they will enter after graduation, by accustoming them to preserving local culture and using it in their future work. This study therefore develops Batik Bakaran media for this topic and tests whether they are feasible, practical, and associated with better learning outcomes.

LITERATURE REVIEW

This research and development study aims to produce a product featuring *Batik Bakaran* from Pati Regency, focused on the topic of animal reproduction for fourth-grade elementary school students. Preliminary observations and interviews showed that teachers relied only on reading materials for this topic. The *Batik Bakaran* resource is intended to give students enjoyable and varied learning experiences and so improve their understanding of animal reproduction. The design draws on the cognitive theory of multimedia learning, which treats learning as building understanding from words and pictures (Mayer, 2014). In the media, content on generative reproduction is presented on a cultural object that students recognize. Students handle the media directly, so the media are meant to support active rather than passive learning, the weakness identified in the preliminary observations.

Research Objectives

This study aims to develop and test an instructional product that meets practical needs and incorporates local content. Specifically, it (a) analyzes teachers' and students' needs for "Batik Bakaran" learning media on generative reproduction in Grade 4 of elementary school, (b) develops valid and suitable "Batik Bakaran" learning media for this topic, and (c) measures the effectiveness of the media in improving students' understanding of generative reproduction at the Grade 4 level.

RESEARCH METHOD

Research Design

This study used a Research and Development (R&D) approach to develop *Batik Bakaran*-themed instructional media for improving fourth-grade elementary students' understanding of animal reproduction. R&D is a method for researching, designing, producing, and validating an educational product (Gall et al., 2007; Sugiyono, 2016). Sugiyono (2016) describes ten steps: (1) identifying potential and problems, (2) data collection, (3) product design, (4) design validation, (5) design revision, (6) product testing, (7) product revision, (8) usage trial, (9) product revision, and (10) mass production. This study carried out the first nine steps.

Respondents of the Study

The data for this study comprise two elements: an analysis of the needs for *Batik Bakaran* instructional media, and an assessment of the media's effectiveness in teaching the topic of animal reproduction to fourth-grade elementary school students. The data sources include fourth-grade students from State Elementary School Karanglegi 02, teachers, and experts.

RESULTS

Based on observations and interviews conducted at SDN Karanglegi 01, Batik Bakaran media are needed to support the learning process and increase student engagement and motivation. Teachers conveyed learning objectives fairly well and delivered the material clearly, but it was unclear whether the material matched the objectives because teachers sometimes forgot to state them. Teachers used learning media during lessons, but with little variety: mostly images and videos from the internet. Teachers could operate the media, though not optimally, and some lacked technological skills and therefore used only images. The media did not engage students actively because only the teacher used them to explain; students did not use them directly.

Students answered questions readily, although not always correctly; when the teacher posed questions to the class, students answered together, sometimes inaccurately. Students listened attentively to the teacher's explanations and appeared more engaged when the teacher used media, even when the media did not involve them actively.

The teacher reported having taught animal generative reproduction using only images and videos, never Batik Bakaran media. The teacher also admitted that the material on animal generative reproduction is quite difficult for students to understand, especially if students are reluctant to read books. Teachers often used learning media, usually technology-based and sourced from the internet, but rarely developed their own; teachers who were less proficient with technology used only images. The teacher reported that students were very enthusiastic in lessons that used media, and that Batik Bakaran media was entirely new to them: they had never seen, used, or heard of it.

Student interviews showed that students had studied animal generative reproduction with images and videos only and had never used Batik Bakaran as a learning medium. For students, the material on animal generative reproduction was quite difficult to understand because it required comprehension. According to students, the media used in class were usually technology-based and taken from the internet rather than created by the teacher. Students were more interested when teachers used learning media because it made learning less boring.

These observations and interviews indicate a need for Batik Bakaran media to support the learning process and increase student engagement and motivation. Such media can also help teachers deliver material on animal generative reproduction.

The developed media were then validated and tried out. Feasibility: the material expert rated the media 3.25 (good), the media expert 4.52 (very good), and the practitioner 3.67 (very good). Practicality: the teacher response was 89.29% (good) and the student response 93.75% (very good). Effectiveness: in two limited trials, students' scores increased from pretest to posttest, with mean n-gain scores of 0.4667 in trial 1 and 0.4627 in trial 2, both in the moderate category.

DISCUSSION

The needs analysis showed that generative reproduction in animals was taught mainly through reading, and that the images and videos teachers used were handled only by the teacher. Students listened but did not work with the media, and the average completion rate was 55% against a KKM of 75. The problem was therefore not a lack of media but the passive way media were used. A medium that students hold and examine themselves addresses that directly. This reading of the needs is consistent with a study in Surakarta, where cardboard wayang media that second graders handled increased their participation and concrete understanding and were cheap to produce (Sabrina et al., 2026). Needs analysis has also guided the design of Android-based media to meet students' need for multiple representations (Setiawan et al., 2021). Local wisdom research reports similar patterns of value integration into teaching materials and media (Jovanda et al., 2026), so Batik Bakaran media fit an established approach.

The experts rated the media feasible: 3.25 from the material expert, 4.52 from the media expert, and 3.67 from the practitioner. The material score was the lowest, which suggests that the scientific content needs more revision than the visual design. The categories are hard to compare, because 3.67 is labelled very good while 3.25 is only good, and 4.52 appears to come from a five-point rather than a four-point scale. Similar products for grade

4 received comparable ratings: a geoboard for plane figures was rated 90% by the material expert and 88% by the media expert (Aflia et al., 2020), and a Javanese-batik worksheet was rated highly feasible (Katon & Sukmawarti, 2026). A coefficient such as Aiken's V would show how far the experts agreed and whether the ratings are reliable (Aiken, 1985).

Students rated the media more practical (93.75%) than the teacher did (89.29%). This fits the interview finding that students were enthusiastic in lessons with media and had never seen Batik Bakaran used in class. Novelty may account for part of the high student rating, and it may fade with repeated use. High practicality ratings from students are common in elementary media studies; first graders rated Canva-based collage media 98% practical (Septiani & Setiawan, 2024), and Wordwall science media for grade 4 were judged very feasible, with improved motivation reported (Wapuah et al., 2025). The teacher's slightly lower rating may reflect the extra preparation the media require, but the paper does not report the item scores that would show this.

Learning outcomes rose in both limited trials, with n-gain scores of 0.4667 and 0.4627, both moderate. The two trials gave almost the same gain, which suggests the result is stable across groups. The gains are close to the 0.48 average Hake (1998) reported for interactive-engagement courses, and somewhat lower than the 0.58 for a batik-based mathematics worksheet (Katon & Sukmawarti, 2026) and the 0.61 for a contextual electronic worksheet (Sakinah et al., 2023). One plausible mechanism is that the media present the topic in words and pictures on a familiar local object, which students can examine themselves (Mayer, 2014). The trials, however, had no comparison group. A quasi-experiment with ethnomathematics media in Banten did compare against conventional teaching and found significantly higher learning outcomes (Krisdiana et al., 2024), and a similar design is needed before Batik Bakaran media can be called effective.

The media also carry a cultural aim that the study did not test. Batik motifs hold cultural and philosophical values as well as mathematical patterns (Prahmana & D'Ambrosio, 2020), and the Introduction argued that using Batik Bakaran in class could accustom students to preserving local culture. The study measured learning outcomes on generative reproduction only, not students' knowledge of or attitudes toward Batik Bakaran. Whether the media strengthen students' connection to their local culture therefore remains an open question, and a short questionnaire or interview after the trials could address it.

For teachers at SDN Karanglegi and other schools in Trangkil District, the results suggest a practical change. Students can handle the media themselves, so teachers can move from showing internet videos to letting students examine and discuss the media in groups. The media are easy to procure and durable, so schools can make them part of their own teaching resources. The local teacher working group could share the media and adapt the approach to other science topics, and the district education office could support collaboration with Batik Bakaran artisans as part of local content learning.

This study has several limitations. The effectiveness data come from limited trials without a control group, so the gains cannot be separated from the effects of testing or of ordinary teaching (Shadish et al., 2002). The number of students in each trial and the number of validators are not reported, and the study site is described as SDN Karanglegi 01 in some sections and SDN Karanglegi 02 in another. The rating scales and category cut-offs differ across validators, and the validity and reliability of the learning outcome test are not reported. The gains were measured immediately after use, so retention is unknown. Future research should compare Batik Bakaran media with ordinary teaching in several Pati schools, report results by item and by learning objective, and examine whether the media also strengthen students' knowledge of and attitudes toward local culture.

CONCLUSION AND RECOMMENDATIONS

The Bakaran Batik learning media attracts students and is needed for teaching animal generative reproduction in grade IV of elementary school. The media is suitable for use. In limited trials, pretest-posttest scores increased, as measured by n-gain. Trial 1 obtained an average n-Gain score of 0.4667 with a moderate category, trial 2 obtained an average n-Gain score of 0.4627 with a moderate category. These results suggest that Bakaran Batik learning media may help improve the learning outcomes of grade IV elementary school students. The media are easy to procure and durable. Teachers are encouraged to keep developing their own learning media.

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REFERENCES

Aflia, K., Yuhana, Y., & Alamsyah, T. (2020). Pengembangan media pembelajaran geoboard untuk kemampuan pemahaman matematis siswa sekolah dasar [Development of geoboard learning media for elementary students' mathematical understanding]. Primary: Jurnal Pendidikan Guru Sekolah Dasar, 9(5), 680–689. https://doi.org/10.33578/jpfkip.v9i5.8028

Aghni, R. I. (2018). Functions and types of learning media in accounting learning. Indonesian Journal of Accounting Education, 16(1), 98–107.

Aiken, L. R. (1985). Three coefficients for analyzing the reliability and validity of ratings. Educational and Psychological Measurement, 45(1), 131–142. https://doi.org/10.1177/0013164485451012

Audie, N. (2019). The role of learning media in improving student learning outcomes. Proceedings of the National Seminar on Education, Faculty of Teacher Training and Education, 2(1), 586–595.

Gall, M. D., Gall, J. P., & Borg, W. R. (2007). Educational research: An introduction (8th ed.). Pearson.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. American Journal of Physics, 66(1), 64–74. https://doi.org/10.1119/1.18809

Jovanda, R., Paais, R. L., Manafe, M. P., Sundari, L., Dewi, A. R., Ohodo, M. M. R., Chasanah, I. A. W., Pratama, A. H., & Waluyo, H. (2026). Local wisdom-based learning approaches for strengthening students' conceptual understanding and character in Indonesia: A systematic literature review [Version 1; peer review: 1 approved with reservations]. F1000Research, 15, Article 1384. https://doi.org/10.12688/f1000research.188148.1

Juhaeni, J., Safaruddin, S., & Salsabila, Z. P. (2021). Articulate Storyline sebagai media pembelajaran interaktif untuk peserta didik madrasah ibtidaiyah [Articulate Storyline as interactive learning media for madrasah ibtidaiyah students]. AULADUNA: Jurnal Pendidikan Dasar Islam, 8(2), 150–159. https://doi.org/10.24252/auladuna.v8i2a3.2021

Katon, A. S., & Sukmawarti. (2026). Pengembangan lembar kerja peserta didik etnomatematika batik Jawa untuk meningkatkan literasi matematika siswa SD [Development of a Javanese batik ethnomathematics student worksheet to improve elementary students' mathematical literacy]. Pendas: Jurnal Ilmiah Pendidikan Dasar, 11(2), 228–240. https://doi.org/10.23969/jp.v11i02.50402

Khaeruman, K., Sudiatmika, A. R., Suma, I. K., & Suardana, I. N. (2023). Meta-analisis: Efektivitas multimedia interaktif terhadap peningkatkan hasil belajar siswa [Meta-analysis: The effectiveness of interactive multimedia in improving student learning outcomes]. Bioscientist: Jurnal Ilmiah Biologi, 11(2), 1630–1639. https://doi.org/10.33394/bioscientist.v11i2.9497

Krisdiana, M., Pujiastuti, H., & Rosmilawati, I. (2024). Pengaruh pembelajaran etnomatematika terhadap hasil belajar matematika siswa kelas VI sekolah dasar [The effect of ethnomathematics learning on the mathematics learning outcomes of grade VI elementary students]. Ideguru: Jurnal Karya Ilmiah Guru, 9(3), 2020–2029. https://doi.org/10.51169/ideguru.v9i3.1286

Mayer, R. E. (2014). Introduction to multimedia learning. In R. E. Mayer (Ed.), The Cambridge handbook of multimedia learning (2nd ed., pp. 1–24). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369.002

Prahmana, R. C. I., & D'Ambrosio, U. (2020). Learning geometry and values from patterns: Ethnomathematics on the batik patterns of Yogyakarta, Indonesia. Journal on Mathematics Education, 11(3), 439–456.

https://doi.org/10.22342/jme.11.3.12949.439-456

Purniasih, N. K. D., Darmawiguna, I. G. M., & Agustini, K. (2020). Development of gamification-oriented energy source learning media for grade 4 students of North Bali Bilingual School. Journal of Technology and Vocational Education, 17(1), 1–10.

Sabrina, S., Prihastari, E. B., & Mustofa, M. (2026). Analisis pemanfaatan media pembelajaran wayang kardus terhadap kreativitas peserta didik pada materi pewayangan kelas 2 SDN Kleco 1 Surakarta [Analysis of the use of cardboard wayang learning media on students' creativity in grade 2 at SDN Kleco 1 Surakarta]. Pendas: Jurnal Ilmiah Pendidikan Dasar, 11(1), 20–29. https://doi.org/10.23969/jp.v11i01.43053

Sakinah, S., Dewi, R. S., & Hakim, Z. R. (2023). Development of contextual-based E-LKPD to improve the ability to understand fraction concepts. EduBasic Journal: Jurnal Pendidikan Dasar, 5(1), 71–82. https://doi.org/10.17509/ebj.v5i1.51576

Septiani, A. A., & Setiawan, D. (2024). Developing Canva-based Sitekol on collage topic for first-grade public elementary school students. Journal of Integrated Elementary Education, 4(2). https://doi.org/10.21580/jieed.v4i2.21977

Setiawan, N. C. E., Sulistina, O., Habiddin, H., & Pavita, R. (2021). Development of Android-based learning media to facilitate multiple representation learning needs. Hydrogen: Jurnal Kependidikan Kimia, 9(1), 38–48. https://doi.org/10.33394/hjkk.v9i1.3801

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). Experimental and quasi-experimental designs for generalized causal inference. Houghton Mifflin.

Sugiyono. (2016). Metode penelitian kuantitatif, kualitatif, dan R&D [Quantitative, qualitative, and R&D research methods]. Alfabeta.

Wapuah, Hartono, & Prasetyo, D. (2025). Development of interactive learning media based on Wordwall in science learning at elementary school. Jurnal Teknologi Pendidikan: Jurnal Penelitian dan Pengembangan Pembelajaran, 10(4), 746–757. https://doi.org/10.33394/jtp.v10i4.18208

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

Academic Supervision and Transformational Leadership on Teacher Performance

Sunarto[1*], **Ahmad Hariyadi**[1] **and Sri Utaminingsih**[1]

[1]*Universitas Muria Kudus, Indonesia*

ABSTRACT

Teacher performance is a key determinant of educational quality and student learning outcomes. However, many primary school teachers still struggle to improve their instructional effectiveness, partly because of limited academic supervision and weak school leadership. This study examined the effects of academic supervision and transformational leadership on teacher performance in public primary schools in Gabus District, Pati Regency, Indonesia. A quantitative explanatory design was used. Data were collected with a structured questionnaire from primary school teachers selected by proportionate stratified random sampling. The research variables included academic supervision and transformational leadership as independent variables and teacher performance as the dependent variable. Data were analyzed using Structural Equation Modeling–Partial Least Squares (SEM-PLS) to evaluate both the measurement and structural models. The findings showed that academic supervision had a positive and significant effect on teacher performance, which may operate through teachers' pedagogical competence, instructional planning, classroom management, and professional development. Transformational leadership also had a positive and significant effect, possibly by motivating teachers, encouraging innovation, strengthening organizational commitment, and creating a supportive school climate. Together, the two variables explained a substantial share of the variance in teacher performance. These findings suggest that strengthening principals' supervisory practices and transformational leadership capacities may support teacher professional development and the quality of primary education. The study provides empirical evidence that academic supervision and transformational leadership are both associated with higher teacher performance in Indonesian primary schools.

KEYWORDS academic supervision | primary school | teacher performance | transformational leadership

INTRODUCTION

Teacher performance is a major determinant of educational quality and student learning outcomes. High-performing teachers are better able to design meaningful learning experiences, use effective instructional strategies, and conduct authentic assessments that support students' cognitive, affective, and psychomotor development (Darling-Hammond et al., 2017). In educational reform, particularly in developing countries, improving teacher performance has become a policy priority, because curriculum implementation depends largely on teachers' professional competence and instructional effectiveness (OECD, 2020).

In Indonesia, the Merdeka Curriculum has raised expectations that teachers be innovative, adaptive, and student-centered. Teachers are expected to master subject content, integrate technology, apply differentiated instruction, and keep developing their professional competencies. However, studies of its implementation report that primary school teachers still struggle with new curriculum concepts, teaching modules and assessment, and that teachers' competence in technology-based learning is uneven (Asmahasanah et al., 2023; Afrillia & Dafit, 2025). Teachers in these studies coped through training, webinars and peer discussion, which points to the role of school-level support. These difficulties suggest that teacher performance depends on organizational and managerial factors within schools as well as on individual competence.

Among organizational factors, academic supervision is a key mechanism for developing teacher professionalism. Academic supervision is a systematic process through which school principals provide guidance, monitoring, constructive feedback, and professional assistance to improve instructional practices (Glickman, Gordon, & Ross-Gordon, 2018). Effective supervision encourages teachers to reflect on their teaching, identify weaknesses, and improve the quality of their instruction. Supervision of this kind is expected to strengthen teachers' pedagogical competence and instructional quality (Sergiovanni & Starratt, 2014). Evidence on a closely

related practice supports this expectation: a meta-analysis of 60 causal studies found that teacher coaching improved instruction by 0.49 SD and student achievement by 0.18 SD (Kraft et al., 2018). In Indonesia, academic supervision and principal leadership were each positively related to the performance of 64 primary school teachers in Lebak Regency (Starlinsky et al., 2022), and principals' supervision and continuous professional development helped primary teachers in Jombang apply deep learning under the Merdeka Curriculum (Hanik et al., 2025).

Another important determinant of teacher performance is transformational leadership. Transformational leaders inspire teachers by articulating a shared vision, encouraging innovation, providing individualized support, and building collaborative school cultures (Bass & Riggio, 2006). In educational settings, transformational leadership has been associated with increased teacher motivation, organizational commitment, professional collaboration, and instructional improvement (Leithwood et al., 2020). A review of 32 studies found that these effects run mainly through school culture, teacher commitment and job satisfaction (Leithwood & Jantzi, 2005), and a meta-analysis of 65 studies in Asia reported positive effects of transformational leadership on teachers' job satisfaction, organizational commitment and self-efficacy (Firmansyah et al., 2022). Meta-analytic evidence also suggests that instructional leadership, which includes the supervision of teaching, has larger effects on student outcomes than transformational leadership (Robinson et al., 2008). This is one reason to study the two practices together. Principals who adopt these practices tend to create supportive environments in which teachers can reach higher levels of performance and professional growth.

Although many studies have examined the effects of academic supervision and transformational leadership on teacher performance separately, few have tested both within one structural model, particularly in Indonesian public primary schools. Indonesian studies of teacher performance have mostly used small samples and correlation, chi-square or path analysis: 37 teachers in three primary schools in Riau (Kamalia et al., 2022), 64 teachers in Lebak (Starlinsky et al., 2022) and 114 teachers in eight senior high schools in Pati Regency (Ardliana et al., 2021). PLS-SEM studies in Jakarta and Aceh Besar examined instructional, distributed or general principal leadership rather than academic supervision and transformational leadership (Amzat et al., 2022; Sariakin et al., 2025). In addition, few studies have used Structural Equation Modeling–Partial Least Squares (SEM-PLS) to analyze the joint effects of instructional supervision and transformational leadership on teacher performance at the primary level.

This study addresses these gaps by examining the direct effects of academic supervision and transformational leadership on teacher performance among public primary school teachers in Gabus District, Pati Regency, Indonesia. Using SEM-PLS, the study estimates how far these supervisory and leadership practices account for differences in teacher performance. Two questions guide the study: does academic supervision predict teacher performance, and does transformational leadership predict teacher performance when both are estimated in the same model? The findings are expected to add to the literature on educational leadership and instructional supervision and to inform policymakers and school principals who design strategies to improve teacher professionalism and educational quality.

LITERATURE REVIEW

Teacher performance refers to how well teachers carry out their professional responsibilities, including instructional planning, classroom management, assessment, and continuous professional development. Previous studies have shown that teacher performance is influenced by both instructional management and school leadership practices (Hallinger, 2011; Leithwood et al., 2020). Accordingly, this study treats academic supervision and transformational leadership as two organizational factors that contribute to teacher performance.

Academic supervision is a systematic process in which school principals help teachers improve instructional quality through classroom observation, constructive feedback, mentoring, and professional coaching (Glickman, Gordon, & Ross-Gordon, 2018). Effective academic supervision enables teachers to identify instructional weaknesses, improve pedagogical competence, and implement more effective learning strategies. Teachers who receive regular, constructive supervision are therefore expected to perform better.

Transformational leadership reflects the ability of school principals to inspire, motivate, and empower teachers to achieve organizational goals. According to Bass and Riggio (2006), transformational leadership consists of four dimensions: idealized influence, inspirational motivation, intellectual stimulation, and individualized consideration. Principals who practise transformational leadership encourage innovation, strengthen teachers' commitment, promote collaboration, and create supportive working environments.

Based on organizational leadership theory and instructional supervision theory, this study assumes that academic supervision directly improves teacher performance by strengthening teachers' instructional competence. Likewise, transformational leadership is assumed to influence teacher performance directly by building motivation, innovation, and organizational commitment. Because the two practices overlap in principals' daily work, they are examined together in one model. This study therefore proposes two direct hypotheses (research model in Figure 1): (H1) Academic supervision positively influences teacher performance, and (H2) Transformational leadership positively influences teacher performance.

Research Objectives

This study aims to examine the influence of academic supervision and transformational leadership on teacher performance in public primary schools in Gabus District, Pati Regency, Indonesia. Specifically, the objectives of this study are:

1. To analyze the effect of academic supervision on teacher performance.
2. To examine the effect of transformational leadership on teacher performance.
3. To determine the contribution of academic supervision and transformational leadership to teacher performance.
4. To provide empirical evidence on the role of instructional supervision and transformational leadership in teacher professionalism and the quality of primary education.

RESEARCH METHOD

Research Design

This study employed a quantitative research design using an explanatory approach to examine the relationships between academic supervision, transformational leadership, and teacher performance. The explanatory design was selected because it allows hypothesized relationships among variables, derived from established theory and prior evidence, to be tested (Creswell & Creswell, 2018). The study was conducted in public primary schools located in Gabus District, Pati Regency, Central Java, Indonesia.

The target population comprised all teachers working in public primary schools within the district. The sample was selected using proportionate stratified random sampling so that each school was represented in proportion to its number of teachers. Data were collected through a structured questionnaire using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire measured three constructs: academic supervision, transformational leadership, and teacher performance. The indicators of academic supervision included supervision planning, classroom observation, feedback, and follow-up activities. Transformational leadership was measured through idealized influence, inspirational motivation, intellectual stimulation, and individualized consideration. Teacher performance was assessed through instructional planning, instructional implementation, learning assessment, and professional responsibilities.

The data were analyzed using Structural Equation Modeling–Partial Least Squares (SEM-PLS). The analysis had two stages. First, the measurement model (outer model) was evaluated for indicator reliability, internal consistency reliability, convergent validity, and discriminant validity. Second, the structural model (inner model) was evaluated through path coefficient analysis, coefficient of determination (R^2), effect size (f^2), predictive relevance (Q^2), and hypothesis testing with the bootstrapping procedure. Statistical significance was determined at a 95% confidence level (Hair, Hult, Ringle, & Sarstedt, 2022).

Respondents of the Study

The respondents of this study were teachers from public primary schools in Gabus District, Grobogan Regency, Central Java, Indonesia. The target population consisted of 343 teachers from 43 public primary schools. These teachers were chosen because they were directly involved in teaching and experienced the academic supervision and transformational leadership of their principals.

A proportionate stratified random sampling technique was employed to ensure proportional representation of teachers from each school. This method was appropriate because the number of teachers varied across schools; it let each school contribute respondents in proportion to its share of the population. Based on the Krejcie and Morgan (1970) sampling table, a total of 185 teachers were selected as the research sample. The selected respondents represented approximately 53.9% of the total population, which is generally considered adequate for Structural Equation Modeling–Partial Least Squares (SEM-PLS) analysis. The distribution of the study population and sample is presented in Table 1.

Table 1. Population and sample of the study

Description	Number
Public Primary Schools	43
Population (Teachers)	343
Sampling Technique	Proportionate Stratified Random Sampling
Sample Size	185
Percentage of Population	53,9%
Data Collection Instrument	Structured Questionnaire
Measurement Scale	Five-point Likert Scale

The respondents completed a structured questionnaire consisting of three constructs: Academic Supervision, Transformational Leadership, and Teacher Performance. Responses were measured using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The data were then analyzed using SEM-PLS to examine the relationships among the research variables.

RESULTS

This section presents the findings from the data collected from 185 public primary school teachers in Gabus District, Pati Regency. The results are presented sequentially, beginning with a descriptive overview, followed by the structural model results (coefficient of determination and hypothesis tests) from Structural Equation Modeling–Partial Least Squares (SEM-PLS). The discussion interprets the findings by relating them to previous empirical studies and relevant educational leadership theories.

Descriptive Analysis

The descriptive analysis showed that respondents rated academic supervision, transformational leadership, and teacher performance relatively highly. These ratings suggest that teachers perceive their principals' supervisory and transformational leadership practices positively.

Structural Model Evaluation

Table 2. Coefficient of determination (R^2)

Endogenous Variable	R^2	Interpretation
Teacher Performance	0.758	Strong

Source: Research Data Analysis (2026).

Table 2 shows that the coefficient of determination (R^2) for Teacher Performance is 0.758. This indicates that 75.8% of the variance in teacher performance is explained jointly by Academic Supervision and Transformational Leadership; the remaining 24.2% is attributable to variables outside the model. Under common PLS-SEM evaluation criteria, an R^2 value of 0.758 indicates strong explanatory power.

Hypothesis Testing

Table 3. Results of hypothesis testing

Hypothesis	Relationship	T-Statistics	P-Value	Decision
H1	Academic Supervision → Teacher Performance	17.978	0.000	Supported
H2	Transformational Leadership → Teacher Performance	10.391	0.000	Supported

Source: SmartPLS Bootstrapping Output.

The results in Table 3 indicate that Academic Supervision has a positive and statistically significant effect on Teacher Performance, with a t-statistic of 17.978 and a p-value of 0.000. Because the t-statistic exceeds the critical value of 1.96 and the p-value is below 0.05, Hypothesis 1 is accepted. This finding suggests that academic supervision may improve teachers' instructional competence and classroom management and, in turn, their professional performance.

Transformational Leadership also has a positive and significant effect on Teacher Performance, with a t-statistic of 10.391 and a p-value of 0.000, so Hypothesis 2 is also accepted. This result suggests that principals who inspire, motivate, and support teachers through transformational leadership practices help improve teachers' professional performance.

Overall, the findings indicate that both Academic Supervision and Transformational Leadership are significant predictors of teacher performance. The R^2 value (0.758) shows that the structural model has strong explanatory power. Improving principals' supervisory practices and transformational leadership may therefore be a useful strategy for enhancing teacher performance in public primary schools.

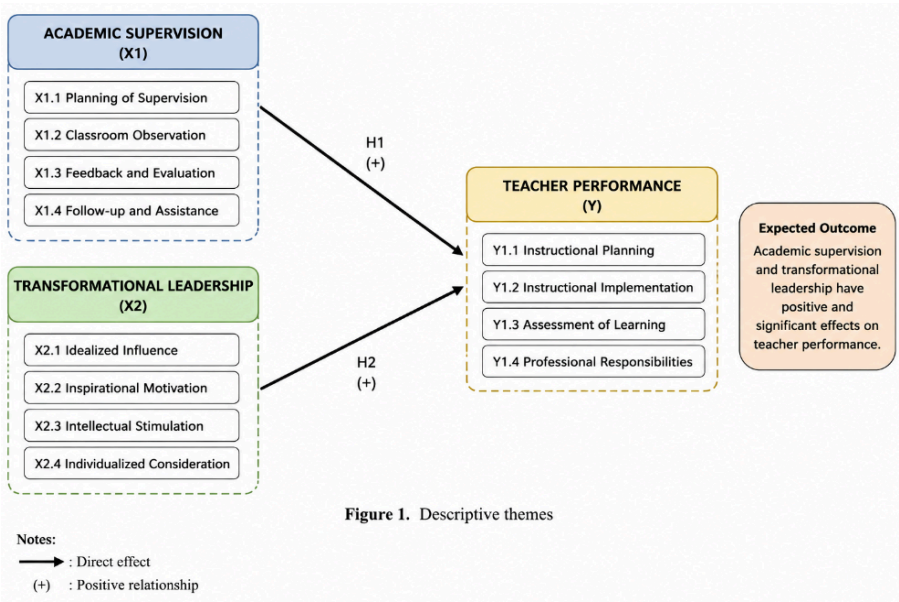

Figure 1. Research model

Figure 1 illustrates the conceptual model of the study, which examines the direct effects of Academic Supervision (X_1) and Transformational Leadership (X_2) on Teacher Performance (Y). Academic supervision is represented by four indicators, namely supervision planning, classroom observation, feedback and evaluation, and follow-up assistance. Transformational leadership and teacher performance are each represented by the four indicators listed under Research design, and the two arrows represent the two hypothesized direct paths.

DISCUSSION

Both hypotheses were supported. Academic supervision ($t = 17.978$, $p < .001$) and transformational leadership ($t = 10.391$, $p < .001$) were each positively related to teacher performance (Table 3), and together they accounted for 75.8% of its variance ($R^2 = 0.758$, Table 2). The t-statistics describe the precision of each estimate rather than its size. Because the path coefficients are not reported, this study cannot say which of the two practices is more strongly related to teacher performance.

The first finding is that teachers who reported more systematic academic supervision also reported higher performance. A plausible mechanism is the content of the supervision cycle itself. Planning, classroom observation, feedback and follow-up assistance give teachers specific information about the same tasks that the performance scale measures: lesson planning, delivery, assessment and professional duties. This pattern agrees with the meta-analysis by Kraft et al. (2018), in which observation-based coaching improved instruction, and with Starlinsky et al. (2022), who found a positive relationship between academic supervision and the performance of primary school teachers in Lebak Regency. It is also consistent with the multiple-case study of Hanik et al. (2025), in which supervision combined with continuous professional development helped primary teachers adopt new practices under the Merdeka Curriculum. The size of the association should be read with care. The supervision indicators and the performance indicators describe closely related classroom activities, and both were reported by the same teachers, which may have strengthened the relationship.

For principals in Gabus District, the practical message is that supervision should run as a full cycle rather than as an administrative check. A supervision visit that ends without feedback or follow-up assistance gives teachers little to act on. Principals could schedule observation cycles across the school year, agree on one or two improvement targets with each teacher, and return to check progress. Teachers can use the feedback when they prepare teaching modules and assessments for the Merdeka Curriculum, the areas where implementation studies report the most difficulty (Asmahasanah et al., 2023; Afrillia & Dafit, 2025).

The second finding is that transformational leadership was positively related to teacher performance. Principals who communicate a shared vision, encourage new ideas and attend to individual teachers may raise teachers' motivation and commitment, which in turn support effort in the classroom. This interpretation agrees with the Asian meta-analysis of Firmansyah et al. (2022) and with Sariakin et al. (2025), who reported a significant path from principal leadership to teacher performance among junior high school teachers in Aceh Besar. In Pati Regency, Ardliana et al. (2021) found that the effect of principal leadership on teacher performance ran partly through work motivation, and Novitasari (2020) found that transformational leadership raised job satisfaction, which in turn raised commitment. These studies suggest that the direct path estimated here may combine several indirect routes that this model does not separate. Leithwood and Jantzi (2006) add a caution: in English primary schools, transformational leadership changed teachers' motivation and classroom practices but not students' achievement gains. Higher teacher performance ratings therefore cannot be taken as evidence of better student learning.

The third observation concerns the two practices together. The joint R^2 of 0.758 is high for a model with two predictors. Robinson et al. (2008) found that leadership focused on teaching and teacher learning had larger effects on student outcomes than transformational leadership, and Hallinger (2011) describes leadership for learning as a combination of instructional focus and shared, motivating leadership. The present results fit this view, since both a teaching-focused practice and a motivational practice were related to performance. The high R^2 should nevertheless be interpreted with care. All three constructs were measured with one questionnaire completed by the same teachers at one time, a design that is open to common method variance (Podsakoff et al., 2003). For the education office and principal training programmes, the findings suggest that supervision skills and transformational leadership can be developed together, for example by linking supervision feedback to a shared school vision for learning.

This study has several limitations. First, the design is cross-sectional and correlational, so the results show associations, not causal effects. Second, the sample came from public primary schools in one district, and the

regency is reported inconsistently in the paper, which limits generalization. Third, teacher performance was self-reported. Ratings by principals, classroom observation records or official performance appraisal scores would give a more independent outcome measure. Fourth, several analyses described in the Methodology are not reported: descriptive statistics, measurement model results (outer loadings, composite reliability, AVE and discriminant validity), path coefficients, effect sizes (f^2) and predictive relevance (Q^2). Without them, the validity of the constructs and the relative strength of the two paths cannot be judged (Hair et al., 2022). Future research could use multi-source data, test mediators such as work motivation, job satisfaction and teacher self-efficacy, and compare schools of different sizes or districts with multi-group analysis.

CONCLUSION AND RECOMMENDATIONS

This study examined the effects of academic supervision and transformational leadership on teacher performance among public primary school teachers in Gabus District, Grobogan Regency, Indonesia. Based on the results of the SEM-PLS analysis, both hypotheses were supported. Academic supervision had a positive and significant effect on teacher performance. This suggests that systematic supervision practices (planning, classroom observation, constructive feedback, and follow-up assistance) help improve teachers' instructional competence and professional performance. Transformational leadership also had a positive and significant effect on teacher performance. Principals who inspire, motivate, encourage innovation, and provide individualized support appear to create a working environment that strengthens teachers' commitment and effectiveness.

The structural model also had strong explanatory power: academic supervision and transformational leadership jointly explained a substantial proportion of the variance in teacher performance. These findings indicate that strengthening instructional supervision and transformational leadership practices can contribute to teacher professionalism and educational quality in primary schools. The study also provides empirical support for integrating supervisory and leadership functions in school management.

Based on the findings, several recommendations are proposed. First, school principals should strengthen the implementation of academic supervision by conducting regular classroom observations, providing constructive feedback, and facilitating continuous professional development for teachers. Second, principals are encouraged to adopt transformational leadership practices by building collaboration, inspiring innovation, recognizing teachers' achievements, and promoting a supportive school climate. Third, education authorities should organize continuous leadership and supervision training programs to improve principals' managerial and instructional competencies. Finally, future research could extend the model with additional variables, such as organizational culture, teacher motivation, job satisfaction, digital leadership, or teacher self-efficacy. Larger samples from different educational levels and regions would also improve the generalizability of the findings.

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REFERENCES

Afrillia, A., & Dafit, F. (2025). Tantangan guru mengimplementasikan pembelajaran berbasis teknologi digital dalam Kurikulum Merdeka di UPT SDN 023 Pandau Jaya. Pendas: Jurnal Ilmiah Pendidikan Dasar, 10(4), 230–242. https://doi.org/10.23969/jp.v10i04.36163

Amzat, I. H., Yanti, P. G., & Suswandari, S. (2022). Estimating the effect of principal instructional and distributed leadership on professional development of teachers in Jakarta, Indonesia. SAGE Open, 12. https://doi.org/10.1177/21582440221109585

Ardliana, B., Rusdarti, R., & Suminar, T. (2021). Effect of principal leadership, school culture and pedagogic competence through work motivation on teachers performance. Educational Management, 10(2), 273–283.

Asmahasanah, S., Chairunnissa, I. C., & Hakim, N. (2023). Navigating Merdeka curriculum in first grade: Teacher challenges and strategies. Journal of Integrated Elementary Education, 3(2), 137–149. https://doi.org/10.21580/jieed.v3i2.17592

Bass, B. M., & Riggio, R. E. (2006). Transformational leadership (2nd ed.). Lawrence Erlbaum Associates.

Creswell, J. W., & Creswell, J. D. (2018). Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.). Sage.

Darling-Hammond, L., Burns, D., Campbell, C., Goodwin, A. L., Hammerness, K., Low, E.-L., McIntyre, A., Sato, M., & Zeichner, K. (2017). Empowered educators: How high-performing systems shape teaching quality around the world. Jossey-Bass.

Firmansyah, F., Prasojo, L. D., Jaedun, A., & Retnawati, H. (2022). Transformational leadership effect on teacher performance in Asia: A meta-analysis. Cypriot Journal of Educational Sciences, 17(6), 2127–2146. https://doi.org/10.18844/cjes.v17i6.7552

Glickman, C. D., Gordon, S. P., & Ross-Gordon, J. M. (2018). *SuperVision* and instructional leadership: A developmental approach (10th ed.). Pearson.

Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2022). A primer on partial least squares structural equation modeling *(PLS-SEM)* (3rd ed.). Sage.

Hallinger, P. (2011). Leadership for learning: Lessons from 40 years of empirical research. Journal of Educational Administration, 49(2), 125–142. https://doi.org/10.1108/09578231111116699

Hanik, H., Nuphanudin, N., Khamidi, A., Roesminingsih, E., Kristanto, A., Trihantoyo, S., & Haq, M. S. (2025). Kepala sekolah sebagai instructional leader: Penguatan kompetensi pedagogik guru untuk pembelajaran mendalam di sekolah dasar. Didaktika, 5(3). https://doi.org/10.17509/didaktika.v5i3.93269

Kamalia, Ayub, D., & Sumarno, S. (2022). The influence of principal leadership and teacher work discipline on elementary school teacher performance. Journal of Educational Sciences, 6(3), 444–458. https://doi.org/10.31258/jes.6.3.p.444-458

Kraft, M. A., Blazar, D., & Hogan, D. (2018). The effect of teacher coaching on instruction and achievement: A meta-analysis of the causal evidence. Review of Educational Research, 88(4), 547–588. https://doi.org/10.3102/0034654318759268

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. Educational and Psychological Measurement, 30, 607–610.

Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven strong claims about successful school leadership revisited. *School Leadership & Management*, *40*(1), 5–22. https://doi.org/10.1080/13632434.2019.1596077

Leithwood, K., & Jantzi, D. (2005). A review of transformational school leadership research 1996–2005. Leadership and Policy in Schools, 4(3), 177–199. https://doi.org/10.1080/15700760500244769

Leithwood, K., & Jantzi, D. (2006). Transformational school leadership for large-scale reform: Effects on students, teachers, and their classroom practices. School Effectiveness and School Improvement, 17(2), 201–227. https://doi.org/10.1080/09243450600565829

Novitasari, D. (2020). Improving job satisfaction and organizational commitment: Analysis of the effects of the principal transformational leadership. Dinamika Pendidikan, 15(2), 172–189. https://doi.org/10.15294/dp.v15i2.25111

OECD. (2020). PISA 2018 results (Volume V): Effective policies, successful schools. OECD Publishing. https://doi.org/10.1787/ca768d40-en

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal of Applied Psychology, 88(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Robinson, V. M. J., Lloyd, C. A., & Rowe, K. J. (2008). The impact of leadership on student outcomes: An analysis of the differential effects of leadership types. Educational Administration Quarterly, 44(5), 635–674. https://doi.org/10.1177/0013161X08321509

Sariakin, S., Yeni, M., Usman, M. B., Mare, A. S., Munzir, M., & Saleh, M. (2025). Fostering a productive educational environment: The roles of leadership, management practices, and teacher motivation. Frontiers in Education, 10, Article 1499064. https://doi.org/10.3389/feduc.2025.1499064

Sergiovanni, T. J., & Starratt, R. J. (2014). Supervision: A redefinition (9th ed.). McGraw-Hill.

Starlinsky, L., Belawati, T., & Rosita, T. (2022). Korelasi antara kepemimpinan kepala sekolah dan supervisi akademik terhadap kinerja guru sekolah dasar di Kecamatan Lebakgedong Kabupaten Lebak. Indonesian Journal of Educational Counseling, 6(1), 26–33. https://doi.org/10.30653/001.202261.190

ICISFS-UMK 2026 CURRICULUM, CULTURE & CHARACTER

The Relationship Between Integrated Religious Values Instruction, Teacher Communication, and Parents' Satisfaction in Public Elementary Schools

Yusuf F. Wicaksono[1*], Sri Utaminingsih[1] and Khamdun[1]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: yusuffajarw@gmail.com

ABSTRACT

This study examines the relationships among integrated religious values instruction, teacher communication, and parent satisfaction in public elementary schools. A quantitative correlational design was used, and the proposed relationships were tested with Structural Equation Modeling (SEM). Data were collected from 353 parents of students in public elementary schools through a Likert-scale questionnaire consisting of 68 items. The proposed model showed a good fit (CMIN/DF = 1.231, CFI = 0.977, RMSEA = 0.026) and was considered adequate for hypothesis testing. The findings showed that integrated religious values instruction had a positive and significant relationship with parent satisfaction (CR = 6.143, $p < 0.001$, standardized estimate = 0.326). Teacher communication also showed a positive and significant relationship with parent satisfaction (CR = 9.018, $p < 0.001$, standardized estimate = 0.494), and this relationship was stronger than that of integrated religious values instruction. The coefficient of determination ($R^2 = 0.55$) showed that the two independent variables together explained 55% of the variance in parent satisfaction. These findings suggest that integrating religious values into classroom instruction and strengthening teacher communication may raise parent satisfaction in public elementary schools.

KEYWORDS integrated religious values instruction | teacher communication | parent satisfaction | public elementary schools

INTRODUCTION

Educational quality has become a central concern for schools, as parents increasingly expect both high academic achievement and educational services that support students' character development. Parent satisfaction is a key indicator of educational service quality because it reflects parents' perceptions of whether schools meet their expectations and needs (Ningsih et al., 2018). Parents' satisfaction is also closely associated with the quality of educational services provided by schools, including learning processes, teacher performance, and school management (Lie et al., 2021). Beyond service quality, schools have made character education a priority, both to develop students' moral values and to improve institutional credibility (Mawardi et al., 2021). The implementation of character education also contributes to a more positive learning environment and supports the achievement of educational goals (Santi & Hasnadi, 2021). Schools that consistently integrate character values into daily learning activities are also better able to build positive relationships with students, parents, and the wider community (Hidayat et al., 2021). Improving educational quality therefore requires schools to provide both effective academic instruction and value-based education that responds to parents' expectations and strengthens public trust.

In Indonesia, character education is now part of the Merdeka Curriculum through the Pancasila student profile, which includes religious and moral values. In one elementary school in Surakarta, these values were instilled through daily habituation such as prayer, Qur'an reading and polite greetings, and teachers reported communication with parents as one of the obstacles (Suryaningsih & Desstya, 2023). Value-based instruction and communication with families are therefore closely linked in daily school practice. Parents are well placed to judge both: they see how their children behave at home, and they receive, or do not receive, information from teachers. Their satisfaction is therefore a useful indicator of how well schools combine the two.

Studies of parent satisfaction point to two groups of school factors. The first is the quality of learning services. Parents' satisfaction in elementary schools has been linked to education service quality (Ruwaidah et al.,

2023) and to service quality, school culture and school image (Triwijayanti et al., 2020). For many Indonesian families, these learning services include moral and religious formation. Integrating religious values into classroom instruction supports students' moral development and helps them internalize positive values through daily learning activities (Arifuddin & Elya, 2021), and religious value integration is described as part of students' holistic development across cognitive, emotional, social and spiritual dimensions (Taja et al., 2021). In public elementary schools in nearby Kudus Regency, the religious dimension of local values was strongly embedded in principals' leadership and teachers' character education (Kamal et al., 2025). The second group of factors concerns communication between teachers and families. In a field experiment, weekly individualized messages from teachers to parents reduced the share of students who failed to earn course credit from 15.8% to 9.3% (Kraft & Rogers, 2015). Two-way teacher-parent communication has also been studied as a route to parental involvement (Nuraini et al., 2025), and a synthesis of nine meta-analyses found that parental involvement is positively related to academic achievement across grade levels (Wilder, 2014).

Although these studies show the importance of character-based learning, teacher communication and educational service quality, most of them examined these variables separately. Studies of religious character education have described how schools build students' religious character (Muhtarom et al., 2021; Alfarikh et al., 2021; Priatmoko et al., 2025) but did not ask how parents evaluate it. Studies of teacher-parent communication have focused on parental involvement and student outcomes (Kraft & Rogers, 2015; Nuraini et al., 2025) rather than on parents' satisfaction with the school. Because parents' satisfaction depends on several aspects of educational services, a model that includes both instructional and communication factors is needed (Bariroh et al., 2025). Evidence on these relationships in Indonesian public elementary schools is also limited. Much of the research on religious character education comes from madrasah and Islamic schools (Hidayatulloh et al., 2024; Zuhri et al., 2025), where religious instruction is the core mission. Public elementary schools integrate religious values through a general curriculum, and parents' views of this integration have received less attention. This study therefore examines the relationships among integrated religious values instruction, teacher communication and parent satisfaction in public elementary schools in Klambu District, Grobogan Regency, using Structural Equation Modeling (SEM). It asks whether integrated religious values instruction is related to parent satisfaction, whether teacher communication is related to parent satisfaction, and which of the two relationships is stronger. The findings are expected to add to the literature on educational service quality and to give schools practical guidance for value-based learning and school-parent partnerships.

LITERATURE REVIEW

Integrated religious values instruction refers to the systematic incorporation of religious and moral values into classroom learning to support students' intellectual, spiritual, and social development. Religious values should be integrated into daily learning activities, rather than taught merely as theoretical knowledge, to help students internalize positive attitudes and behaviors (Arifuddin & Elya, 2021). Value-based learning also enables students to develop holistically by integrating cognitive, affective, psychomotor, and spiritual competencies within the educational process (Taja et al., 2021). Character education grounded in religious values helps shape students' personalities and strengthens the quality of educational institutions (Mawardi et al., 2021). Consistent implementation of religious and character education also creates a positive learning environment, improves students' discipline and responsibility, and supports the achievement of broader educational objectives (Santi & Hasnadi, 2021).

Integrated religious values instruction is often described as a way to strengthen students' character through meaningful learning experiences. Religious character can be instilled through curricular integration, daily religious routines and community programmes rather than through one subject alone (Priatmoko et al., 2025). Integrating character values into innovative learning models also encourages students to develop positive attitudes, responsibility, and social awareness (Ardianti & Wanabuliandari, 2019). Value integration is more effective when teachers consistently model religious attitudes and embed moral values into classroom routines and school culture (Ratna & Robandi, 2024). Successful value-based learning also requires collaboration among teachers, parents,

and the school environment, so that students experience consistent character development inside and outside the classroom (Astuti et al., 2023).

Previous empirical studies have also shown that integrated religious values instruction contributes positively to various educational outcomes. The integration of religious values enhances students' discipline and learning motivation by connecting academic content with moral principles (Sopandi & Siswanto, 2021). Value-based instruction strengthens students' religious awareness and social responsibility through continuous habituation and reflective learning activities (Khadijah et al., 2021). Schools that implement integrated character education create more positive learning environments and improve students' behavioral development (Muhtarom et al., 2021). Internalization of religious values encourages students to demonstrate ethical behavior both at school and within their communities (Alfarikh et al., 2021). Systematic integration of religious values also improves the quality of classroom learning by promoting meaningful interactions between teachers and students (Hidayatulloh et al., 2024). Successful implementation depends on teachers' commitment and consistency in embedding religious values throughout the instructional process (Sabrina et al., 2021). Finally, continuous integration of religious values strengthens students' character formation and helps establish a positive school culture that supports holistic development (Hidayat et al., 2021).

Teacher-parent communication is central to collaboration between schools and families. It is the main channel through which parents receive information about their children's learning and progress. Experimental evidence supports its value: individualized teacher messages to parents improved students' course completion, and messages that told parents what their child could improve had larger effects than messages about what the child was doing well (Kraft & Rogers, 2015). Two-way communication has been examined as a route to parental involvement (Nuraini et al., 2025), and a synthesis of nine meta-analyses linked parental involvement to higher achievement, most strongly when involvement took the form of parents' expectations for their children (Wilder, 2014).

Communication between teachers and parents also shapes trust within the school community. Parents' involvement in their children's schooling depends on both personal and contextual factors (Inman et al., 2019). Collaboration between schools and parents is described as a strategy for improving the quality of educational services (Bariroh et al., 2025), and open, responsive communication is expected to build parents' trust in teachers and schools (Nuraini et al., 2025).

Parent satisfaction reflects parents’ perceptions and evaluations of the quality of educational services provided by schools. Parent satisfaction is influenced by the extent to which schools meet parents’ expectations through effective services, clear information, and positive interactions with educational stakeholders (Lie et al., 2021). The indicators of parent satisfaction include service quality, teacher performance, responsiveness, and the ability of schools to fulfill students’ educational needs (Ningsih et al., 2018). Parents’ satisfaction is closely associated with school responsiveness, communication effectiveness, and the quality of learning services. Several factors shape parents’ satisfaction with school services (Triwijayanti et al., 2020). Service quality, teacher performance, and school responsiveness are important factors influencing parents’ satisfaction with educational services (Ruwaidah et al., 2023). Effective communication and positive relationships between schools and parents increase parents’ trust and satisfaction (Bariroh et al., 2025).

Research Objectives

This study aims to examine the relationships among integrated religious values instruction, teacher communication, and parent satisfaction in public elementary schools. Using Structural Equation Modeling (SEM), it seeks to provide empirical evidence for improving educational service quality.

RESEARCH METHOD

Research Design

This study employed a quantitative correlational research design to examine the relationship between integrated religious values instruction, teacher communication, and parent satisfaction in public elementary schools. A cross-sectional survey was conducted, and the proposed research model was analyzed using Structural Equation Modeling (SEM) with AMOS. SEM was chosen because it estimates the relationships among latent variables and evaluates the proposed model as a whole. It analyzes measurement models and structural relationships simultaneously and allows direct and indirect effects among constructs to be tested (Kline, 2023). The validity and reliability of the measurement indicators can be assessed before the structural relationships are examined, for example with the average variance extracted (Fornell & Larcker, 1981). Model fit was judged with CMIN/DF, CFI and RMSEA; Hu and Bentler (1999) recommend CFI values close to .95 or higher and RMSEA values close to .06 or lower.

Respondents of the Study

The study population consisted of 3,037 parents of students enrolled in 26 public elementary schools in Klambu District, Grobogan Regency, Central Java, Indonesia. Using the Slovin formula with a 5% margin of error, the minimum required sample size was 353 respondents. Through proportional allocation, 353 valid questionnaires were obtained and included in the final analysis. Parents were selected as respondents because they directly experience and evaluate the educational services provided by schools, particularly learning practices and teacher communication.

Sample

The sample was determined using a proportionate stratified random sampling technique so that each school was represented in proportion to its size. The inclusion criteria required respondents to be parents or legal guardians of students who were actively enrolled in public elementary schools and willing to participate voluntarily in the research. From the population of 3,037 parents, the sample size was calculated with the Slovin formula described above. A total of 353 valid questionnaires were collected and analyzed. This number is generally regarded as adequate for Structural Equation Modeling (SEM), which needs enough observations to estimate latent constructs, evaluate measurement models, and analyze structural relationships.

$$n = \frac{N}{1 + (N\alpha^2)}$$

$$n = \frac{3037}{1 + \left(3037\, x\, 0,05^2\right)}$$

n = 353

Table 1. Population and sample by school

Public Elementary School	Parent Population	Sampling Calculation	Sample
SDN 1 Selojari	101	(101/3037)×354 = 11,77	12
SDN 2 Selojari	127	(127/3037)×354 = 14,80	15
SDN 1 Taruman	92	(92/3037)×354 = 10,72	11
SDN 2 Taruman	95	(95/3037)×354 = 11,07	11
SDN 3 Taruman	91	(91/3037)×354 = 10,60	11
SDN 4 Taruman	90	(90/3037)×354 = 10,49	10
SDN 1 Kandangrejo	90	(90/3037)×354 = 10,49	10
SDN 2 Kandangrejo	101	(101/3037)×354 = 11,77	12
SDN 3 Kandangrejo	119	(119/3037)×354 = 13,87	14
SDN 4 Kandangrejo	95	(95/3037)×354 = 11,07	11
SDN 1 Penganten	107	(107/3037)×354 = 12,48	12

Public Elementary School	Parent Population	Sampling Calculation	Sample
SDN 2 Penganten	78	(78/3037)×354 = 9,09	9
SDN 3 Penganten	135	(135/3037)×354 = 15,74	16
SDN 1 Klambu	148	(148/3037)×354 = 17,25	17
SDN 2 Klambu	79	(79/3037)×354 = 9,20	9
SDN 3 Klambu	152	(152/3037)×354 = 17,71	18
SDN 4 Klambu	159	(159/3037)×354 = 18,53	18
SDN 1 Menawan	167	(167/3037)×354 = 19,46	19
SDN 2 Menawan	125	(125/3037)×354 = 14,56	15
SDN 3 Menawan	148	(148/3037)×354 = 17,25	17
SDN 1 Terkesi	119	(119/3037)×354 = 13,87	14
SDN 2 Terkesi	208	(208/3037)×354 = 24,29	24
SDN 3 Terkesi	105	(105/3037)×354 = 12,24	12
SDN 1 Jenengan	138	(138/3037)×354 = 16,09	16
SDN 2 Jenengan	111	(111/3037)×354 = 12,94	13
SDN Wandankemiri	57	(57/3037)×354 = 6,64	7
Total	**3037**		**353**

RESULTS

This section presents the findings of the study based on the Structural Equation Modeling (SEM) analysis. The analysis covers model fit evaluation, hypothesis testing, and the coefficient of determination for the relationships among integrated religious values instruction, teacher communication, and parent satisfaction.

Model Fit Evaluation

The first stage of SEM analysis was to evaluate the overall model fit. This assessment was conducted to determine whether the proposed model adequately represented the observed data before testing the research hypotheses.

Table 2. Goodness of fit

Fit Index	Cut-off	Result	Decision
CMIN/DF	≤ 2	1.231	Good
CFI	≥ 0.95	0.977	Good
RMSEA	≤ 0.08	0.026	Good

**Abbreviations:* *CMIN/DF, Chi-square/degrees of freedom; CFI, Comparative Fit Index; RMSEA, Root Mean Square Error of Approximation.*

As presented in Table 2, all goodness-of-fit indices satisfied the recommended criteria. The values of CMIN/DF (1.231), CFI (0.977), and RMSEA (0.026) indicate a good fit between the proposed model and the observed data. The structural model was therefore considered appropriate for hypothesis testing.

Hypothesis Testing

Hypothesis testing was conducted to examine the relationships between integrated religious values instruction, teacher communication, and parents' satisfaction. The significance of each relationship was evaluated using the Critical Ratio (CR), probability value (*p*-value), and standardized regression estimate. A hypothesis was accepted when the CR value exceeded 1.96 and the *p*-value was less than 0.05. The results of the hypothesis testing are presented in Table 3.

Table 3. Results of hypothesis testing

Hypothesis	Relationship	Standardized Regression Weight (β)	CR	*p*-value	Decision
H1	Integrated Religious Values Instruction → Parent Satisfaction	0.326	6.143	< 0.001	Accepted
H2	Parent Teacher Communication → Parent Satisfaction	0.494	9.018	< 0.001	Accepted

** **Notes:** CR = Critical Ratio; p-value = probability value; Standardized Regression Weight (β) = standardized path coefficient; Accepted = hypothesis supported at $p < 0.05$.*

As shown in Table 3, integrated religious values instruction has a positive and statistically significant relationship with parent satisfaction (β = 0.326, CR = 6.143, p < 0.001). Parents who perceived stronger integration of religious values in classroom instruction tended to be more satisfied with educational services. Teacher communication also has a positive and significant relationship with parent satisfaction (β = 0.494, CR = 9.018, $p < 0.001$). The standardized estimates indicate that teacher communication has a stronger relationship with parent satisfaction than integrated religious values instruction. Therefore, both research hypotheses were supported.

Coefficient of Determination

The explanatory power of the structural model was assessed using the coefficient of determination (R^2). This analysis was conducted to determine the proportion of variance in parent satisfaction explained by the independent variables included in the structural model. The results are presented in Table 4.

Table 4. Coefficient of determination

Dependent Variable	R^2	Interpretation
Parent Satisfaction	0.550	Moderate to High Explanatory Power

As presented in Table 4, the coefficient of determination (R^2) for parent satisfaction is 0.550, indicating that 55% of the variance in parent satisfaction is explained jointly by integrated religious values instruction and teacher communication. The remaining 45% is attributable to other variables beyond the scope of the present study. The model therefore has moderate to high explanatory power for parent satisfaction in public elementary schools.

Structural Equation Model

Figure 1 presents the final Structural Equation Model (SEM). It shows the hypothesized relationships among integrated religious values instruction, teacher communication, and parent satisfaction, with the standardized regression estimates.

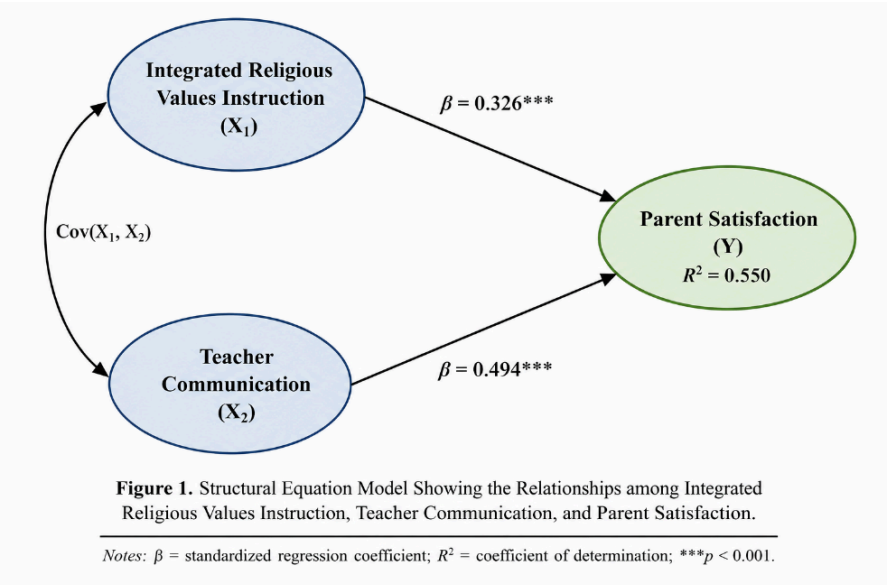

Figure 1. Structural Equation Model Showing the Relationships among Integrated Religious Values Instruction, Teacher Communication, and Parent Satisfaction.

Notes: β = standardized regression coefficient; R^2 = coefficient of determination; ***$p < 0.001$.

As illustrated in Figure 1, both integrated religious values instruction and teacher communication exhibit positive relationships with parent satisfaction. Teacher communication has a stronger standardized effect (β = 0.494) than integrated religious values instruction (β = 0.326), which suggests that teacher-parent communication is more strongly related to parents' satisfaction. The structural model explains 55% of the variance in parent satisfaction ($R^2 = 0.550$).

DISCUSSION

The structural model fitted the data well (CMIN/DF = 1.231, CFI = 0.977, RMSEA = 0.026; Table 2), and both hypothesized relationships were positive and significant. Together, integrated religious values instruction and teacher communication accounted for 55% of the variance in parent satisfaction ($R^2 = 0.550$; Table 4). Because the design is cross-sectional and correlational, these results describe associations in parents' perceptions, not effects of one variable on another.

The first finding is that parents who perceived stronger integration of religious values in classroom instruction were more satisfied with the school (β = 0.326, CR = 6.143, $p < 0.001$; Table 3). One explanation is that many parents judge a school partly by whether their children's behaviour and religious practice develop at school. When teachers link lessons to prayer, honesty, politeness and responsibility, parents may see results at home that match their expectations. This is consistent with studies in which religious character was built through curricular integration, religious routines and teacher role modelling (Priatmoko et al., 2025; Zuhri et al., 2025), and with the strong religious dimension of character education reported in public elementary schools in Kudus Regency (Kamal et al., 2025). Those studies, however, described students' character or teachers' practices, while this study measured parents' evaluations. The present result adds that value integration is also visible to parents and is associated with their satisfaction. For teachers in Klambu District, this suggests that value integration should be planned within lessons and made visible to parents, for example by reporting the habits that students practise at school. Because public schools serve students of different faiths, the values chosen should be ones that all families can recognize.

The second finding is that teacher communication had the larger standardized coefficient (β = 0.494, CR = 9.018, $p < 0.001$; Table 3). Communication is the part of school work that parents experience directly, whereas classroom instruction is usually seen only through the child's reports and results. Clear and regular information about learning and progress may therefore weigh heavily in parents' overall judgement of the school. This interpretation agrees with Kraft and Rogers (2015), whose experiment showed that brief, individualized teacher messages changed students' outcomes, and with studies that link two-way communication to parental involvement (Nuraini et al., 2025) and parental involvement to achievement (Wilder, 2014). It is also consistent with Indonesian work that treats school-parent collaboration as part of educational service quality (Bariroh et al., 2025) and finds that service quality is related to parents' satisfaction (Lie et al., 2021; Ruwaidah et al., 2023). The two coefficients were not compared with a formal test, so the conclusion that communication is the stronger correlate should be treated as descriptive. For schools, the practical implication is that teacher communication skills deserve the same attention as instructional skills in professional development. Short, regular and specific messages about each child's progress, together with real opportunities for parents to respond, are a low-cost way to act on this finding.

The two predictors also covaried in the model (Figure 1), which suggests that teachers who integrate values well may also communicate well with parents, or that parents who view the school positively rate both aspects highly. The remaining 45% of the variance in parent satisfaction is likely related to factors outside the model. Earlier studies point to learning facilities (Lie et al., 2021) and to school culture and school image (Triwijayanti et al., 2020) as candidates. The covariance also has a practical side. In the Surakarta school studied by Suryaningsih and Desstya (2023), communication with parents was an obstacle to value habituation, because habits practised at school need support at home. Schools in Klambu District could therefore treat the two practices as one programme: teachers explain to parents which values are being practised in class, ask parents to support the same habits at home, and report back on progress. Principals can support this by planning regular class meetings with

parents at the start of each term and by including both value integration and parent communication in teacher supervision.

Several limitations should be noted. First, the cross-sectional correlational design does not allow causal conclusions. Second, all constructs were rated by the same parents in one questionnaire, so common method variance may have inflated the relationships (Podsakoff et al., 2003). Parents also rated classroom instruction that they observe only indirectly. Third, the paper reports model fit and structural paths but not the measurement model: factor loadings, composite reliability, average variance extracted and discriminant validity (Fornell & Larcker, 1981) are needed to show that the 68 items measure three distinct constructs. TLI is also named in the Methodology but not reported. Fourth, the sample comes from public elementary schools in one district, which limits generalization to other regions and to madrasah. Future research could combine parents' ratings with teachers' records of communication or classroom observation, test parental trust or involvement as mediators, compare public schools and madrasah with multi-group analysis, and follow parents over a school year.

CONCLUSION AND RECOMMENDATIONS

This study found that integrated religious values instruction and teacher communication are both positively and significantly related to parents' satisfaction in public elementary schools. The Structural Equation Modeling analysis showed that the proposed model fits the observed data well. Teacher communication had a stronger relationship with parent satisfaction than integrated religious values instruction. The model explains 55% of the variance in parent satisfaction, which suggests that these two factors are important in shaping parents' perceptions of school quality and educational services.

Based on these findings, schools should strengthen the integration of religious values into daily learning activities and develop teachers' communication competencies through continuous professional development. Effective communication between teachers and parents should be promoted to build trust, collaboration, and satisfaction with educational services. Future studies are encouraged to examine additional variables, such as school leadership, service quality, parental involvement, or school climate, to explain more of the variation in parents' satisfaction.

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REFERENCES

Alfarikh, R. F., Saleh, F. A., Hartati, S., Puspita, E., Hartini, Y., & Ramadhani, H. (2021). Implementation religious character values for students through extracurricular programs, 1, 111–123.

Ardianti, S. D., & Wanabuliandari, S. (2019). Module to build character education for elementary school students.

Arifuddin, M. A., & Elya, E. (2021). Character education based on religious values: The case of elementary schools in Palu, Indonesia, 9(8), 54–70.

Astuti, H. P., Kadwi, A., Putri, L., Maqfiroh, A. D., Lestari, L. A., & Rondli, W. S. (2023). Peran guru PPKn dalam penguatan karakter siswa SD Negeri 02 Panjang Kudus, 2, 231–243.

Bariroh, U., Salafudin, M. A., Fahma, A., Hidayah, K. R. N., & Assharofi, F. A. M. (2025). The synergy of school and parent: A strategy to improve the quality of educational services. *At-Taqaddum*, 17(1), 68–77. https://doi.org/10.21580/at.v17i1.26796

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research, 18(1), 39–50. https://doi.org/10.1177/002224378101800104

Hidayat, W., Dewi, P., & Nurdiana, Y. (2021). Strengthening the character values in the online learning process, 4, 150–164.

Hidayatulloh, T., Saumantri, T., & Ramdani, Z. (2024). Integrating living values education into Indonesian Islamic schools: An innovation in character building, 22(1), 137–152. https://doi.org/10.32729/edukasi.v22.i1.1743

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Structural Equation Modeling: A Multidisciplinary Journal, 6(1), 1–55. https://doi.org/10.1080/10705519909540118

Inman, A. G., Pendse, A. C., & Luu, L. P. (2019). Person-context influences on educational involvement in rural Cambodian schools. *Journal of School-Based Counseling Policy and Evaluation*, 1(3), 85–99. https://doi.org/10.25774/h7nv-9238

Kamal, J., In'am, A., & Khozin, K. (2025). Culturally-rooted school leadership: The role of Gusjigang values in enhancing character education at the primary level. Elmidad, 17(2). https://doi.org/10.20414/elmidad.v17i2.14134

Khadijah, K., Suciati, I., Khaerani, K., Manaf, A., & Sutamrin, S. (2021). Schools' character education values and students' mathematics learning achievement: A meta-analysis. Jurnal Cakrawala Pendidikan, 40(3), 670–683. https://doi.org/10.21831/cp.v40i3.39924

Kline, R. B. (2023). Principles and practice of structural equation modeling (5th ed.). Guilford Press.

Kraft, M. A., & Rogers, T. (2015). The underutilized potential of teacher-to-parent communication: Evidence from a field experiment. Economics of Education Review, 47, 49–63. https://doi.org/10.1016/j.econedurev.2015.04.001

Lie, D., Sihombing, E. H., Sofian, & Matondang, S. A. (2021). The effect of service quality and learning facilities to the parents' satisfaction. *IAR Journal of Business Management*, 2(2), 1–6. https://doi.org/10.47310/iarjbm.2021.v02i02.020

Mawardi, I., Raharjo, A. B., & Fahm, A. G. O. (2021). Teachers strategies in strengthening character education based on Islamic values in online learning during the Covid-19 pandemic. Jurnal Tarbiyatuna, 12(2), 87–97. https://doi.org/10.31603/tarbiyatuna.v12i2.5991

Muhtarom, M., Priyatna, S., Yoseptry, R., & Koswara, N. (2021). Islamic religious education learning management in forming the religious character of students. International Journal of Nusantara Islam, 9(2), 411–425. https://doi.org/10.15575/ijni.v9i2.16577

Ningsih, D. A., Imron, A., & Triwiyanto, T. (2018). Hubungan persepsi tentang kualitas dan pelayanan pendidikan dengan kepuasan orang tua siswa sekolah menengah kejuruan negeri. Jurnal Administrasi dan Manajemen Pendidikan, 1(2), 245–254. https://doi.org/10.17977/um027v1i22018p245

Nuraini, F., Saryono, D., Latif, A., Zain, A. B., Ishaq, M., Sudarsono, B., & Supriyanto, A. (2025). Beyond school contact: Two-way teacher–parent communication and parental involvement in Islamic early childhood education. *Al-Athafal: Jurnal Pendidikan Anak*, 11(2), 481–492.

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal of Applied Psychology, 88(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Priatmoko, S., Rahman, S. A., Inayah, S. R., Ekawati, R., & Mustakim, S. S. (2025). Exploration of religious character education in pesantren-based madrasah ibtidaiyah. Mudarrisa: Jurnal Kajian Pendidikan Islam, 17(1), 1–28. https://doi.org/10.18326/mudarrisa.v17i1.3329

Ratna, A., & Robandi, B. (2024). Kompetensi pedagogik keteladanan pada pendidikan antikorupsi di Provinsi Lampung, 15.

Ruwaidah, Lubis, M. S., & Siregar, J. S. (2023). Analysis of the effect of education service quality on parent satisfaction in elementary schools. In Proceedings of the 1st Annual Dharmawangsa International Conference (pp. 73–80).

Sabrina, U., Ardianti, S. D., & Ermawati, D. (2021). Kendala dalam menumbuhkan karakter religius anak usia sekolah dasar selama pandemi Covid-19, 3(5), 3079–3089.

Santi, C. S. M., & Hasnadi. (2021). The implementation of character education through religious activities in the school, 7(2), 215–228.

Sopandi, E., & Siswanto, A. (2021). Implementasi pendidikan agama dalam nilai karakter di lembaga pendidikan PAUD, 19(3), 303–316.

Suryaningsih, M. R., & Desstya, A. (2023). Implementasi nilai-nilai profil pelajar Pancasila dalam Kurikulum Merdeka di sekolah dasar. Muallimuna: Jurnal Madrasah Ibtidaiyah, 9(1), 12–26. https://doi.org/10.31602/muallimuna.v9i1.10961

Taja, N., Nurdin, E. S., Kosasih, A., Suresman, E., & Supriyadi, T. (2021). Character education in the pandemic era: A religious ethical learning model through Islamic education, 20(11), 132–153.

Triwijayanti, N., Sanoto, H., & Paseleng, M. (2020). Pengaruh kualitas layanan pendidikan, budaya sekolah, citra sekolah terhadap kepuasan orang tua, 74–80.

Wilder, S. (2014). Effects of parental involvement on academic achievement: A meta-synthesis. Educational Review, 66(3), 377–397. https://doi.org/10.1080/00131911.2013.780009

Zuhri, A., Mas'ud, A., & Syukur, F. (2025). Strengthening religious character in madrasah: Integrating pesantren values as an educational strategy. Al-Tarbawi Al-Haditsah: Jurnal Pendidikan Islam, 10(1), 71–92. https://doi.org/10.24235/tarbawi.v10i1.19819

ICISFS-UMK 2026 LEARNING INNOVATION

Collage-Based Science Learning: Comparative Study of PBL and Discovery Learning on Students' Critical Thinking Skills

Sri Handayatik[1*], Nur Fajrie[1] and Khamdun[1]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: nabilionabilio8@gmail.com

ABSTRACT

This study compared Problem-Based Learning (PBL) and Discovery Learning (DL), both combined with collage-based science learning on the ecosystem topic, in improving elementary students' critical thinking skills. A pretest-posttest design with two experimental groups was used with fifth-grade students from four public elementary schools in Geyer District, Indonesia. Critical thinking skills were assessed with a test based on Ennis' indicators: identifying problems, analyzing information, evaluating alternatives, and drawing logical conclusions. Paired sample t-tests showed significant gains in critical thinking for both PBL and DL ($p < 0.05$). The PBL group achieved a higher average N-Gain score of 0.72 (high category), while the DL group achieved an N-Gain of 0.59 (moderate–high category). An independent sample t-test showed a statistically significant difference in posttest scores in favour of PBL. Classroom observations suggested that collage media supported conceptual visualization and student engagement. These findings suggest that combining active learning models with visual, contextual media such as collage can help develop critical thinking in elementary science.

KEYWORDS problem-based learning | discovery learning | collage art | critical thinking skills | science education

INTRODUCTION

Developing critical thinking skills is a core objective of 21st-century education, particularly in science learning at the elementary level. As global problems grow more complex, students need to be able to analyze, evaluate, and make decisions based on evidence and logic. However, science instruction in many elementary schools still emphasizes rote memorization and passive learning, which limits students' opportunities for higher-order thinking. To address this issue, active learning models such as Problem-Based Learning (PBL) and Discovery Learning (DL) have been widely recommended. Both models are rooted in constructivist theory and promote student-centered learning through exploration, problem-solving, and collaboration. PBL challenges students with real-life problems that require critical inquiry and group discussion to find solutions, while DL encourages students to independently discover scientific concepts through guided exploration. Evidence for PBL is strong. Meta-analyses of Indonesian elementary studies report large effects of PBL on critical thinking, with a mean effect size of 1.065 across 12 studies (Setyowati & Sutikno, 2024) and a strong effect across 25 studies (Sa'diyah et al., 2024). A meta-analysis of 42 science studies at several education levels found a large effect on critical thinking and problem solving (ES = 0.798; Aripin et al., 2025). Evidence for discovery learning is more conditional. Across 164 studies, unassisted discovery was less effective than explicit instruction (d = -0.38), whereas guided discovery with feedback, worked examples or scaffolding outperformed other forms of instruction (d = 0.30; Alfieri et al., 2011). In a one-group study with 17 sixth graders, discovery learning raised critical thinking scores from 63.24 to 77.65, a moderate N-Gain of 0.38 (Putri et al., 2026).

Critical thinking can be taught, but how it is taught matters. A meta-analysis of 341 studies found a small average effect of instruction on critical thinking (g = 0.30), and a larger effect (g = 0.57) when dialogue, authentic problems and mentoring were combined (Abrami et al., 2015). In Indonesian elementary science (IPAS), reviews report that active models improve critical thinking, but that limited teacher competence, limited facilities and a lack of scaffolding for critical thinking remain obstacles (Prakoso et al., 2026). A review of 20 studies concluded that PBL consistently improves elementary students' academic performance, together with conceptual

understanding, critical thinking, creativity and motivation (Ningrum, 2025). Few studies have compared PBL and discovery learning directly in the same school setting, so teachers have little evidence on which of the two to choose for a given topic.

Even with these approaches, many science concepts remain abstract and difficult for young learners to grasp. Integrating visual and creative media such as collage art may help students' understanding by providing concrete, contextual representations of scientific content. Ainsworth et al. (2011) argue that when students create their own visual representations, they have to decide what to include and how parts relate, which supports reasoning in science. Collage is already part of the elementary art curriculum, and digital media for teaching it have been developed for first graders (Septiani & Setiawan, 2024). Collage, a technique of assembling visual elements from various materials, can promote both conceptual clarity and creative engagement. Yet few studies have examined collage-based learning combined with active instructional models such as PBL and DL, especially in science education. In an ecosystem unit, a collage can show food chains, habitats and interactions, and the choices students make when arranging it can become material for questioning and justification.

This study addresses that gap by testing PBL and DL, each using collage art as a learning medium, on the ecosystem topic. Specifically, the research examines (1) the effectiveness of each model in improving students' critical thinking skills, (2) the difference in effectiveness between the two models, and (3) how collage art was used by students in both groups, as described in classroom observations. The ecosystem topic was chosen because it asks students to reason about relationships among living things and their environment, which suits both problem-based and discovery activities. Based on the evidence above, we expected both models to improve critical thinking and PBL to produce the larger gain. The results are expected to inform more contextual, visual, and inquiry-based approaches in elementary science education.

LITERATURE REVIEW

This study is grounded in constructivist learning theory, which emphasizes that knowledge is actively constructed by learners through experience, exploration, and interaction. Within this framework, both Problem-Based Learning (PBL) and Discovery Learning (DL) are active instructional models that promote student-centered learning and critical engagement with content. Problem-Based Learning (PBL) provides students with complex, real-life problems that they must solve collaboratively, which develops analytical thinking, argumentation, and reflective inquiry. Discovery Learning (DL), by contrast, asks students to investigate scientific concepts independently through hypothesis formation, experimentation, and conceptual reasoning.

To support these models, this study adds collage art as a visual learning medium. Collage, with its tactile and visual elements, allows students to represent scientific ideas, such as the structure and interactions of ecosystems, through creative compositions. This visual expression works as a cognitive tool that clarifies abstract concepts and as a reflective medium that supports understanding.

The central variable measured in this study is critical thinking skills, defined through Ennis' framework (Ennis, 1993), which includes the abilities to identify problems, analyze information, evaluate alternative solutions, and draw logical conclusions. It is hypothesized that both PBL and DL will improve students' critical thinking skills, but PBL may yield greater improvement due to its emphasis on collaborative problem-solving and structured inquiry. The use of collage art is also expected to support both models by providing a visual-conceptual bridge between abstract scientific ideas and students' lived experiences.

The conceptual framework therefore connects three components:

1. Learning Models (PBL and DL),
2. Learning Media (Collage Art), and
3. Learning Outcomes (Critical Thinking Skills).

Research Objectives

The primary objective of this study is to investigate the effectiveness of collage-based science learning in developing elementary students' critical thinking skills through the application of two active learning models: Problem-Based Learning (PBL) and Discovery Learning (DL). Specifically, the study seeks to determine how each model, when integrated with collage art as a learning medium, affects students' ability to analyze, evaluate, and reflect on ecosystem concepts. It also compares the effectiveness of PBL and DL in developing critical thinking and explores the role of collage as a visual and contextual tool for students' engagement and conceptual understanding in science learning.

RESEARCH METHOD

Research Design

This study employed a quantitative approach using a quasi-experimental pretest–posttest design with two treatment groups and no untreated control group. The research involved two experimental groups: one group was taught using the Problem-Based Learning (PBL) model and the other using the Discovery Learning (DL) model, both integrated with collage as a learning medium. This design allowed the researchers to measure the effectiveness of each instructional model by comparing students' critical thinking skills before and after the treatment. Classes, rather than individual students, were randomly assigned to the two models, which reduces but does not remove the influence of external variables. The pretest and posttest allowed learning gains to be quantified for each model.

Respondents of the Study

The respondents of this study consisted of fifth-grade students and their classroom teachers from four public elementary schools located in Geyer District, Grobogan Regency, Central Java, Indonesia. The participating schools included SD Negeri 1 Jambangan, SD Negeri 2 Jambangan, SD Negeri 1 Gundih, and SD Negeri 2 Gundih. These schools were selected purposively based on their accessibility, teacher cooperation, and curriculum compatibility with the research objectives. Students were the main source of data on the effectiveness of the instructional models; the classroom teachers supported the implementation and observation phases. A cluster random sampling technique was used to select two classes from this population, with one class assigned to the Problem-Based Learning (PBL) model and the other to the Discovery Learning (DL) model. This procedure was intended to make the comparison between the two groups fair.

RESULTS

This study examined the effectiveness of Problem-Based Learning (PBL) and Discovery Learning (DL) models in improving elementary students' critical thinking skills through the integration of collage-based science learning. Data were obtained through pretests and posttests administered to both experimental groups, and the results were analyzed using paired sample t-tests, independent sample t-tests, and normalized gain scores (N-Gain). Group means and N-Gain values are shown in Table 1, and the comparison of posttest scores in Table 2.

Effectiveness of the PBL Model

The results of the paired sample t-test showed a significant improvement in students' critical thinking scores after the application of the PBL model. The mean pretest score was 58.4, and the posttest score increased to 84.7. The p-value was 0.000 ($p < 0.05$), indicating a statistically significant improvement. The average N-Gain was 0.72, which falls into the high category.

Effectiveness of the DL Model

The DL group also showed significant improvement. The mean pretest score was 60.1, and the posttest score increased to 78.2. The paired sample t-test was significant ($p < 0.05$), and the N-Gain score was 0.59, categorized as moderate to high.

Table 1. Pretest, posttest, and N-Gain results of both experimental groups

Group	Mean Pretest	Mean Posttest	N-Gain Score	N-Gain Category	p-value (Paired t-test)
PBL	58.4	84.7	0.72	High	0.000
DL	60.1	78.2	0.59	Moderate–High	0.000

Comparison Between the PBL and DL Models

An independent sample t-test was conducted to compare the posttest scores of the two groups. The result showed a significant difference between the PBL and DL groups with a p-value of 0.023 ($p < 0.05$). This indicates that posttest critical thinking scores were significantly higher in the PBL group than in the DL group.

Table 2. Independent sample t-test results on posttest scores

Groups Compared	Mean Difference	p-value (Independent t-test)	Interpretation
PBL vs. DL (Posttest)	6.5	0.023	Significant Difference (PBL > DL)

The Role of Collage as a Learning Medium

Classroom observations and teacher feedback indicated that collage-based learning helped students visualize abstract ecosystem concepts more concretely. Students appeared more engaged and creative. Collage worked both as a creative activity and as a scaffold for organizing scientific knowledge in visual, contextual form, which may have contributed to the development of critical thinking skills.

DISCUSSION

Both groups improved their critical thinking scores between the pretest and the posttest: from 58.4 to 84.7 in the PBL group and from 60.1 to 78.2 in the DL group (paired t-tests, $p = 0.000$; Table 1). The PBL group's posttest mean was 6.5 points higher than that of the DL group ($p = 0.023$; Table 2). Because the design had no untreated control group, the pretest-posttest gains combine the effect of each model with the effects of regular teaching, practice with the test and maturation (Shadish et al., 2002). The comparison between the two models is therefore the stronger part of the evidence.

The larger gain under PBL (N-Gain 0.72 against 0.59) agrees with the meta-analytic evidence for PBL in Indonesian elementary schools (Setyowati & Sutikno, 2024; Sa'diyah et al., 2024) and in science learning more widely (Aripin et al., 2025; Yanto et al., 2026). A likely mechanism is the fit between the PBL syntax and the indicators of the test. An ecosystem problem, such as the decline of an animal population in a local habitat, asks students to identify the problem, analyze information, weigh possible causes and draw a conclusion, which are the same abilities that the Ennis-based test measured (Ennis, 1993). PBL also builds in group discussion and teacher guidance. Abrami et al. (2015) found that critical thinking instruction had its largest effects when dialogue, authentic problems and mentoring were combined, and PBL contains all three. For teachers, the finding suggests that ecosystem topics can be organized around a local problem, with group discussion of evidence and a final conclusion that students must justify.

The DL group also improved, but less. This pattern is consistent with Alfieri et al. (2011), who found that discovery learning helps only when it is guided by feedback, worked examples or scaffolding. Fifth graders working on an ecosystem topic may not yet know which observations matter or how to test an idea, so open discovery can leave some students without a clear path to a conclusion. The size of the DL gain is close to findings for guided inquiry and discovery in Indonesian elementary schools, where critical thinking also improved significantly (Aras et al., 2024; Putri et al., 2026). Teachers who prefer discovery learning could add structured worksheets, guiding questions and short teacher summaries at the end of each discovery phase. The DL group started with a slightly higher pretest mean (60.1 against 58.4), so the posttest advantage of PBL is not explained by a better starting point. An analysis of covariance with the pretest as covariate would test this formally.

Collage was used in both groups, so this study cannot estimate its effect on critical thinking. The classroom observations suggest that collage helped students visualize ecosystem components and their relationships. This is consistent with the argument of Ainsworth et al. (2011) that creating visual representations requires students to select, arrange and explain information, which are reasoning steps in themselves. In a collage of an ecosystem, each placement of an organism or a link between organisms is a claim that students can be asked to justify. Teachers can use this property by asking groups to explain their collage and to respond to questions from other groups. This links the art activity to the critical thinking indicators rather than treating it as decoration. Because collage is already taught in elementary art (Septiani & Setiawan, 2024), the approach also allows science and art learning to be combined without extra lesson time. Whether collage adds to the effect of PBL or DL should be tested in a design that includes groups with and without collage.

In sum, this study adds a direct comparison of PBL and DL in the same setting, with the same topic and the same visual medium. In this sample, PBL produced larger critical thinking gains than DL when both were supported by collage. For schools, the practical value of such a comparison is that it helps teachers choose a model for a specific topic rather than for science in general. Teacher working groups (KKG) at district level could share PBL lesson designs that use collage and develop the guidance that discovery lessons appear to need.

Several limitations should be noted. First, only two intact classes took part, and the number of students in each group is not reported; this makes it hard to judge statistical power and generalizability. Second, the paper reports p-values but not standard deviations, t-values, degrees of freedom or effect sizes, which are needed to judge the size of the differences (Lakens, 2013). Third, the N-Gain values reported in Table 1 are higher than the values obtained by applying the N-Gain formula to the group means, and the category "moderate to high" is not one of the standard categories (low, medium, high) proposed by Hake (1998); the authors should check whether the values are means of individual gains. Fourth, the validity and reliability of the critical thinking test are not described, and the classroom observations of collage use were not structured. Fifth, each model was implemented in a different intact class with its own classroom teacher, so teacher and class effects cannot be separated from model effects. Future research could use larger samples with several classes per model, include groups with and without collage, report effect sizes, and test whether the gains are retained after several weeks.

CONCLUSION AND RECOMMENDATIONS

The results of this study show that both Problem-Based Learning (PBL) and Discovery Learning (DL), when integrated with collage as a visual learning medium, improved elementary students' critical thinking skills on the ecosystem topic. PBL produced higher posttest scores and N-Gain values than DL. Its structured, collaborative, and problem-oriented approach may better support students' analysis, evaluation, and reasoning. Observations also suggest that collage supported students' engagement and understanding by turning abstract science concepts into visual, concrete forms. It may also have served as a cognitive scaffold for exploration and reflection.

Based on these findings, elementary school teachers are encouraged to adopt active learning strategies such as PBL and incorporate visual media like collage into their science instruction. Teacher professional development should also focus on equipping educators with the skills to design interdisciplinary, student-centered learning experiences. Schools could also support collaboration between science and art educators to develop engaging and meaningful learning environments. Future studies could explore the application of collage-based learning in different subjects or age groups, and investigate its long-term impact on students' critical thinking and academic achievement. Qualitative data such as student reflections, learning journals, or project portfolios would give a fuller picture of the learning process.

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REFERENCES

Abrami, P. C., Bernard, R. M., Borokhovski, E., Waddington, D. I., Wade, C. A., & Persson, T. (2015). Strategies for teaching students to think critically: A meta-analysis. Review of Educational Research, 85(2), 275–314. https://doi.org/10.3102/0034654314551063

Ainsworth, S., Prain, V., & Tytler, R. (2011). Drawing to learn in science. Science, 333, 1096–1097.

Alfieri, L., Brooks, P. J., Aldrich, N. J., & Tenenbaum, H. R. (2011). Does discovery-based instruction enhance learning? Journal of Educational Psychology, 103(1), 1–18. https://doi.org/10.1037/a0021017

Aras, N. F., Lestari, M., Pendit, S. S. D., & Sani, N. K. (2024). The critical thinking skills of students through guided inquiry models in elementary school. Jurnal Studi Guru dan Pembelajaran, 7(3). https://doi.org/10.30605/jsgp.7.3.2024.4703

Aripin, N., Festiyed, Yerimadesi, Alberida, H., Ahda, Y., & Mufit, F. (2025). The impact of problem-based learning on science learning to improve students' critical thinking and problem-solving skills: A meta-analysis. Jurnal Penelitian Pendidikan IPA, 11(6), 45–57. https://doi.org/10.29303/jppipa.v11i6.10051

Ennis, R. H. (1993). Critical thinking assessment. Theory Into Practice, 32(3), 179–186. https://doi.org/10.1080/00405849309543594

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. American Journal of Physics, 66(1), 64–74. https://doi.org/10.1119/1.18809

Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for t-tests and ANOVAs. Frontiers in Psychology, 4, Article 863. https://doi.org/10.3389/fpsyg.2013.00863

Ningrum, A. S. (2025). Studi literatur: Efektifitas model problem based learning terhadap hasil belajar siswa SD. Pendas: *Jurnal* Ilmiah *Pendidikan* Dasar, 10(4), 610–621. https://doi.org/10.23969/jp.v10i04.31698

Prakoso, G. B., Manafe, M. P., & Atmojo, I. R. W. (2026). Analisis keterampilan berpikir kritis siswa pada pembelajaran IPAS SD berbasis STEAM: Systematic literature review. Pendas: *Jurnal* Ilmiah *Pendidikan* Dasar, 11(2), 292–308. https://doi.org/10.23969/jp.v11i02.48311

Putri, M. Y., Miftakhuddin, & Adiyan, F. (2026). Pengaruh model discovery learning terhadap kemampuan berpikir kritis di sekolah dasar. *Jurnal* Tunas Pendidikan, 9(1), 209–217. https://doi.org/10.52060/pgsd.v9i1.4422

Sa'diyah, H., Umalihayati, Hidayah, R., Salimi, M., Fajari, L. E. W., Mashudi, & Aini, S. (2024). The effect of problem based learning model on critical thinking skills in elementary school: A meta analysis study. Jurnal Iqra': Kajian Ilmu Pendidikan, 9(1). https://doi.org/10.25217/ji.v9i1.4456

Septiani, A. A., & Setiawan, D. (2024). Developing Canva-based Sitekol on collage topic for first-grade public elementary school students. Journal of Integrated Elementary Education, 4(2). https://doi.org/10.21580/jieed.v4i2.21977

Setyowati, N., & Sutikno, P. Y. (2024). Meta analisis: Model pembelajaran problem based learning (PBL) terhadap keterampilan berpikir kritis siswa sekolah dasar. *Jurnal* Inovasi Pendidikan dan Pembelajaran Sekolah Dasar, 8(2), 587–599. https://doi.org/10.24036/jippsd.v8i2.127679

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). Experimental and quasi-experimental designs for generalized causal inference. Houghton Mifflin.

Yanto, F., Sulistianingsih, M., Erfani, D., Nisa, K., Aini, N., & Dito. (2026). Effectiveness of problem-based learning on science problem-solving skills: A meta-analysis. Journal of Turkish Science Education, 23(1), 91–108. https://doi.org/10.36681/tused.2026.005

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

School Leadership and Teacher Motivation for Digital Literacy Competence

Sutarti[1*], Ahmad Hariyadi[1] and Gunawan[1]

[1]*Universitas Muria Kudus, Indonesia*

ABSTRACT

This study examines the influence of school leadership and teacher motivation on teachers' digital literacy competence in public elementary schools. As digital technology enters everyday teaching, teachers need adequate digital literacy competence; effective school leadership and strong work motivation are expected to support it. This quantitative survey involved 180 teachers selected through proportional random sampling. Data were collected using structured questionnaires and analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS 4. The measurement model was evaluated against the criteria of indicator loadings of at least 0.70, Average Variance Extracted (AVE) of at least 0.50, and Composite Reliability of at least 0.70. The structural model revealed that school leadership had a positive and significant effect on teachers' digital literacy competence ($\beta = 0.421$, $p < 0.001$), and teacher motivation also had a positive and significant effect ($\beta = 0.387$, $p < 0.001$). Together, school leadership and teacher motivation explained 62.8% ($R^2 = 0.628$) of the variance in teachers' digital literacy competence, a moderate level of explanatory power. These findings suggest that both school leadership and teacher motivation matter for teachers' digital literacy competence. School administrators may therefore use leadership strategies that encourage innovation, continuous professional development, and motivational support to improve teachers' readiness for technology-integrated learning.

KEYWORDS digital literacy competence | elementary school teachers | school leadership | teacher motivation

INTRODUCTION

Digital technology has changed education systems worldwide and requires teachers to keep adapting their pedagogical practices and digital competencies. Digital competence is now treated as a core teacher competence. The European DigCompEdu framework describes 22 educator competences in six areas, from professional engagement to facilitating learners' own digital competence (Redecker, 2017), and it is used as a reference for teacher professional development (Caena & Redecker, 2019). Teachers with strong digital literacy are better able to design innovative learning environments, integrate educational technologies into classroom instruction, and improve students' learning outcomes (Redecker, 2017). Strengthening teachers' digital literacy competence has therefore become a priority in educational development.

In Indonesia, the *Merdeka Curriculum* has accelerated the integration of digital technology into teaching and learning activities. Teachers are expected to master subject knowledge and to use digital platforms, learning management systems, and interactive educational applications effectively. However, Indonesian studies report that teachers' digital competence is uneven. In a case study of fifth-grade teachers, competence (including TPACK) was uneven, ICT infrastructure was underused and school support varied (Afrillia & Dafit, 2025). Most of 72 junior high school teachers surveyed with a DigCompEdu-based questionnaire were at the B1 (Integrator) level (Arimbawa et al., 2024), and madrasah teachers struggled with digital religious instruction because of difficulty operating tools, limited infrastructure and low digital literacy (Pabbajah et al., 2025). A survey of 153 elementary school teachers in Yogyakarta found that all of them used technology for distance learning, and its authors recommended school-provided training (Suwarjo et al., 2022). These conditions suggest that improving teachers' digital literacy depends on both organizational and individual factors.

School leadership is an important organizational influence on teachers' professional competence. Effective school leaders create a supportive organizational climate, encourage innovation, provide professional development opportunities, and facilitate the integration of technology into educational practices. School leadership affects

student learning largely through teachers' motivation, capacity and working conditions (Leithwood et al., 2020). In Indonesia, principals' digital leadership was directly related to the performance of elementary school teachers (Timan et al., 2022), and principals' leadership was related to the innovative work behaviour of 1,200 teachers (Hidayat & Patras, 2022). A review of 14 studies found that principals' digital leadership shapes teachers' acceptance and use of artificial intelligence through resources, professional development, learning communities and school culture, and that it strengthens teachers' technological self-efficacy (Zeng et al., 2025). Through visionary leadership, principals can motivate teachers to adopt new teaching approaches and continuously improve their competencies in response to educational changes. Conversely, ineffective leadership may reduce teachers' willingness to engage in innovation and technology adoption.

Teacher motivation also shapes teachers' willingness to improve their digital competencies. Motivation encourages teachers to participate in professional development activities, learn new digital skills, and apply technology in instructional practices. According to Ryan and Deci (2020), motivation influences individuals' persistence, engagement, and performance in achieving learning goals. Teachers with higher intrinsic and extrinsic motivation tend to show greater commitment to continuous professional development and technology integration in education. Ertmer and Ottenbreit-Leftwich (2010) add that teachers' knowledge, self-efficacy, pedagogical beliefs and school culture together determine whether teachers change their use of technology, which places motivation alongside organizational conditions.

Several previous studies have examined the relationships between leadership, motivation, and teacher competence. For example, Hallinger (2011) concluded from four decades of research that leadership affects learning mainly indirectly, through the conditions in which teachers work. Ryan and Deci (2020) also argued that motivated individuals are more likely to engage in lifelong learning and competency development. Although previous research has investigated these variables separately, empirical studies examining the simultaneous effects of school leadership and teacher motivation on teachers' digital literacy competence remain limited, particularly in the context of Indonesian elementary schools. Most existing studies focus on technology acceptance or digital readiness and do not explain how organizational leadership and teacher motivation jointly contribute to digital literacy competence. Indonesian writing on leadership in the digital era is also largely conceptual (Tobondo, 2025).

This research addresses this gap by examining the influence of school leadership and teacher motivation on teachers' digital literacy competence using the Partial Least Squares Structural Equation Modeling (PLS-SEM) approach. This method examines the measurement and structural models simultaneously. The findings are expected to add empirical evidence to the educational leadership literature on the determinants of teachers' digital literacy competence. The results may also help policymakers, school principals, and educational institutions design leadership strategies and motivational programs that strengthen teachers' digital competencies.

LITERATURE REVIEW

Teachers' digital literacy competence has become a fundamental requirement for effective teaching and learning in the digital era. Digital literacy encompasses teachers' ability to access, evaluate, create, and communicate information using digital technologies to support instructional practices (Redecker, 2017). The TPACK framework adds that effective technology use depends on combining technological, pedagogical and content knowledge (Koehler et al., 2014). The development of this competence is influenced by both organizational and individual factors, among which school leadership and teacher motivation are considered important determinants.

School leadership refers to the ability of school principals to influence, guide, and support teachers in achieving educational goals through effective management, instructional supervision, professional development, and organizational innovation (Hallinger, 2011). Effective school leaders establish a supportive school climate, provide access to technological resources, and encourage teachers to integrate digital technology into classroom instruction. Effective leadership is therefore expected to have a positive influence on teachers' digital literacy competence.

Teacher motivation refers to the internal and external forces that drive teachers to continuously improve their professional knowledge, skills, and instructional practices. According to Ryan and Deci (2020), motivation increases individuals' engagement, persistence, and willingness to learn. Motivated teachers are more likely to participate in professional development programs, adopt innovative teaching strategies, and use digital technologies effectively. Higher teacher motivation is therefore expected to contribute positively to teachers' digital literacy competence.

Based on the theoretical perspectives and previous empirical studies, this research proposes that school leadership and teacher motivation are exogenous variables that directly influence teachers' digital literacy competence as the endogenous variable. The conceptual framework (Figure 1) illustrates the hypothesized relationships. H1 states that school leadership is positively related to teachers' digital literacy competence, and H2 that teacher motivation is positively related to it. The joint contribution of the two variables (H3) is assessed with the coefficient of determination (R^2) in Partial Least Squares Structural Equation Modeling (PLS-SEM).

Research Objectives

This study aims to investigate the influence of school leadership and teacher motivation on teachers' digital literacy competence in public elementary schools. Specifically, the study examines the individual effects of school leadership and teacher motivation on teachers' digital literacy competence, as well as their simultaneous influence. It also estimates how much of the variance in teachers' digital literacy competence these variables explain, using the Partial Least Squares Structural Equation Modeling (PLS-SEM) approach.

RESEARCH METHOD

Research Design

This study employed a quantitative research design using an explanatory survey approach to examine the relationships among school leadership, teacher motivation, and teachers' digital literacy competence. A quantitative approach was considered appropriate because it allows variables to be measured objectively and the hypothesized relationships among latent constructs to be tested statistically (Creswell & Creswell, 2018).

The study adopted a cross-sectional design, in which data were collected at a single point in time from public elementary school teachers. This design allows the relationships proposed in the research model to be tested efficiently (Saunders, Lewis, & Thornhill, 2019).

Data were collected using a structured questionnaire consisting of indicators measuring school leadership, teacher motivation, and teachers' digital literacy competence. All questionnaire items were assessed using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Prior to hypothesis testing, the measurement model was evaluated through convergent validity, discriminant validity, and construct reliability to check the adequacy of the research instrument.

Teachers' digital literacy competence was measured across six dimensions: knowledge, skills, attitudes, ethical and responsible use, digital communication and collaboration, and problem solving and innovation. The knowledge dimension, for example, refers to teachers' understanding of digital technologies and their educational use, and was measured through indicators of teachers' understanding of digital applications, information literacy, digital communication, online learning platforms, digital ethics and cybersecurity awareness, in line with the DigCompEdu framework (Redecker, 2017).

The proposed research model was analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS 4 software. PLS-SEM was selected because it is suitable for examining complex relationships among latent variables, accommodates data that may not meet multivariate normality assumptions, and is appropriate for prediction-oriented research (Hair, Hult, Ringle, & Sarstedt, 2022). The analysis first evaluated the measurement model (*outer model*) through indicator reliability, convergent validity, discriminant validity, and internal consistency reliability. It then evaluated the structural model (*inner model*) using path coefficients, coefficient of determination (R^2), effect size (f^2), predictive relevance (Q^2), and hypothesis testing through the bootstrapping procedure.

Table 1. Research variables

Variable	Code	Number of Indicators	Measurement Scale
School Leadership	X1	*(sesuai tesis)*	Five-point Likert Scale
Teacher Motivation	X2	*(sesuai tesis)*	Five-point Likert Scale
Teachers' Digital Literacy Competence	Y	*(sesuai tesis)*	Five-point Likert Scale

Table 2. Measurement criteria of the outer model

Assessment	Criteria	Reference
Indicator Reliability	Outer Loading ≥ 0.70	Hair et al. (2022)
Convergent Validity	AVE ≥ 0.50	Hair et al. (2022)
Internal Consistency Reliability	Composite Reliability ≥ 0.70	Hair et al. (2022)
Reliability	Cronbach's Alpha ≥ 0.70	Hair et al. (2022)
Discriminant Validity	HTMT < 0.90	Henseler et al. (2015)

Table 3. Structural model evaluation criteria

Assessment	Criteria	Reference
Coefficient of Determination	R^2 = 0.25 (weak), 0.50 (moderate), 0.75 (substantial)	Hair et al. (2022)
Effect Size	f^2 = 0.02 (small), 0.15 (medium), 0.35 (large)	Cohen (1988)
Predictive Relevance	$Q^2 > 0$	Hair et al. (2022)
Hypothesis Testing	t-value > 1.96 and p-value < 0.05	Hair et al. (2022)
Model Fit	SRMR < 0.08	Hair et al. (2022)

RESULTS

Table 4 shows that school leadership had a positive and significant effect on teachers' digital literacy competence ($\beta = 0.421$, $t = 5.86$, $p < 0.001$), so H1 was supported.

Teacher motivation also had a positive and significant effect on teachers' digital literacy competence ($\beta = 0.387$, $t = 5.01$, $p < 0.001$), so H2 was supported.

Together, the two variables explained 62.8% of the variance in teachers' digital literacy competence ($R^2 = 0.628$, as reported in the abstract), which is moderate by the criteria in Table 3. Table 4 lists H3 (the joint effect) as supported; in PLS-SEM this joint contribution is expressed by R^2 rather than by a separate test.

Table 4. Hypothesis testing

Hypothesis	β	t	p	Result
H1	0.421	5.86	<0.001	Supported
H2	0.387	5.01	<0.001	Supported
H3	Simultaneous	—	—	Supported

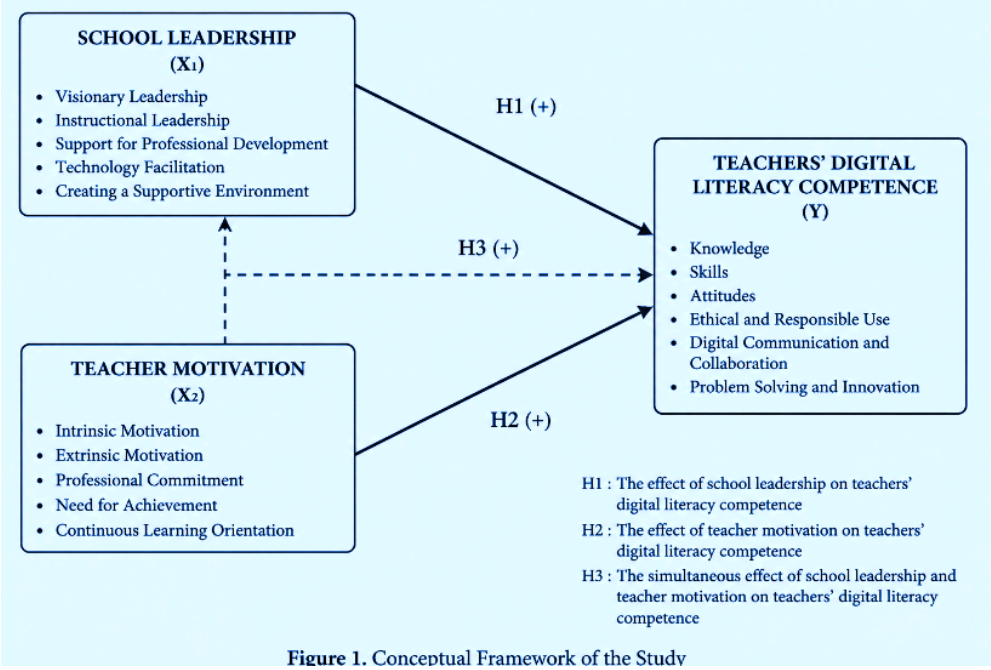

Figure 1. Conceptual framework of the study

DISCUSSION

Both hypothesized paths were supported. School leadership (β = 0.421, t = 5.86) and teacher motivation (β = 0.387, t = 5.01) were each positively related to teachers' digital literacy competence ($p < 0.001$; Table 4), and the two coefficients were similar in size. Together they explained 62.8% of the variance, a moderate level by the criteria in Table 3. The design is cross-sectional, so the results describe associations; they do not show that leadership or motivation caused higher competence.

The first finding is that teachers who rated their principal's leadership more positively also reported higher digital literacy competence. Principals decide how time, devices, internet access and training budgets are used, and they set expectations for how technology is used in class. These decisions shape the opportunities teachers have to practise digital skills. The result agrees with Leithwood et al. (2020), who conclude that leadership works largely through teachers' motivation, capacity and working conditions, and with Indonesian studies that link principals' digital leadership to teacher performance (Timan et al., 2022) and principals' leadership to teachers' innovative work behaviour (Hidayat & Patras, 2022). Zeng et al. (2025) describe the same mechanisms in their review: resource allocation, professional development, learning communities and a supportive culture. Hallinger (2011), however, found that most leadership effects run indirectly through school conditions. The direct path estimated here therefore probably combines several indirect routes, such as school culture and access to training, that the model does not separate. For principals of public elementary schools, the practical implication is to plan digital development as part of school management: regular in-school training, peer mentoring by more experienced teachers, and a small innovation team. Ofita et al. (2024) found that principal support, teacher digital literacy and innovation teams were key to digital leadership in junior high schools, while budget limits and uneven infrastructure held it back.

The second finding is that more motivated teachers reported higher digital literacy competence. Self-determination theory explains why: when teachers learn digital skills because they value them or find them

interesting, they persist longer and practise more (Ryan & Deci, 2020). Ertmer and Ottenbreit-Leftwich (2010) also show that teachers' self-efficacy and beliefs shape whether they change their use of technology, and motivation is closely tied to both. The finding fits Indonesian reports that teachers' adaptation to digital learning varies between individuals, for example between younger and senior teachers (Afrillia & Dafit, 2025), and that teachers can use technology when they have to but still need training (Suwarjo et al., 2022). Because motivation was measured as a single construct, this study cannot say whether intrinsic or extrinsic motivation matters more. For schools and education offices, the implication is that digital training should give teachers some choice of tools and goals, show the classroom value of each skill, and recognize teachers who apply what they learn.

The two predictors had coefficients of similar size, which suggests that organizational support and individual motivation complement each other. A teacher with high motivation but no devices, time or training may not develop much digital competence, and good leadership may not help a teacher who sees no value in technology. The two factors may also be linked: Tobondo (2025) argues that transformational leadership helps teachers adapt to technology partly by keeping them motivated, and Figure 1 indicates a relationship between the two predictors. Future studies could test teacher motivation as a mediator between leadership and digital competence rather than as a parallel predictor. For district education offices, the complementarity suggests that training programmes for teachers and for principals should be linked. A workshop that raises teachers' skills will have little lasting effect if principals do not protect time for practice, provide equipment and follow up in supervision. Training for principals could therefore include how to plan school-based digital development, how to use peer mentoring, and how to recognize teachers' progress, so that leadership support and teacher motivation reinforce each other.

Several limitations should be noted. First, the cross-sectional design does not allow causal conclusions. Second, all three constructs were self-reported by the same teachers, so common method variance may have inflated the relationships (Podsakoff et al., 2003). Teachers' digital literacy competence in particular was self-rated rather than assessed through performance tasks or observation. Third, the paper describes the measurement model criteria (Table 2) and structural model criteria (Table 3) but does not report the results: outer loadings, composite reliability, AVE, Cronbach's alpha, HTMT (Henseler et al., 2015), f^2 (Cohen, 1988), Q^2 and SRMR. Without these values, the validity of the constructs and the size of each effect cannot be judged (Hair et al., 2022). Fourth, the population, schools, district and response rate are not described, and the number of indicators per variable is missing from Table 1, which limits generalization and replication. Future research could combine self-reports with performance-based assessments of teachers' digital competence based on DigCompEdu (Redecker, 2017; Arimbawa et al., 2024), test mediation, compare schools in urban and rural districts, and follow teachers through a training programme to see whether changes in leadership practice are followed by changes in competence.

CONCLUSION AND RECOMMENDATIONS

This study investigated the influence of school leadership and teacher motivation on teachers' digital literacy competence using the Partial Least Squares Structural Equation Modeling (PLS-SEM) approach. The findings show that school leadership has a positive and significant effect on teachers' digital literacy competence. Effective school leaders may contribute by creating a supportive organizational environment: facilitating technology integration, encouraging professional development, and providing instructional guidance that strengthens teachers' digital capabilities.

The results also indicate that teacher motivation positively and significantly affects teachers' digital literacy competence. Teachers with higher levels of intrinsic and extrinsic motivation are more likely to participate in continuous professional learning, adopt innovative instructional practices, and use digital technologies effectively in teaching and learning.

Together, school leadership and teacher motivation explain a moderate proportion of the variance (R^2 = 0.628) in teachers' digital literacy competence, suggesting that organizational and individual factors complement one another in improving teachers' readiness to implement technology-based learning. These findings are consistent with previous studies that emphasize educational leadership and teacher motivation in digital

transformation within schools. Strengthening school leadership and teacher motivation therefore appear to be useful strategies for improving teachers' digital literacy competence.

Schools are encouraged to strengthen leadership practices and provide continuous support for teachers' professional development in digital literacy. Teachers should actively improve their digital competencies through training and self-directed learning. Future studies could examine additional variables and different educational contexts to broaden understanding of the factors affecting teachers' digital literacy competence.

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REFERENCES

Afrillia, A., & Dafit, F. (2025). Tantangan guru mengimplementasikan pembelajaran berbasis teknologi digital dalam Kurikulum Merdeka di UPT SDN 023 Pandau Jaya. Pendas: Jurnal Ilmiah Pendidikan Dasar, 10(4), 230–242. https://doi.org/10.23969/jp.v10i04.36163

Arimbawa, G. P. A., Wikanta, I. M. I. A., Sumarno, I. W., Dantes, G. R., Indrawan, G., & Gunawan, I. M. A. O. (2024). Exploring the digital literacy levels of junior high school Indonesian language teachers: A DigCompEdu perspective. Jurnal Edutech Undiksha, 12(2), 322–333. https://doi.org/10.23887/jeu.v12i2.86129

Caena, F., & Redecker, C. (2019). Aligning teacher competence frameworks to 21st century challenges: The case for the European Digital Competence Framework for Educators (DigCompEdu). European Journal of Education. https://doi.org/10.1111/ejed.12345

Cohen, J. (1988). Statistical power analysis for the behavioral sciences (2nd ed.). Lawrence Erlbaum Associates.

Creswell, J. W., & Creswell, J. D. (2018). Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.). Sage.

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. Journal of Research on Technology in Education, 42(3), 255–284.

Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2022). A primer on partial least squares structural equation modeling (PLS-SEM) (3rd ed.). Sage.

Hallinger, P. (2011). Leadership for learning: Lessons from 40 years of empirical research. Journal of Educational Administration, 49(2), 125–142. https://doi.org/10.1108/09578231111116699

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. Journal of the Academy of Marketing Science, 43(1), 115–135. https://doi.org/10.1007/s11747-014-0403-8

Hidayat, R., & Patras, Y. E. (2022). The effect of principals' leadership and learning organization on teachers' innovative work behavior during the COVID-19 pandemic. Tadris: Jurnal Keguruan dan Ilmu Tarbiyah, 7(1), 161–175. https://doi.org/10.24042/tadris.v7i1.11355

Koehler, M. J., Mishra, P., Kereluik, K., Shin, T. S., & Graham, C. R. (2014). The technological pedagogical content knowledge framework. In J. M. Spector, M. D. Merrill, J. Elen, & M. J. Bishop (Eds.), Handbook of research on educational communications and technology (pp. 101–111). Springer.

Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven strong claims about successful school leadership revisited. School Leadership & Management, 40(1), 5–22. https://doi.org/10.1080/13632434.2019.1596077

Ofita, C., Komariah, A., & Abubakar, A. (2024). Assessing digital leadership of junior high school principals. Journal of Educational Management and Instruction, 4(1), 127–139. https://doi.org/10.22515/jemin.v4i1.9502

Pabbajah, M., Hassan, Z., Juhansar, J., Widyanti, R. N., & Fitria, A. Z. (2025). Unpreparedness of Indonesian madrasah teachers in utilizing technology for digital religious learning-teaching. Jurnal Tarbiyatuna, 16(1), 1–15. https://doi.org/10.31603/tarbiyatuna.v16i1.11390

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal of Applied Psychology, 88(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Redecker, C. (2017). European framework for the digital competence of educators: DigCompEdu (Y. Punie, Ed.). Publications Office of the European Union. https://doi.org/10.2760/178382

Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. Contemporary Educational Psychology, 61, Article 101860. https://doi.org/10.1016/j.cedpsych.2020.101860

Saunders, M., Lewis, P., & Thornhill, A. (2019). Research methods for business students (8th ed.). Pearson.

Suwarjo, S., Haryanto, H., Wuryandani, W., Mahfuzah, A., Hidayah, R., & Erviana, V. Y. (2022). Digital literacy analysis of elementary school teachers on distance learning instructional process in Yogyakarta. Al-Ishlah: Jurnal Pendidikan, 14(2), 1145–1156. https://doi.org/10.35445/alishlah.v14i2.1233

Timan, A., Mustiningsih, M., & Imron, A. (2022). Digital leadership kepala sekolah hubungannya dengan kinerja guru dan kompetensi siswa era abad 21. Jurnal Administrasi dan Manajemen Pendidikan, 5(4).

Tobondo, Y. A. (2025). Manajemen sekolah di era digital: Optimalisasi kepemimpinan transformasional untuk peningkatan kinerja guru di Indonesia. Sukma: Jurnal Pendidikan, 9(1), 61–83. https://doi.org/10.32533/09104.2025

Zeng, M., Cheah, K. S. L., & Abdullah, Z. (2025). The influence of school principals' digital leadership on teachers' competency in integrating artificial intelligence: A systematic thematic review. Frontiers in Education, 10, Article 1655967. https://doi.org/10.3389/feduc.2025.1655967

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

Work Culture and Principal Leadership Impact on Elementary Teachers' Job Satisfaction

Indar Wiyati[1*], Gunawan Setiadi[1] and Sri Utaminingsih[1]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: indarwiyati@gmail.com

ABSTRACT

This study examines the influence of work culture and principal leadership on teacher job satisfaction in public elementary schools in Grobogan Regency, Indonesia. Using a quantitative survey design, the study collected data from 373 teachers across 19 sub-districts. Validated instruments covered dimensions of work culture (organizational norms, collaboration, group dynamics) and principal leadership (transformational, participative, instructional styles), as well as multiple facets of teacher job satisfaction. Data analysis was conducted using Structural Equation Modeling (SEM) with AMOS 26. Most respondents were female (81%) and civil servants (85%), in line with national patterns in the teaching profession. Work culture and principal leadership both had positive but non-significant direct effects on teacher job satisfaction. Model fit indices (GFI = 0.913, CFI = 0.954, RMSEA = 0.065) indicate an acceptable structural model, and the two independent variables together explain only 49.2% of the variance in job satisfaction. These findings suggest that teacher job satisfaction may also depend on factors outside the examined organizational variables, such as economic welfare, administrative workload, and facilities. Practical implications include the need to strengthen supportive leadership, provide more opportunities for participation, and improve working conditions. Further research should examine additional determinants and use longitudinal or comparative designs in other educational contexts.

KEYWORDS work culture | principal leadership | teacher job satisfaction | elementary education

INTRODUCTION

Teacher job satisfaction matters to schools because it is tied to how teachers work and whether they stay in the profession. Teachers who report high stress and low satisfaction are more likely to experience emotional exhaustion and to consider leaving teaching (Skaalvik & Skaalvik, 2017). Reviews of school leadership research also treat teachers' satisfaction, commitment and motivation as the main channels through which principals influence student learning (Leithwood & Jantzi, 2005; Leithwood et al., 2020). Knowing which school conditions are associated with satisfaction is therefore a practical question for district offices and principals.

In Indonesia, public elementary teachers teach several subjects to one class and also carry a growing load of administrative reporting, while curriculum expectations have risen with successive reforms. Since decentralization, district governments manage public elementary schools, and the school cultures and leadership practices that teachers experience can differ between and within districts. Research on teachers' work shows that local context shapes what teachers need and how school organization affects them (Matsko & Hammerness, 2014). Findings from one region may therefore not transfer to another, and district policy needs local evidence.

Work culture is one organizational characteristic that shapes teachers' daily experience. It refers to the shared values, beliefs, norms and practices of a school, including both its working environment and the social relations among staff (Schoen & Teddlie, 2008). Indonesian studies link these features to teachers' attitudes. In a qualitative case study, a school culture of innovation, results orientation and support for professional growth raised teachers' work motivation (Imawati et al., 2025). In 163 public elementary school teachers in Sukabumi, school organizational culture correlated positively with job satisfaction (r = 0.620) (Nurhadidjah et al., 2023). In Pati Regency, school culture was related to teacher performance, with work motivation mediating part of that effect (Ardliana et al., 2021).

Principal leadership is the second factor. Leadership research distinguishes transformational, participative and instructional dimensions, each of which may relate differently to teachers' experiences (Hallinger & Liu, 2016).

Reviews of successful school leadership describe principals as shaping teachers' working conditions, motivation and capacity (Day & Sammons, 2016; Leithwood et al., 2020). Quantitative syntheses support a positive association with satisfaction. A meta-analysis of ten studies found a moderate correlation between principals' transformational leadership and teacher job satisfaction (r = 0.50) (Juhji & Tarihoran, 2022), and a meta-analysis of 65 Asian studies found positive effects of transformational leadership on teachers' job satisfaction, commitment and self-efficacy (Firmansyah et al., 2022). In the Sukabumi study, principals' transformational leadership correlated with satisfaction at r = 0.694, and leadership and culture together accounted for 54% of its variance (Nurhadidjah et al., 2023).

This evidence has three limits for the present setting. Much of it rests on bivariate correlations, which cannot show whether culture and leadership each relate to satisfaction once the other is taken into account. Several Indonesian studies examine secondary or vocational schools or teacher performance rather than satisfaction (Ardliana et al., 2021; Novitasari, 2020). The findings are also not uniform: in Batam elementary schools, principals' distributed leadership alone had no significant effect on education quality, whereas teacher leadership did (Yasrizal et al., 2022). Few studies have modelled work culture and principal leadership together for elementary teachers in a rural regency of Central Java.

The authors' preliminary observations in Grobogan Regency point to teacher turnover, lower motivation, and uneven satisfaction across elementary schools, which may reflect weaknesses in organizational culture and leadership. The regency has 19 sub-districts with diverse socioeconomic characteristics, so school contexts vary in ways that may influence the relationships between organizational variables and teacher satisfaction. However, these relationships have not been investigated systematically in the regency, which limits evidence-based policy and school improvement.

This study examines the influence of work culture and principal leadership on elementary teacher job satisfaction within the specific context of Grobogan Regency, Indonesia. The specific objectives are: (1) analyzing the direct effect of work culture dimensions on teacher job satisfaction levels; (2) evaluating the direct impact of principal leadership styles on teacher job satisfaction; (3) assessing the simultaneous influence of work culture and principal leadership on teacher job satisfaction; and (4) determining the relative contribution of each variable to the variance in teacher job satisfaction.

The study uses structural equation modeling on survey data from teachers in every sub-district of the regency, which allows both predictors to be estimated in one model. It contributes evidence from a rural regency, where most published Indonesian studies have not been conducted, and it reports a case in which the expected effects were not significant. For district education offices and principals, the results indicate whether strengthening work culture and leadership alone is likely to raise teacher satisfaction, or whether working conditions also need attention.

LITERATURE REVIEW

The conceptual framework of this study is constructed to examine the direct and simultaneous effects of work culture and principal leadership on teacher job satisfaction in public elementary schools. It draws on organizational behavior theory and the educational leadership literature, both of which emphasize the importance of organizational climate and leadership in shaping teacher attitudes and outcomes (Hallinger & Liu, 2016; Leithwood & Jantzi, 2005).

Organizational Work Culture Theory

Work culture encompasses the shared norms, values, beliefs, and practices that characterize an organization and influence members’ experiences and motivation (Schoen & Teddlie, 2008). In school contexts, elements such as collegiality, shared vision, collaboration, and a supportive atmosphere have been linked to teachers' work motivation and job satisfaction (Imawati et al., 2025; Nurhadidjah et al., 2023).

Educational Leadership Theory

Principal leadership is recognized as a multidimensional construct involving transformational, participative, and instructional styles (Hallinger & Liu, 2016). Effective leadership inspires teachers, encourages their participation in decision-making, and guides daily instructional practice, which supports professional growth and job satisfaction.

Teacher Job Satisfaction Theory

Teacher job satisfaction refers to the emotional response of teachers to their professional roles, influenced by personal, organizational, and external factors (Skaalvik & Skaalvik, 2017). High satisfaction is linked to improved performance, commitment, and well-being.

Framework Structure

The framework is structured as follows:

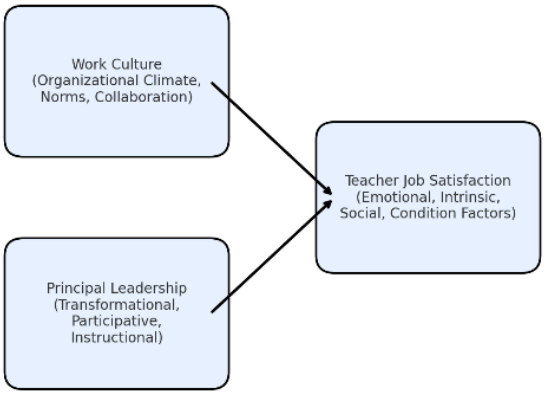

Figure 1. Conceptual framework

Research Hypotheses

Based on the framework, the study tests the following hypotheses:

H1: Work culture has a positive and significant effect on teacher job satisfaction.

H2: Principal leadership has a positive and significant effect on teacher job satisfaction.

H3: Work culture and principal leadership together significantly predict teacher job satisfaction.

Research Objectives

The research objectives were formulated to provide an empirical understanding of the organizational factors that affect teacher job satisfaction in public elementary schools. They address the central issues, knowledge gaps, and theoretical propositions highlighted in the conceptual framework. The specific research objectives are as follows:

1. ***To analyze the direct effect of work culture on teacher job satisfaction***

This objective examines how the perceived organizational environment (collegiality, shared norms, group dynamics, and collaboration among teachers) affects the emotional, social, and intrinsic aspects of elementary teachers' job satisfaction, drawing on theories of organizational climate (Schoen & Teddlie, 2008; Imawati et al., 2025).

2. ***To evaluate the direct effect of principal leadership on teacher job satisfaction***

This objective assesses how the principal's leadership style (transformational, participative, or instructional) affects teachers' job satisfaction. The study seeks to clarify which leadership behaviors most influence professional fulfillment, engagement, and workplace motivation, consistent with leadership theory (Hallinger & Liu, 2016).

3. ***To assess the simultaneous influence of work culture and principal leadership on teacher job satisfaction***

This objective investigates the joint contribution of work culture and leadership to the variance in teacher job satisfaction. The aim is to determine whether these factors reinforce each other and to inform strategies for improving satisfaction.

4. ***To identify the proportion of teacher job satisfaction that can be explained by work culture and principal leadership***

This objective uses Structural Equation Modeling to quantify the relative contribution of the independent variables in predicting teacher job satisfaction, while acknowledging other organizational and contextual influences.

5. ***To recommend evidence-based strategies for improving teacher job satisfaction at the primary education level***

Based on the findings, the study aims to provide practical recommendations for policymakers, school principals, and stakeholders regarding effective organizational development and leadership approaches in elementary schools.

By addressing these objectives, the study aims to fill the identified gaps in the literature, support local policy interventions, and inform theory and practice on the organizational determinants of teacher satisfaction in the Indonesian context and comparable educational systems.

RESEARCH METHOD

This study adopts a quantitative research approach with a survey design to empirically examine the influence of work culture and principal leadership on teacher job satisfaction in public elementary schools in Grobogan Regency, Indonesia. This design supports objectivity, replicability, and statistical generalization to the population of public elementary school teachers in the regency.

Research Design

A survey design was selected because it allows data to be collected from a large sample to measure relationships among organizational, leadership, and satisfaction variables using standardized instruments (Creswell & Creswell, 2018). The study tests hypotheses and models the structure of these relationships statistically.

Population and Sample

Population: The population consists of all teachers employed in public elementary schools within the 19 sub-districts of Grobogan Regency, totaling 5,493 individuals.

Sample: Using proportional random sampling, 373 teachers were selected, to obtain proportional representation across sub-districts, gender, and employment status. The sample was considered large and diverse enough for robust statistical analysis.

Sample Distribution by Sub-district:

Table 1. Sample distribution by sub-district

No	Sub-district	Teachers	Male	Female
1	Purwodadi	585	156	429
...	...	...	...	...
19	Klambu	170	45	125
	Total	5,493	1,699	3,794

Research Variables and Measurement

- Independent Variables:

    - Work Culture: Measured with 20 items spanning physical/social environment, organizational norms, collaboration, and group dynamics.
    - Principal Leadership: Operationalized through 20 items covering transformational, participative, and instructional leadership styles.
- Dependent Variable:
    - Teacher Job Satisfaction: Evaluated with 20 items, including emotional response, intrinsic factors (autonomy, development), collegial/student relationships, and working conditions.

Instruments were adapted from published scales and validated through expert review and pilot testing.

- Response Scale: A Likert-type scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

Data Collection

Data were gathered through self-administered questionnaires distributed to selected teachers. Respondents were assured of anonymity and confidentiality to promote honest and unbiased responses.

Data Analysis Techniques

The study used Structural Equation Modeling (SEM) in AMOS 26 to test the hypothesized relationships and model fit. The analysis included:

- Descriptive statistics (mean, SD, min, max) for all variables.
- Validity analysis (convergent and discriminant) using Average Variance Extracted (AVE), factor loadings, and model fit indices.
- Reliability analysis using Cronbach's Alpha.
- Tests for normality, multicollinearity (Variance Inflation Factor/VIF), and heteroskedasticity.
- Path analysis to determine the magnitude, direction, and significance of direct and simultaneous effects between variables.

Model fit was assessed using standard indices such as CMIN/DF, GFI, AGFI, RMSEA, CFI, TLI, and NFI. Measurement and structural model criteria were determined based on established cut-off values (Hu & Bentler, 1999).

Ethical Considerations

All data collection and analysis procedures followed ethical research guidelines, including informed consent, voluntary participation, and data privacy protection.

Limitations

This methodology does not account for in-depth qualitative perspectives, potential response bias, or longitudinal changes. However, it allows hypothesis testing on a large sample, and the results may generalize to comparable educational contexts.

RESULTS

Descriptive Statistics

Of the 373 respondents, 81% were female, a higher share than in the teacher population, which is 69% female (3,794 of 5,493; Table 1). The largest age group was 31–40 years (38%), and most respondents were civil servants (ASN, 84.5%), indicating high employment stability among public elementary school teachers.

Mean scores for the three main variables indicate generally favorable perceptions:

- Work Culture: Mean = 4.12, SD = 0.48
- Principal Leadership: Mean = 3.99, SD = 0.51
- Teacher Job Satisfaction: Mean = 4.05, SD = 0.46

The standard deviations for all variables are small, indicating that participants' perceptions were consistent.

Instrument Validity and Reliability

- Convergent validity: All constructs exceeded the AVE threshold (>0.50), and most items had satisfactory factor loadings.
- Discriminant validity: The square root of AVE for each construct was greater than the correlations between constructs (Work Culture = 0.78, Leadership = 0.76, Job Satisfaction = 0.79).
- Reliability: Cronbach's Alpha values were above 0.90 for the principal constructs, indicating very high reliability.

Model Fit (SEM Analysis)

The SEM results indicated an acceptable model fit:

- GFI = 0.913
- CFI = 0.954
- RMSEA = 0.065. Chi-Square/df was within the accepted range, although the chi-square test was significant (p = 0.000), which is common with large samples (Hu & Bentler, 1999).

Hypothesis Testing (Path Analysis)

Table 2. Results of hypothesis testing (path analysis)

Pathway	Estimate	S.E.	C.R.	P value	Conclusion
Teacher Job Satisfaction ← Work Culture	2.91	1.956	1.487	0.137	Not significant
Teacher Job Satisfaction ← Leadership	0.001	0.012	0.103	0.918	Not significant

Both work culture (estimate = 2.91, SE = 1.956, C.R. = 1.487, p = 0.137) and principal leadership (estimate = 0.001, SE = 0.012, C.R. = 0.103, p = 0.918) showed *positive but not statistically significant* direct effects on teacher job satisfaction (Table 2).

Explained Variance

The simultaneous influence of work culture and leadership explains 49.2% (R^2 = 0.492) of the variance in teacher job satisfaction, which indicates moderate explanatory power and leaves room for other factors.

DISCUSSION

The Role of Work Culture and Principal Leadership

Neither H1 nor H2 was supported. The path from work culture to job satisfaction was positive but not significant (estimate = 2.91, SE = 1.956, p = 0.137), and the path from principal leadership was close to zero (estimate = 0.001, SE = 0.012, p = 0.918) (Table 2). These are unstandardized estimates, so their sizes cannot be compared directly, but neither path differs reliably from zero. The result contrasts with most earlier work. In Sukabumi, transformational leadership and school culture each correlated with elementary teachers' satisfaction at r = 0.694 and r = 0.620 (Nurhadidjah et al., 2023), and meta-analyses report moderate positive associations between principal leadership and teacher job satisfaction (Firmansyah et al., 2022; Juhji & Tarihoran, 2022). The lack of significance here may reflect conditions in Indonesian public elementary education, such as bureaucratic procedures, limited resources or external economic incentives, which could weaken or overshadow organizational influences.

The model also reports that work culture and leadership together explain 49.2% of the variance in satisfaction (R^2 = 0.492). Two predictors that are each non-significant yet jointly explain about half of the variance usually indicates that they are strongly correlated with each other, so that neither adds much once the other is held constant (Kline, 2023). Teachers who rate their school culture favorably probably also rate their principal favorably, because principals help shape that culture. The paper does not report the correlation between the two constructs or the VIF values, so this explanation cannot be confirmed here. If it holds, the result means that culture and leadership are associated with satisfaction as a combined perception of the school, and that the data cannot

separate their individual contributions. H3 should be read in this way, as a joint association rather than as two independent effects.

Possible Explanations and Supporting Evidence

Several explanations are possible:

- Working Conditions and Resource Constraints: In resource-limited settings, even a positive work culture or effective leadership may not sufficiently address teachers' needs and frustrations if basic support (infrastructure, remuneration, job security) is lacking (Skaalvik & Skaalvik, 2017).
- Uniform Perceptions: The small standard deviations and high means suggest that most respondents perceived the organizational climate positively. This restricted range could reduce detectable differences in satisfaction. When nearly all teachers rate their school and principal favorably, there is little variation for the model to relate to differences in satisfaction, and path estimates become unstable, which is consistent with the large standard error for work culture.
- Dominance of External Factors: Economic well-being, administrative workload, and institutional support may play a stronger role in shaping job satisfaction than internal organizational dynamics alone. These were not measured here, so this explanation remains a hypothesis for later studies.
- Indirect Influence: Leadership research suggests that principals affect teachers mainly indirectly, by shaping school conditions, culture and teachers' motivation (Hallinger, 2011; Leithwood & Jantzi, 2005). In Pati Regency, work motivation mediated the effects of principal leadership and school culture on teacher performance (Ardliana et al., 2021). The present model estimated only direct paths from each predictor to satisfaction. If leadership works through work culture or through teacher motivation, its direct path would be small even when its total influence is not.

Comparison with Previous Studies

The results agree with earlier work on direction, since both estimates were positive, but differ on strength. Studies in other Indonesian provinces found significant positive links between transformational leadership and job satisfaction, for example among 131 vocational teachers in Tangerang (Novitasari, 2020) and 250 teachers in Riau, where transformational leadership mediated the effects of reward and commitment on satisfaction (Hardianto et al., 2025). The Grobogan findings are closer to studies that report weaker or non-significant leadership effects, such as the Batam study in which principals' distributed leadership alone did not significantly affect school quality (Yasrizal et al., 2022). One methodological difference may matter. The leadership scale in this study combined transformational, participative and instructional styles in one construct, whereas a meta-analysis found that instructional leadership had an average effect on student outcomes three to four times that of transformational leadership (Robinson et al., 2008). Combining styles with different effects may blur the relationship with satisfaction.

Practical Implications

For policy and practice:

- Focus on Working Conditions: Policies should address broader issues such as reducing administrative burdens, improving remuneration, and enhancing basic facilities. For the Grobogan education office, this suggests reviewing the reporting tasks required of elementary teachers and the support given to teachers who are not civil servants.
- Supportive Leadership Development: Although leadership was not significant in this model, continued investment in principal leadership, especially in facilitative and participative approaches, remains advisable. A review of servant leadership studies in education links supportive, staff-centred leadership with teacher engagement, commitment and job satisfaction (Hossain et al., 2026), and the positive estimates in this study do not argue against such investment.
- Empowerment & Voice: Creating channels for teacher input and strengthening teachers' professional voice could reinforce their sense of ownership and satisfaction.

Limitations and Further Research

This study has several limitations. The design is cross-sectional, so the associations cannot be read as causal effects. All three variables were measured by teachers' self-reports in one questionnaire, which can inflate correlations among constructs through common method variance (Podsakoff et al., 2003). The sample is 81% female, while the population in Table 1 is 69% female, so the sample is not proportional on gender as the sampling plan intended. Several results needed to interpret the model are not reported: standardized path coefficients, the correlation between work culture and leadership, VIF values, and the CMIN/DF value. Finally, work culture and leadership were each treated as single constructs, so the analysis cannot show whether particular dimensions behave differently. Further research could:

- Examine *moderating or mediating variables* such as organizational commitment, teacher autonomy, work motivation or perceived fairness, testing indirect effects with bootstrap confidence intervals (Zhao et al., 2010).
- Conduct *longitudinal studies* to capture changes in satisfaction before and after leadership or cultural interventions.
- Explore cross-context comparisons with urban regions or other provinces to validate context-specific findings.

CONCLUSION AND RECOMMENDATIONS

This study found that work culture and principal leadership have positive but not statistically significant effects on elementary teachers' job satisfaction in Grobogan, Indonesia. Although the model explains nearly half of the variance in satisfaction, other factors such as economic welfare, workload, and employment status may have stronger influences. To improve satisfaction, policymakers should focus on fair compensation, supporting non-permanent teachers, and improving working conditions. School leaders should practice participative and instructional leadership. Future research should examine broader determinants, use comparative and longitudinal designs, and include qualitative data to better understand teacher satisfaction in Indonesian primary education.

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REFERENCES

Ardliana, B., Rusdarti, R., & Suminar, T. (2021). Effect of principal leadership, school culture and pedagogic competence through work motivation on teachers performance. *Educational Management*, *10*(2), 273–283.

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.

Day, C., & Sammons, P. (2016). *Successful school leadership*. Education Development Trust. https://www.educationdevelopmenttrust.com

Firmansyah, F., Prasojo, L. D., Jaedun, A., & Retnawati, H. (2022). Transformational leadership effect on teacher performance in Asia: A meta-analysis. *Cypriot Journal of Educational Sciences*, *17*(6), 2127–2146. https://doi.org/10.18844/cjes.v17i6.7552

Hallinger, P. (2011). Leadership for learning: Lessons from 40 years of empirical research. *Journal of Educational Administration*, *49*(2), 125–142. https://doi.org/10.1108/09578231111116699

Hallinger, P., & Liu, S. (2016). Leadership and teacher learning in urban and rural schools in China: Meeting the dual challenges of equity and effectiveness. *International Journal of Educational Development*, *51*, 163–173. https://doi.org/10.1016/j.ijedudev.2016.10.001

Hardianto, H., Hidayat, H., & Setiawan, M. N. A. (2025). Reward and commitment toward transformational leadership and teachers' job satisfaction. *Jurnal Cakrawala Pendidikan*, *44*(3), 673–684. https://doi.org/10.21831/cp.v44i3.83084

Hossain, M. F., Uddin, M. S., Rana, M. S., & Siddique, M. N.-E.-A. (2026). A systematic literature review of servant leadership in education. *Journal of Ethnic and Cultural Studies*, *13*(1), 1–28. https://doi.org/10.29333/ejecs/2562

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1–55. https://doi.org/10.1080/10705519909540118

Imawati, Maryani, I., & Zuhaery, M. (2025). School culture in fostering teachers' work motivation. *JMKSP (Jurnal Manajemen, Kepemimpinan, dan Supervisi Pendidikan), 10*(1), 778–801. https://doi.org/10.31851/jmksp.v10i1.19207

Juhji, J., & Tarihoran, N. (2022). A meta-analysis study of principal leadership and teacher job satisfaction. *Al-Ishlah: Jurnal Pendidikan, 14*. https://doi.org/10.35445/alishlah.v14i1.1498

Kline, R. B. (2023). *Principles and practice of structural equation modeling* (5th ed.). Guilford Press.

Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven strong claims about successful school leadership revisited. *School Leadership & Management, 40*(1), 5–22. https://doi.org/10.1080/13632434.2019.1596077

Leithwood, K., & Jantzi, D. (2005). A review of transformational school leadership research 1996–2005. *Leadership and Policy in Schools, 4*(3), 177–199. https://doi.org/10.1080/15700760500244769

Matsko, K. K., & Hammerness, K. (2014). Unpacking the "urban" in urban teacher education: Making a case for context-specific preparation. *Journal of Teacher Education, 65*(2), 128–144. https://doi.org/10.1177/0022487113511645

Novitasari, D. (2020). Improving job satisfaction and organizational commitment: Analysis of the effects of the principal transformational leadership. *Dinamika Pendidikan, 15*(2), 172–189. https://doi.org/10.15294/dp.v15i2.25111

Nurhadidjah, A., Rusti, E. R., & Hidayat, Z. (2023). Hubungan gaya kepemimpinan transformasional kepala sekolah dan budaya organisasi sekolah dengan kepuasan kerja guru SD di Kecamatan Cidahu. *Journal of Contemporary Issue in Elementary Education, 1*(1), 62–71. https://doi.org/10.33830/jciee.v1i1.5111

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology, 88*(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Robinson, V. M. J., Lloyd, C. A., & Rowe, K. J. (2008). The impact of leadership on student outcomes: An analysis of the differential effects of leadership types. *Educational Administration Quarterly, 44*(5), 635–674. https://doi.org/10.1177/0013161X08321509

Schoen, L., & Teddlie, C. (2008). A new model of school culture: A response to a call for conceptual clarity. *School Effectiveness and School Improvement, 19*(2), 129–153. https://doi.org/10.1080/09243450802095278

Skaalvik, E. M., & Skaalvik, S. (2017). Teacher stress and teacher self-efficacy: Relations and consequences. In T. M. McIntyre, S. E. McIntyre, & D. J. Francis (Eds.), *Educator stress: An occupational health perspective* (pp. 101–125). Springer. https://doi.org/10.1007/978-3-319-53053-6_5

Yasrizal, Y., Dahlan, J. A., & Chandrawati, T. (2022). Pengaruh kepemimpinan distribusi kepala sekolah dan kepemimpinan guru terhadap mutu pendidikan sekolah dasar. *Lentera: Jurnal Ilmiah Kependidikan, 15*(1), 23–38.

Zhao, X., Lynch, J. G., Jr., & Chen, Q. (2010). Reconsidering Baron and Kenny: Myths and truths about mediation analysis. *Journal of Consumer Research, 37*(2), 197–206. https://doi.org/10.1086/651257

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

The Influence of Principal Leadership on Teacher Job Satisfaction and Professional Performance of Elementary School Teachers in Gebog District, Kudus Regency

Nunung Noor Hayati[1*], Ahmad Hariyadi[1] and Wawan Shokib Rondli[1]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: nunungnoorhayati2558@gmail.com

ABSTRACT

This study was motivated by declining teacher professional performance and teacher dissatisfaction with principal leadership. This study aims to (1) determine the influence of principal leadership on the job satisfaction of public elementary school teachers in Gebog District, Kudus Regency; (2) determine the influence of principal leadership on the professional performance of public elementary school teachers in Gebog District, Kudus Regency; and (3) determine whether principal leadership has a significant influence on teacher job satisfaction and professional performance of public elementary school teachers in Gebog District, Kudus Regency. The study used a quantitative design. The population comprised all elementary school teachers in Gebog District, Kudus Regency, totaling 665 teachers from 55 elementary schools. A sample of 250 teachers was drawn by proportional random sampling. Principal leadership was the exogenous variable, and teacher job satisfaction and teacher professional performance were the endogenous variables. Data were collected with a questionnaire. The data were analyzed with Structural Equation Modeling (SEM), a multivariate technique that models the relationships between variables and their indicators, the relationships among variables, and measurement error. The results indicate that Principal Leadership (X) has a positive and significant relationship with Teacher Job Satisfaction (Y1). It also has a positive and significant relationship with Teacher Professional Performance (Y2). Taken together, Principal Leadership (X) is significantly related to both Teacher Job Satisfaction (Y1) and Teacher Professional Performance (Y2).

KEYWORDS principal leadership | teacher job satisfaction | teacher professional performance

INTRODUCTION

Teacher performance shapes what students learn, because teachers are the people who work most directly with students. In Indonesia, a teacher's performance is usually judged by how well the teacher plans, carries out and evaluates learning, guides students and acts as a role model. Teachers are also expected to uphold their professional status through integrity, dedication and responsibility (Russamsi et al., 2020). Meeting these expectations requires subject knowledge, pedagogical skill and professional attitudes, but it also depends on the conditions in which teachers work. Studies of Indonesian teachers link performance to internal factors such as motivation, discipline and job satisfaction, and to external factors such as leadership style, supervision, the work environment and school facilities (Pratiwi et al., 2021; Ratnasari et al., 2023).

Job satisfaction is one of the internal factors in this list. It refers to teachers' evaluation of their work and its conditions, including relations with the principal and colleagues, workload, recognition and opportunities to develop. Satisfaction and performance are related through the way teachers experience their work. A synthesis of 165 studies found that teacher self-efficacy was linked both to the quality of classroom practice and to teachers' well-being, including job satisfaction and commitment, and negatively to burnout (Zee & Koomen, 2016). Conditions that leave teachers satisfied may therefore also support the planning, teaching and evaluation that define professional performance, although the direction of such links is hard to establish.

Among the external factors, principal leadership is the one most directly under the control of the school. Reviews of school leadership research conclude that principals influence student learning largely through their effects on teachers' motivation, capacity and working conditions (Leithwood et al., 2020). A review of 32 studies

found that transformational school leadership worked mainly indirectly, through school culture, teacher commitment and job satisfaction (Leithwood & Jantzi, 2005). A meta-analysis of 27 studies found that the leadership dimension with the largest effect on student outcomes was promoting and participating in teacher learning and development (Robinson et al., 2008). These reviews treat teachers' satisfaction and performance as the main channels through which leadership reaches students.

Indonesian studies support a positive link between principal leadership and teacher job satisfaction. A meta-analysis of ten Indonesian studies reported a moderate correlation between principals' transformational leadership and teacher job satisfaction (r = 0.50) (Juhji & Tarihoran, 2022). Among 163 public elementary school teachers in Sukabumi, the correlation was r = 0.694 (Nurhadidjah et al., 2023). Structural models of vocational teachers in Tangerang and of 250 teachers in Riau found that transformational leadership raised job satisfaction (Hardianto et al., 2025; Novitasari, 2020).

Evidence on leadership and teacher performance points in the same direction. A meta-analysis of 65 Asian studies found positive effects of transformational leadership on teacher performance indicators (Firmansyah et al., 2022). Among elementary teachers in Lebak Regency and in North Rupat, Riau, principal leadership was positively related to teacher performance (Kamalia et al., 2022; Starlinsky et al., 2022). Other Indonesian studies have examined leadership together with motivation, competence, school climate and discipline as predictors of performance (Deluma et al., 2020; Hamzah et al., 2024; Herdiana & Rohendi, 2021; Sijabat & Yusup, 2024; Soelistya, 2024). Several of them suggest that leadership works partly through teachers' motivation. In Pati Regency, close to Kudus, work motivation mediated the effects of principal leadership and school culture on teacher performance (Ardliana et al., 2021).

Most of these studies examine either job satisfaction or performance, and many were conducted in secondary or vocational schools or in other provinces. Few have modelled the relationships of principal leadership with both the job satisfaction and the professional performance of elementary teachers in one analysis. No published study has examined these relationships in Gebog District, Kudus Regency. The present study was prompted by concerns about declining teacher professional performance and teacher dissatisfaction with principal leadership in the district.

This study therefore examines, first, the relationship between principal leadership and the job satisfaction of public elementary school teachers in Gebog District; second, the relationship between principal leadership and their professional performance; and third, whether principal leadership is significantly related to both outcomes when they are modelled together. The findings are intended to help principals, school supervisors and the Kudus Regency Education Office create working conditions that support teaching quality.

LITERATURE REVIEW

The performance of human resources, including teachers, is influenced by both internal and external factors. Pratiwi et al. (2021) identified eight factors that can influence teacher performance: personality and dedication, professional development, teaching ability, communication, community relations, discipline, welfare, and the work climate. Leithwood et al. (2020) similarly describe teachers' contribution to learning as depending on their capacity, their motivation and their working conditions, all of which principals can influence. In the context of this study, teacher performance is measured by how well teachers plan, implement, and evaluate the learning process. Good leadership and a positive organizational climate can strengthen motivation and create conditions that improve teacher performance.

In line with this, Ratnasari et al. (2023) noted that internal factors influencing teacher performance include motivation, positive and negative emotions, responsibility for tasks, discipline in task completion, concern for students, and job satisfaction. Meanwhile, external factors affecting teacher performance include leadership style, the work environment, evaluation and supervision mechanisms, information and communication technology facilities, and school-based facilities such as clean water, sanitation, electricity, and the condition of the school building. Work discipline and teachers' own competence are also linked to performance (Kamalia et al., 2022; Soelistya, 2024).

In summary, teacher performance is influenced by various internal and external factors. Internal factors include personality, motivation, dedication, emotions, responsibility, discipline, and concern for students. External factors include leadership style, the work environment, evaluation, supervision, and supporting school facilities, such as information technology, sanitation, and infrastructure. High performance is evident when teachers plan, implement, and evaluate learning effectively. Compensation, discipline, and competence also influence teachers' work outcomes, and good leadership and a positive work climate support better performance.

Research Objectives

The subjects of this study are teachers serving as either class teachers or subject teachers at public elementary schools in Gebog District, Kudus Regency. The objectives are to determine whether principal leadership is positively related to teachers' job satisfaction, whether it is positively related to their professional performance, and whether it is significantly related to both outcomes when they are modelled together.

RESEARCH METHOD

Research Design

This study used a questionnaire survey to obtain data on principal leadership, teacher job satisfaction, and the professional performance of teachers at public elementary schools in Gebog District, Kudus Regency. The study is quantitative because it tests hypotheses statistically with numerical data. The data were analyzed with Structural Equation Modeling (SEM), a multivariate technique that models the relationships between variables and their indicators, the relationships among variables, and measurement error (Kline, 2023).

Respondents of the Study

The population consisted of 665 public elementary school teachers in Gebog District, Kudus Regency.

The study used proportional random sampling (Sugiyono, 2020), which draws from each area in proportion to its share of the population. The sample size was determined with Slovin's formula:

$$n = \frac{N}{1 + Ne^2}$$

Where:

n = required sample size

N = total population

e = tolerable margin of error (5%)

For a population of 665 teachers, the formula gives approximately 249.76, which was rounded up to 250 respondents. The respondents were then selected from the schools by proportional random sampling.

RESULTS

Construct validity can be assessed with Exploratory Factor Analysis (EFA) or Confirmatory Factor Analysis (CFA). This study used EFA in SPSS 25.0, together with product-moment correlations, to assess construct validity.

Reliability indicates how consistent a measuring instrument is; it was tested with Cronbach's Alpha.

Respondent Characteristics

The subjects of this study were teachers serving as classroom or subject teachers at public elementary schools in Gebog District, Kudus Regency. The study population included all teachers across 55 public elementary schools, with a total population of 665 teachers. From this number, a sample of 250 respondents was selected using proportional random sampling. The data analyzed were teachers' perceptions of the teachers' attitudes toward the school. Demographic data were collected from the 250 respondents to describe the sample. These characteristics included gender, age, and length of service as a teacher. These data are presented in the table below as context for the variables principal leadership (X), teacher job satisfaction (Y1), and teacher professional performance (Y2).

This overview describes the composition of the sample and provides context for the hypothesis tests.

Table 1. Statistical description of respondent characteristics

Characteristic	Category	Frequency	Percentage (%)
Gender	Male	126	50.40%
	Female	124	49.60%
Age	< 30 years	79	31.60%
	30 - 40 years	72	28.80%
	41 - 50 years	58	23.20%
	> 50 years	41	16.40%
Years of Service	< 5 years	71	28.40%
	5 - 15 years	75	30.00%
	16 - 25 years	58	23.20%
	> 25 years	46	18.40%
Total		250	100.00%

All research variables show a positive trend: for nearly all indicators, most respondents chose "Somewhat Agree" (score 3) or "Agree" (score 4). The mean of every indicator also exceeds the neutral midpoint (3.0). Means range from 3.076 to 3.452, which indicates that teachers hold a moderately favorable view of the principal's leadership, are moderately satisfied with their jobs, and rate their own professional performance as fairly good.

DISCUSSION

The descriptive results show that teachers in Gebog District rated principal leadership, their own job satisfaction and their own professional performance above the neutral midpoint of the scale, with indicator means between 3.076 and 3.452. These values indicate moderately favorable views rather than high ones. Most responses fell on "Somewhat Agree" or "Agree", and no indicator approached the top of the scale. The pattern fits the concerns that prompted the study: teachers do not reject their principals' leadership, but they do not endorse it strongly, and their satisfaction is moderate. Because performance was self-rated, the performance scores may be higher than ratings by supervisors would be, since self-reports are open to social desirability (Podsakoff et al., 2003).

The abstract and conclusions report that principal leadership was positively and significantly related to teacher job satisfaction. The direction agrees with earlier Indonesian studies. A meta-analysis of ten studies found a moderate correlation (r = 0.50) between principals' transformational leadership and teacher job satisfaction (Juhji & Tarihoran, 2022), and among elementary teachers in Sukabumi the correlation was r = 0.694 (Nurhadidjah et al., 2023). Structural models in Tangerang and Riau also found that transformational leadership raised teachers' satisfaction (Hardianto et al., 2025; Novitasari, 2020). A plausible mechanism is that principals shape much of what teachers judge when they rate their satisfaction: clarity of direction, fairness, communication, recognition and the work climate (Leithwood et al., 2020). However, the paper does not yet report the path coefficient, its significance or the explained variance, so the strength of the relationship in Gebog cannot be compared with these studies.

The same sections describe a positive and significant relationship between leadership and professional performance. Studies of elementary teachers in Lebak and North Rupat found similar positive relationships (Kamalia et al., 2022; Starlinsky et al., 2022), and the Asian meta-analysis found positive effects of transformational leadership on teacher performance indicators (Firmansyah et al., 2022). Other studies indicate that the link is partly indirect. In Aceh Besar, principal leadership affected teacher motivation (0.422) as well as performance (0.388) (Sariakin et al., 2025), and in Pati Regency work motivation mediated the effects of leadership and school culture on performance (Ardliana et al., 2021). Robinson et al. (2008) found that leadership focused on teacher learning and instruction had larger effects than transformational leadership alone. For Gebog, this suggests that academic supervision and support for professional learning deserve particular attention.

The conclusions also describe a model in which leadership and job satisfaction together account for 74% of the variation in professional performance. This differs from the model stated in the abstract and method, where job satisfaction and performance are both outcomes of leadership. If job satisfaction lies between leadership and performance, the appropriate test is a mediation model with a bootstrap test of the indirect effect (Zhao et al., 2010). Reviews of transformational leadership describe this kind of pathway, in which leadership effects run through teachers' commitment and job satisfaction (Leithwood & Jantzi, 2005). Until the structural model and its estimates are reported, the 74% figure and the relative weight of leadership and satisfaction cannot be evaluated.

The respondent profile in Table 1 adds context to these results. The sample was balanced by gender (50.40% male and 49.60% female), and it was relatively young: 31.60% of respondents were under 30 years old and 28.40% had less than five years of service. Early-career teachers usually depend more on guidance from the principal and on collegial support than experienced teachers do, so their views of leadership may weigh heavily in the averages. The paper does not compare scores across these groups, so it is not known whether satisfaction or self-rated performance differed by age or length of service. Such a comparison would show whether support should be targeted at newer teachers.

For principals in Gebog District, the moderate ratings indicate room to communicate more clearly, give clearer direction, and use academic supervision as support rather than inspection. For the Kudus Regency Education Office and school supervisors, principal development programs could focus on instructional leadership and on practices that build a supportive work climate, which Indonesian guidance on principal professionalism also stresses (Muspawi, 2020). Supervision that takes the form of regular coaching is supported by a meta-analysis of 60 causal studies, which found pooled effects of 0.49 SD on instruction and 0.18 SD on student achievement (Kraft et al., 2018). These recommendations rest on descriptive scores and on relationships whose statistics are not yet reported, so they are directions to examine rather than tested remedies.

The study has several limitations. The design is cross-sectional, so the relationships cannot be read as causal effects. All variables, including professional performance, were measured by teachers' self-reports in one questionnaire, which can inflate relationships among constructs through common method variance (Podsakoff et al., 2003); ratings by supervisors or classroom observation would give a stronger test. Construct validity was assessed with EFA and item-total correlations, whereas an SEM study would normally report a confirmatory measurement model with loadings, composite reliability, AVE and fit indices (Kline, 2023). The sample comes from one district, which limits generalization to the rest of Kudus Regency or Central Java. Future studies should report the full measurement and structural models, test job satisfaction as a mediator, and add variables such as work motivation and school culture, which earlier Indonesian studies have linked to teacher performance (Ardliana et al., 2021).

CONCLUSION AND RECOMMENDATIONS

Based on the analysis of the influence of school principal leadership and job satisfaction on the professional performance of teachers in public elementary schools in Gebog District, Kudus Regency, the following conclusions can be drawn: School Principal Leadership (X1) was found to have a positive and significant relationship with Teacher Professional Performance (Y). This suggests that improving principal leadership, including managerial skills, supervision, and motivation, may improve teachers' professional performance. Teacher Job Satisfaction (X2) was found to have a positive and significant relationship with Teacher Professional Performance (Y). This implies that teachers' job satisfaction, covering relationships with superiors, colleagues, and the work environment, is an important factor in their professional performance. School Principal Leadership (X1) and Teacher Job Satisfaction (X2) are jointly and significantly related to Teacher Professional Performance (Y). Together, these two variables account for 74% of the variation in Teacher Professional Performance, indicating that leadership and job satisfaction together predict a substantial share of teacher performance.

Recommendations

Based on the findings, the following recommendations are made for stakeholders and future researchers. For School Principals: Principals should regularly evaluate and develop their leadership competencies, particularly effective communication, clear direction, and a conducive work climate. Because leadership was a significant predictor in this study, efforts to become inspiring and supportive leaders may help improve teacher performance. For the Education Office and School Supervisors: The Kudus Regency Education Office, through school supervisors, is advised to design and implement continuous professional development programs focused on enhancing the managerial and leadership capacities of principals. Policies should also aim to improve teachers' job satisfaction, which the study associates with performance. For Future Researchers: The model explains 74% of the variance in teacher performance, so 26% is attributable to other factors. Therefore, future researchers are encouraged to examine variables outside this model, such as school culture, teacher competence, work motivation, or parental involvement. Testing a model that includes these variables could identify further factors that shape teachers' professional performance.

REFERENCES

Ardliana, B., Rusdarti, R., & Suminar, T. (2021). Effect of principal leadership, school culture and pedagogic competence through work motivation on teachers performance. *Educational Management*, *10*(2), 273–283.

Deluma, R. Y., MS, Z., & Asmawi, M. (2020). The effect of principal leadership style, work motivation, and professional competence of primary school teacher performance in Kendari City. *JETL (Journal of Education, Teaching and Learning)*, *5*(1), 145. https://doi.org/10.26737/jetl.v5i1.1134

Firmansyah, F., Prasojo, L. D., Jaedun, A., & Retnawati, H. (2022). Transformational leadership effect on teacher performance in Asia: A meta-analysis. *Cypriot Journal of Educational Sciences*, *17*(6), 2127–2146. https://doi.org/10.18844/cjes.v17i6.7552

Hamzah, H., Manafe, H. A., Kaluge, A. H., & Niha, S. S. (2024). Pengaruh kepemimpinan, iklim sekolah, motivasi, terhadap kinerja dan disiplin guru. *Journal of Education Research*, *5*(3), 4192–4205. https://doi.org/10.37985/jer.v5i3.1499

Hardianto, H., Hidayat, H., & Setiawan, M. N. A. (2025). Reward and commitment toward transformational leadership and teachers' job satisfaction. *Jurnal Cakrawala Pendidikan*, *44*(3), 673–684. https://doi.org/10.21831/cp.v44i3.83084

Herdiana, H., & Rohendi, A. (2021). Pengaruh kompetensi manajerial dan kompetensi supervisi kepala sekolah terhadap kinerja guru SMK Negeri di Kabupaten Bandung Barat. *Jurnal Manajemen Jasa*, *3*(1), 28–38.

Juhji, J., & Tarihoran, N. (2022). A meta-analysis study of principal leadership and teacher job satisfaction. *Al-Ishlah: Jurnal Pendidikan, 14*. https://doi.org/10.35445/alishlah.v14i1.1498

Kamalia, Ayub, D., & Sumarno, S. (2022). The influence of principal leadership and teacher work discipline on elementary school teacher performance. *Journal of Educational Sciences*, *6*(3), 444–458. https://doi.org/10.31258/jes.6.3.p.444-458

Kline, R. B. (2023). *Principles and practice of structural equation modeling* (5th ed.). Guilford Press.

Kraft, M. A., Blazar, D., & Hogan, D. (2018). The effect of teacher coaching on instruction and achievement: A meta-analysis of the causal evidence. *Review of Educational Research*, *88*(4), 547–588. https://doi.org/10.3102/0034654318759268

Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven strong claims about successful school leadership revisited. *School Leadership & Management*, *40*(1), 5–22. https://doi.org/10.1080/13632434.2019.1596077

Leithwood, K., & Jantzi, D. (2005). A review of transformational school leadership research 1996–2005. *Leadership and Policy in Schools*, *4*(3), 177–199. https://doi.org/10.1080/15700760500244769

Muspawi, M. (2020). Strategi menjadi kepala sekolah profesional. *Jurnal Ilmiah Universitas Batanghari Jambi*, *20*(2), 402. https://doi.org/10.33087/jiubj.v20i2.938

Novitasari, D. (2020). Improving job satisfaction and organizational commitment: Analysis of the effects of the principal transformational leadership. *Dinamika Pendidikan*, *15*(2), 172–189. https://doi.org/10.15294/dp.v15i2.25111

Nurhadidjah, A., Rusti, E. R., & Hidayat, Z. (2023). Hubungan gaya kepemimpinan transformasional kepala sekolah dan budaya organisasi sekolah dengan kepuasan kerja guru SD di Kecamatan Cidahu. *Journal of Contemporary Issue in Elementary Education*, *1*(1), 62–71. https://doi.org/10.33830/jciee.v1i1.5111

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology, 88*(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Pratiwi, W. A., Prasetyo, I., & Shabrina, M. N. (2021). Faktor-faktor yang berpengaruh terhadap kinerja guru taman kanak-kanak. *Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini*, *5*(2), 1741–1753. https://doi.org/10.31004/obsesi.v5i2.970

Ratnasari, S. L., Dewi, D. Z. P., Ukhriyawati, C. F., Hasibuan, R., Wibowo, E. A., & Desi, V. T. (2023). Kinerja guru dan faktor-faktor yang mempengaruhinya. *Prosiding Seminar Nasional Forum Manajemen Indonesia, 1*, 595–604. https://doi.org/10.47747/snfmi.v1i.1531

Robinson, V. M. J., Lloyd, C. A., & Rowe, K. J. (2008). The impact of leadership on student outcomes: An analysis of the differential effects of leadership types. *Educational Administration Quarterly, 44*(5), 635–674. https://doi.org/10.1177/0013161X08321509

Russamsi, Y., Hadian, H., & Nurlaeli, A. (2020). Pengaruh kepemimpinan kepala sekolah dan peningkatan profesional guru terhadap kinerja guru di masa pandemi COVID-19. *Managere: Indonesian Journal of Educational Management, 2*(3), 244–255.

Sariakin, S., Yeni, M., Usman, M. B., Mare, A. S., Munzir, M., & Saleh, M. (2025). Fostering a productive educational environment: The roles of leadership, management practices, and teacher motivation. *Frontiers in Education, 10*, Article 1499064. https://doi.org/10.3389/feduc.2025.1499064

Sijabat, H., & Yusup, Y. (2024). Pengaruh kepemimpinan kepala sekolah, lingkungan kerja, motivasi kerja terhadap disiplin kerja serta dampaknya pada kinerja guru di SMA Negeri 1 Mandau Kabupaten Bengkalis. *Menara Ekonomi, 10*(1), 56–71. https://doi.org/10.31869/me.v10i1.5291

Soelistya, D. (2024). Empowering teachers: The impact of transformational leadership and teacher competence on performance through organizational commitment. *Journal of Educational Management and Instruction (JEMIN), 4*(1), 159–173. https://doi.org/10.22515/jemin.v4i1.9555

Starlinsky, L., Belawati, T., & Rosita, T. (2022). Korelasi antara kepemimpinan kepala sekolah dan supervisi akademik terhadap kinerja guru sekolah dasar di Kecamatan Lebakgedong Kabupaten Lebak. *Indonesian Journal of Educational Counseling, 6*(1), 26–33. https://doi.org/10.30653/001.202261.190

Sugiyono. (2020). *Metode penelitian kuantitatif, kualitatif dan kombinasi (mixed methods)*. Alfabeta.

Zee, M., & Koomen, H. M. Y. (2016). Teacher self-efficacy and its effects on classroom processes, student academic adjustment, and teacher well-being: A synthesis of 40 years of research. *Review of Educational Research, 86*(4), 981–1015. https://doi.org/10.3102/0034654315626801

Zhao, X., Lynch, J. G., Jr., & Chen, Q. (2010). Reconsidering Baron and Kenny: Myths and truths about mediation analysis. *Journal of Consumer Research, 37*(2), 197–206. https://doi.org/10.1086/651257

ICISFS-UMK 2026 EDUCATIONAL TECHNOLOGY & MEDIA

Development of "Maran Gepesan" for Fifth Grade Students of Public Elementary School

Purwanti[1*], Gunawan Setiadi[1] and Fina Fakhriyah[1]

[1]*Muria Kudus University, Kudus, Indonesia*

Corresponding author: purwanti03081984@gmail.com

ABSTRACT

This study aimed to develop an educational game-based learning medium called "Maran Gepesan" using the Articulate Storyline 3 application to improve fifth-grade students' learning outcomes in the respiratory system topic at SD Negeri Dabin 1, Geyer District, Grobogan Regency. The study was motivated by students' low learning motivation and outcomes, which were attributed to the dominance of lecture methods and limited use of technology in classrooms. The research employed a Research and Development (R&D) approach using the ADDIE model, encompassing the stages of Analysis, Design, Development, Implementation, and Evaluation. The product was validated by material and media experts and then tested in a limited trial and a wider field trial. The expert validation rated the game as highly feasible, and students' scores improved from pretest to posttest. The N-Gain score was 0.66, indicating a moderate increase in learning outcomes. Students responded positively and described the game as engaging, easy to use, and helpful for understanding the content. The study concludes that "Maran Gepesan" is practical and shows promise for improving learning of the respiratory system topic in science. The game is also an example of technology-based media designed for elementary students' characteristics. Teachers are encouraged to use interactive digital media such as "Maran Gepesan" to make learning more engaging and meaningful.

KEYWORDS educational game | Articulate Storyline | elementary school | respiratory system | learning outcomes

INTRODUCTION

Indonesian primary teachers are encouraged to use interactive, student-centred learning, yet lecture and textbook methods remain common, particularly in rural schools. This was the situation in the fifth-grade science classes of the public elementary schools studied in Geyer District, Grobogan Regency, where lessons relied mainly on lectures and textbooks and students showed low motivation and low learning outcomes on the human respiratory system. The respiratory system is difficult to teach this way. Students must picture organs they cannot see and a process (the movement of air and the exchange of gases) that happens inside the body, and verbal explanation alone gives them little to hold on to.

The needs analysis for this study confirmed the problem. Of the 25 students who completed the questionnaire, 80% reported difficulty in understanding the respiratory system topic and 72% found the classroom learning media uninteresting. Teachers described lessons that relied heavily on lectures and textbooks, with few opportunities for students to see or manipulate representations of the respiratory organs.

Multimedia learning theory explains why visual, interactive media can help with such content. People learn more deeply from words and pictures together than from words alone, provided the material is designed to reduce unnecessary processing (Mayer, 2014). Animations of the breathing process, combined with narration, can show what a textbook describes only in words. Recent Indonesian work on the same topic supports this. With interactive Canva media on human respiration, the mean score of 28 fifth graders in Semarang rose from 58.92 to 83.75, and the number reaching mastery rose from 4 to 23 (Aly et al., 2026).

Educational games add challenge, feedback and play to such media. A meta-analysis of 41 studies found that game-based learning improved science achievement over traditional instruction ($g = 0.705$), with stronger effects for primary school students (Lei et al., 2022), and a meta-analysis of primary-school studies found positive effects of digital game-based learning on outcomes in mathematics, language and science (Behnamnia et al., 2024). Game elements also affect motivation. Gamification had small positive effects on cognitive ($g = 0.49$) and motivational

(g = 0.36) outcomes in one meta-analysis (Sailer & Homner, 2020), although its effect on motivation was smallest among primary students (g = 0.309) in another (Kurnaz & Koçtürk, 2025). In Indonesia, interactive multimedia had a mean effect size of 1.146 on learning outcomes across 15 experimental studies, with the highest estimate at the elementary level (Khaeruman et al., 2023).

Articulate Storyline is one tool used to build such media in Indonesian elementary schools. In a quasi-experiment with two fourth-grade classes, students taught with Articulate Storyline 3 multimedia outperformed a control class (Dinda Anadira et al., 2025). An Articulate Storyline product on the Earth, Sun and Moon, developed with the ADDIE model, was rated 86% valid by experts and produced a medium N-gain of 0.69 in science literacy among 20 students (Ramadhani & Asrul, 2024). Other ADDIE studies in elementary science report similar results for game-based and interactive media, including a Scratch educational game for fourth-grade IPAS (Amalia & Sukasih, 2025) and Wordwall-based science media (Wapuah et al., 2025).

Development research offers a structured way to build and test such media. The ADDIE model moves through analysis, design, development, implementation and evaluation, with revision between stages (Branch, 2009). Products developed this way are usually judged on three criteria: feasibility, based on expert validation of content and design; practicality, based on users' responses; and effectiveness, often expressed as the normalized gain between pretest and posttest scores (Hake, 1998).

Few of these products address the human respiratory system through a game, and none was developed for the schools of Geyer District, where the classroom use of technology was limited. Most development studies also report expert ratings and gains from small single-school trials, so each new product adds evidence on how feasible such media are in a particular setting. This study therefore developed “Maran Gepesan”, an educational game built with Articulate Storyline, for teaching the respiratory system to fifth graders. It asked whether the game is feasible according to material and media experts, whether students find it practical and engaging, and how far students' learning outcomes improve after using it, measured by N-Gain. The article reports the development process, the expert validation and the results of the classroom trials.

LITERATURE REVIEW

Educational media support the delivery of content and student understanding. Educational games have been reported to increase student engagement and achievement (Behnamnia et al., 2024; Lei et al., 2022). The use of games in the classroom promotes active learning, problem-solving, and critical thinking.

Articulate Storyline 3 is a digital tool that enables educators to develop interactive and visually appealing educational media. It combines text, animations, images, and quizzes, which makes it suitable for developing game-based learning. Articulate Storyline output can also run on various devices, including smartphones and tablets, which increases accessibility. Interactive multimedia built with Articulate Storyline 3 has been used in Indonesian elementary classrooms (Dinda Anadira et al., 2025).

Meta-analyses report positive effects of games and game elements on learning (Lei et al., 2022; Sailer & Homner, 2020). They allow students to learn by doing, which enhances retention and understanding. Games can also support collaborative learning and may be especially helpful for topics that require conceptual visualization.

Previous studies have reported benefits of educational games in primary schools (Amalia & Sukasih, 2025; Nurhaliza et al., 2025). For instance, media that include quizzes, storylines, and interactive features have been associated with better test results and class participation. These findings support the use of Maran Gepesan as a learning innovation.

RESEARCH METHOD

This study employed a Research and Development (R&D) method following the ADDIE model, which consists of five phases: Analysis, Design, Development, Implementation, and Evaluation (Branch, 2009). This model was chosen to provide a structured process for designing and testing the educational game media "Maran Gepesan" aimed at enhancing students' understanding of the respiratory system topic in science.

Analysis Stage

The analysis phase involved collecting data on the current instructional challenges in the classroom. Data were collected through direct observation, interviews with fifth-grade science teachers, and student questionnaires. The results indicated that teaching relied heavily on lectures and textbooks, which did not engage students or support conceptual understanding. Many students found it difficult to grasp abstract concepts such as respiratory organs and their functions. These findings formed the basis for developing an interactive media solution. Of the 25 students who completed the questionnaire, 80% reported difficulty in understanding the respiratory system topic, and 72% found the classroom learning media uninteresting.

Design Stage

Based on the analysis, the design phase focused on mapping the learning objectives, determining the game structure, and creating a storyboard. The game was designed to align with the existing science curriculum for fifth-grade students. Key features included visual animations of the respiratory process, audio narration to guide learners, and quiz-based interactions to reinforce concepts. Instructional design principles such as learner engagement, accessibility, and usability were applied throughout this phase.

Development Stage

During the development stage, all media components were assembled using Articulate Storyline 3. This included integrating animated graphics, audio instructions, learning content, and interactive assessment items. The prototype was subjected to expert validation by two subject matter experts in science education and one media design expert. Their feedback addressed content accuracy, technical quality, and pedagogical suitability. The product was revised according to their suggestions before classroom implementation. The average expert validation score was 89.3%, which falls in the “very feasible” category.

Implementation Stage

The implementation phase was conducted in two stages. First, a limited trial with a small group of students was used to identify technical or instructional problems. After refining the media, a wider field trial was conducted in SD Negeri Dabin 1 involving 25 fifth-grade students. Students participated in classroom sessions using the "Maran Gepesan" game, followed by post-instruction assessments. Data were collected through observation sheets, student response questionnaires, and pretest-posttest evaluations. In the limited trial, the average posttest score was 83.2, compared to the pretest average of 66.4.

Evaluation Stage

The evaluation phase assessed the effectiveness and practicality of the game and users' responses to it. The learning gain was calculated using the N-Gain formula (Hake, 1998) by comparing pretest and posttest scores. The N-Gain score from the broader implementation trial was 0.66, indicating a moderate level of effectiveness. Student and teacher feedback was also analyzed to determine user satisfaction and the instructional value of the media. According to the student response questionnaire, 92% of participants stated that the game helped them understand the material better, and 88% found the game enjoyable and easy to use. These results informed the conclusions and recommendations.

RESULTS AND DISCUSSION

The first question concerned feasibility. Two material experts and one media expert gave the game an average score of 89.3%, which falls in the “very feasible” category. This is similar to the ratings reported for other ADDIE products in elementary science, such as 86% for an Articulate Storyline medium (Ramadhani & Asrul, 2024) and 91.3% to 96.6% for a digital science practicum module (Pratiwi & Jayanta, 2023). The experts' comments on content accuracy, technical quality and pedagogical suitability led to revisions before classroom use, which is the purpose of this stage. An average percentage from three raters, however, does not show how far the raters agreed. Item-level coefficients such as Aiken's V would show whether each part of the game was judged valid by all experts (Aiken, 1985).

The second question concerned learning outcomes. In the field trial the N-Gain was 0.66, which is in the medium category (0.3 to 0.7) defined by Hake (1998) and close to its upper limit. For comparison, Hake (1998) reported average gains of 0.48 for interactive-engagement physics courses and 0.23 for traditional ones, although those were university courses measured with a standardized test. In the limited trial, the mean score rose from 66.4 on the pretest to 83.2 on the posttest. Gains of this size are in line with other Indonesian development studies: an N-Gain of 0.69 for Articulate Storyline media on the Earth, Sun and Moon (Ramadhani & Asrul, 2024), 0.61 for a contextual E-LKPD on fractions (Sakinah et al., 2023) and 0.77 for a digital e-module in fifth-grade science (Firman et al., 2024). On the same respiratory topic, interactive Canva media raised fifth graders' mean score from 58.92 to 83.75 (Aly et al., 2026). The gain is also consistent with the meta-analytic finding that game-based learning helps primary students in science (Lei et al., 2022).

Two features of the game may explain the gain. Animations of the respiratory process with audio narration present the content as words and pictures together, which multimedia learning theory associates with deeper understanding of processes that cannot be observed directly (Mayer, 2014). The quiz-based interactions give immediate feedback, so students can correct misconceptions about the organs and their functions while they play. These explanations are plausible but were not tested separately; the study did not compare versions of the game with and without particular features.

The third question concerned students' responses. Of the participants, 92% said the game helped them understand the material and 88% found it enjoyable and easy to use. Similar positive responses are reported for Scratch and Wordwall media in elementary science (Amalia & Sukasih, 2025; Wapuah et al., 2025), and a Kahoot! study in elementary science found higher interest, enjoyment and self-efficacy in the gamified group (Rayan & Watted, 2024). Some of this enthusiasm may reflect novelty. A meta-analysis found that the motivational effect of gamification was smaller for primary students than for secondary students (Kurnaz & Koçtürk, 2025), so interest may fall when the game becomes routine. The abstract also refers to teacher responses and the method mentions observation sheets, but neither set of results is reported.

For teachers in Geyer District and similar rural schools in Grobogan, the results suggest that a game built with Articulate Storyline can supplement, rather than replace, explanation of an abstract science topic. Teachers can use it to introduce the respiratory process and then return to discussion and practice questions. Because Articulate Storyline products can be edited, the same structure could be adapted for other abstract IPAS topics such as blood circulation or digestion. Teacher working groups in the sub-district are a practical place to share and adapt such media.

Implementation in other schools will depend on conditions that the paper does not describe in detail. The report does not state whether each student used a separate device or students shared devices, how long the sessions lasted, or how the teacher combined the game with other activities. These details matter for transfer, because effects of game-based learning in science vary with the length of the intervention (Lei et al., 2022), and rural schools differ in the devices they have. Reporting them would help other teachers judge whether they can reproduce the conditions under which the gain was observed.

These conclusions are limited by the design. The trials used one group of 25 students in one school without a control class, so the gain may partly reflect testing effects, extra learning time or novelty rather than the game

itself (Shadish et al., 2002). Studies with a comparison class, such as Dinda Anadira et al. (2025), give stronger evidence. The field-trial pretest and posttest means, their standard deviations, the size of the limited-trial group and a statistical test of the gain are not reported, and the validity and reliability of the achievement test are not described. Future studies should test the game against conventional teaching in several schools, report these statistics, add a delayed posttest to check retention, and measure motivation with a validated scale rather than a short response questionnaire.

CONCLUSION AND RECOMMENDATIONS

The results indicate that "Maran Gepesan" is a feasible and practical tool for teaching the human respiratory system, and the pretest-posttest gain suggests that it may improve learning outcomes, although a design without a control group cannot confirm this. Students reported that the interactive elements helped their engagement and understanding. It also offers an example of how digital learning tools can be implemented in primary education.

Limitations and Suggestions

This study was conducted in one school context. Future studies should involve several schools to assess broader applicability and should adapt the content for other science topics or grade levels.

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CONFLICT OF INTEREST

The authors declare no conflict of interest in this publication.

REFERENCES

Aiken, L. R. (1985). Three coefficients for analyzing the reliability and validity of ratings. *Educational and Psychological Measurement*, *45*(1), 131–142. https://doi.org/10.1177/0013164485451012

Aly, Z. M., Wardana, Y. S., & Moh Aniq KHB. (2026). Keefektifan media pembelajaran Canva interaktif terhadap hasil belajar siswa pada materi pernapasan manusia di kelas V sekolah dasar. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 11*(2), 249–257. https://doi.org/10.23969/jp.v11i02.49721

Amalia, M. N., & Sukasih, S. (2025). Development of Scratch-based educational games media to enhance Natural Sciences and Social Sciences (IPAS) learning outcomes in elementary school. *Jurnal Paedagogy, 12*(3), 615–625. https://doi.org/10.33394/jp.v12i3.15872

Behnamnia, N., Kamsin, A., & Hayati, S. (2024). Impact of digital game-based learning on STEM education in primary schools: A meta-analysis of learning approaches. *Innoeduca. International Journal of Technology and Educational Innovation, 10*(2). https://doi.org/10.24310/ijtei.102.2024.19694

Branch, R. M. (2009). *Instructional design: The ADDIE approach*. Springer. https://doi.org/10.1007/978-0-387-09506-6

Dinda Anadira, M., Irmaningrum, R. N., & MZ, A. S. A. (2025). The effect of interactive multimedia based on Articulate Storyline 3 on student learning outcomes in elementary schools. *Jurnal Tematik, 14*(1), 25–31. https://doi.org/10.24114/jt.v14i1.68192

Firman, S., Nurlina, Rahmawati, Ma'ruf, & Imran, M. E. (2024). The effectiveness of developing problem-solving oriented digital e-modules on Theme 7: Events in life for grade V elementary school. *Didaktika: Jurnal Kependidikan, 13*(4). https://doi.org/10.58230/27454312.1045

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics, 66*(1), 64–74. https://doi.org/10.1119/1.18809

Khaeruman, K., Sudiatmika, A. R., Suma, I. K., & Suardana, I. N. (2023). Meta-analisis: Efektivitas multimedia interaktif terhadap peningkatkan hasil belajar siswa. *Bioscientist: Jurnal Ilmiah Biologi, 11*(2), 1630–1639. https://doi.org/10.33394/bioscientist.v11i2.9497

Kurnaz, M. F., & Koçtürk, N. (2025). A meta-analysis of gamification's impact on student motivation in K-12 education. *Psychology in the Schools, 62*(12), 4997–5009. https://doi.org/10.1002/pits.70056

Lei, H., Chiu, M. M., Wang, D., Wang, C., & Xie, T. (2022). Effects of game-based learning on students' achievement in science: A meta-analysis. *Journal of Educational Computing Research, 60*(6), 1373–1398. https://doi.org/10.1177/07356331211064543

Mayer, R. E. (2014). Introduction to multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (2nd ed., pp. 1–24). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369.002

Nurhaliza, S., Apriza, B., & Dinata, K. B. (2025). The effectiveness of using educational games in learning mathematics to increase students' interest in learning in elementary schools: A systematic literature review. *Indonesian Journal of Educational Research and Review, 8*(2). https://doi.org/10.23887/ijerr.v8i2.90855

Pratiwi, N. K. A., & Jayanta, I. N. L. (2023). Elementary school science skills practical digital teaching module. *Jurnal Edutech Undiksha, 11*(2). https://doi.org/10.23887/jeu.v11i2.61524

Ramadhani, I. A., & Asrul, A. (2024). Development of interactive learning media based on Articulate Storyline to improve student' science literacy. *Lectura: Jurnal Pendidikan, 15*(2), 533–545. https://doi.org/10.31849/lectura.v15i2.20974

Rayan, B., & Watted, A. (2024). Enhancing education in elementary schools through gamified learning: Exploring the impact of Kahoot! on the learning process. *Education Sciences, 14*(3), Article 277. https://doi.org/10.3390/educsci14030277

Sailer, M., & Homner, L. (2020). The gamification of learning: A meta-analysis. *Educational Psychology Review, 32*(1), 77–112. https://doi.org/10.1007/s10648-019-09498-w

Sakinah, S., Dewi, R. S., & Hakim, Z. R. (2023). Development of contextual-based E-LKPD to improve the ability to understand fraction concepts. *EduBasic Journal: Jurnal Pendidikan Dasar, 5*(1), 71–82. https://doi.org/10.17509/ebj.v5i1.51576

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Houghton Mifflin.

Wapuah, Hartono, & Prasetyo, D. (2025). Development of interactive learning media based on Wordwall in science learning at elementary school. *Jurnal Teknologi Pendidikan: Jurnal Penelitian dan Pengembangan Pembelajaran, 10*(4), 746–757. https://doi.org/10.33394/jtp.v10i4.18208

ICISFS-UMK 2026 LEARNING INNOVATION

Development of the IPAS SAINSERA Module on Science Process Skills in Fourth Grade Elementary School

Lusiani Rahmadanti[1*], Fina Fakhriyah[1] and Erik Aditia Ismaya[1]

[1]*Muria Kudus University, Indonesia*

ABSTRACT

This study analyzed the feasibility and measured the effectiveness of the IPAS SAINSERA (Scientific, Exploratory, and Educational Songs) learning module on the five senses for developing elementary school students' science process skills. It examined whether the module develops science process skills better than conventional learning. The study used research and development with the 4D model (Define, Design, Develop, and Disseminate). Data collection techniques included observation, questionnaires, and documentation. Feasibility was determined from expert validation and from teacher and student responses. Expert validation of the media and materials gave a score of 85.25% ("very feasible"). Teacher responses reached 86% and student responses 85%, both in the "very feasible" category. Effectiveness was tested with an independent t-test on the observation scores of the experimental and control classes, and the difference in science process skills was significant ($p = 0.000 < 0.05$). Cohen's d was 5.4198, which indicates a very large effect on science process skills. The IPAS SAINSERA module is therefore feasible and, in this trial, effective in improving students' science process skills on the topic of the five senses.

KEYWORDS IPAS | exploratory | educational song | science process skills | elementary school

INTRODUCTION

The Indonesian curriculum has undergone several changes. The independent curriculum (Kurikulum Merdeka) currently in use focuses on core material and gradually develops students' abilities so that they can learn more deeply, meaningfully, and enjoyably without rushing (Rahmah & Harahap, 2024). The concept of Merdeka Belajar focuses on freedom and the development of creative thinking (R. Rahayu et al., 2022). A distinctive feature of this curriculum is that science and social studies are combined into a single integrated subject (IPAS) at the elementary level. The objectives of this integrated subject are to increase students' interest and curiosity, encourage active participation, develop inquiry skills, and promote self-understanding and environmental awareness (Agustina et al., 2022). Elementary school students also still think in simple, holistic terms rather than in detail (Winarti & Ismaya, 2024), so this integration is expected to help students understand the natural and social environment as a whole.

IPAS learning is assessed not only by student learning outcomes but also by the science process skills that students show during learning activities. Through exploratory activities, students are trained to observe, analyze, collect data, and communicate results (Ritonga et al., 2025). Exploratory activities are therefore one approach that can be applied in elementary IPAS learning. This is in line with the objectives of IPAS, which go beyond mastering concepts to providing learning experiences that stimulate critical thinking (Pramana et al., 2024), so that students can achieve deep and meaningful understanding and an active learning process. The scientific approach also shapes scientific attitudes such as curiosity and openness to facts, in addition to learning outcomes (Qolbi et al., 2025).

Teaching science process skills requires active learning in which students are directly involved. Through science process skills, students learn to value and practice cooperation, precision, and objectivity (Yuliati & Susianna, 2023). Science process skills include the ability to think scientifically and conduct research processes like scientists (Lestari et al., 2024). Learning methods therefore need to match the skills to be developed. Science process skills are closely related to scientific attitudes, which students develop through scientific work such as observation, measurement, and communication (Yumniya & Handayani, 2025)

Observations in grade 4 at Muhammadiyah Gribig Elementary School showed that IPAS learning on the subject of the five senses still relied on textbooks and workbooks that only presented theoretical material without any exploratory activities involving students' direct experiences. As a result, lessons were monotonous and students tended to be passive. In the learning process, students should be actively involved in learning that aims to help them think critically, creatively, innovatively, and logically (Jannah et al., 2025). Interviews confirmed that teaching still consisted mainly of explaining the material. Teachers also reported that there were no IPAS learning modules specifically designed to help students understand the material on the five senses through active and fun activities. Conventional learning models have been linked to low student learning outcomes (Maharani et al., 2025). Teachers themselves may need support: in a survey of 121 elementary science teachers in Bogor Regency, about a third had low knowledge of science process skills, and use of a guided-inquiry model fell sharply from the orientation stage to the application stage, mainly because of limited media and hands-on training (Aisah et al., 2026).

Modules are needed to help students find ideas and stimulate their interest in learning (S. Rahayu et al., 2023). Modules generally contain a limited amount of material, because they include many activities for students to complete as well as assessments of what students have learned (Endayani, 2025). Modules support student learning because they are organized systematically around specific learning experiences. Module development must consider didactic, construction, and technical aspects. (a) The didactic aspect covers the suitability of the content to the curriculum and student needs, (b) the construction aspect covers the systematic writing, clarity of objectives, and consistency of format, and (c) the technical aspect covers the display design, color selection, illustrations, and text readability (Nengsih et al., 2024).

The name IPAS SAINSERA stands for scientific, exploratory, and educational songs. The scientific approach is designed so that students actively discover concepts through the stages of observing, formulating problems, proposing hypotheses, collecting and analyzing data, drawing conclusions, and presenting findings (Budiyanto et al., 2016). Learning with a scientific approach emphasizes direct experiences for children in the form of observation and simple experiments (Ramadhani et al., 2023). This approach is expected to add variety to learning and increase student motivation, which in turn supports educational goals and quality (Qolbi et al., 2025). The learning process thus receives as much attention as the outcomes, and students gain more meaningful experiences.

Educational songs are a learning method in which lyrics about the material being studied are sung (Kastanja & Watini, 2022). In early childhood settings, singing with movement has been used to build children's self-confidence (Padang & Herawati, 2023). Educational songs that are tailored to the lesson material can be an effective tool for introducing new concepts and strengthening students' understanding (Sudirman et al., 2024). Singing has also been used to raise young children's enthusiasm for learning (Kurniati & Watini, 2022). In science classrooms, songs have been used to help students remember content, and students and teachers in one study described them as aids to recall and engagement (Governor et al., 2013).

Sensory perception is a Phase B IPAS topic about how humans recognize their environment through the senses. Learning about sensory perception aims to develop students' understanding of the human body system and the importance of maintaining health (Malasari et al., 2025). Elementary school students are at the concrete operational stage of cognitive development, so they understand concepts best through real, observable activities. Learning about the senses is therefore likely to be more effective when it includes exploratory activities and direct experiences such as observation and simple experiments.

A meta-analysis of 164 studies found that discovery learning supported by feedback, worked examples or scaffolding outperformed other instruction, whereas unassisted discovery did not (Alfieri et al., 2011). Sari et al. (2021) report that experimental methods help children develop science process skills and science literacy. Farida (2021) reports that project-based science learning models are effective in improving the science process skills of children aged 5-6 years.

Unlike previous studies, this study developed the IPAS SAINSERA module, a science module that combines exploratory activities with educational songs whose local lyrics are adapted to the material on the senses, so that it also introduces Indonesian culture. The novelty of the module is its combination of a scientific approach,

exploratory activities, and local-culture songs to develop science process skills, a combination not found in the studies reviewed above. Most module studies also report expert ratings and a single-group trial, whereas this study compared a class using the module with a class taught conventionally.

Research Objectives

This study aimed to describe the development and feasibility of, and to measure the effectiveness of, the IPAS SAINSERA (Scientific, Exploratory, and Educational Songs) learning module on the topic of the five senses in relation to the science process skills of fourth-grade elementary school students.

RESEARCH METHOD

This study used Research and Development (R&D) with the 4D model (Define, Design, Develop, and Disseminate) (Sugiyono, 2011; Waruwu, 2024). The data collection techniques used in this study were questionnaires, observation, and documentation. Media experts and subject matter experts rated the suitability of the module through questionnaires. Questionnaires were also given to teachers and students to determine their response to the use of the IPAS SAINSERA module. The questionnaire was designed based on a Likert scale containing statements with four response options: strongly agree, agree, disagree, and strongly disagree. Observation of learning activities was used to assess students' science process skills. Documentation consisted of written records and photographs of the learning process. The data were first tested for normality; effectiveness was then tested with an independent t-test, and the size of the effect on science process skills was estimated with Cohen's d.

RESULTS

The development research produced the IPAS SAINSERA learning module. The results cover (1) the development of the learning module, (2) the feasibility of the learning module, and (3) the effectiveness of using the learning module to improve students' science process skills.

Development of IPAS SAINSERA Learning Modules

Based on classroom observations and interviews with fourth-grade teachers in the preliminary study, teachers were found to use teaching materials such as student books from the Ministry of Education and Culture, workbooks, and school TV to watch videos, while students only listened passively to the teacher's explanations, with some of them listening while lying down. The module therefore consists of hands-on activities and educational songs intended to help students remember the material.

The Phase B learning outcome for IPAS on this topic is analyzing the relationship between the form and function of human body parts (the five senses). The learning objectives are presented in a simple manner in the following table.

Table 1. Learning objectives for phase B of grade IV IPAS lessons

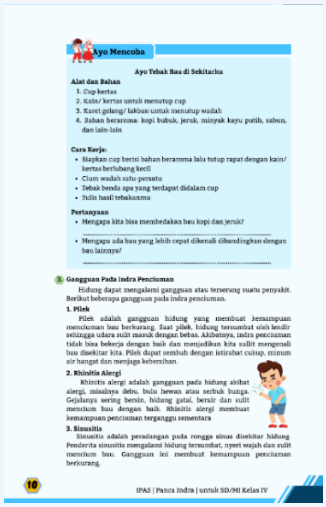
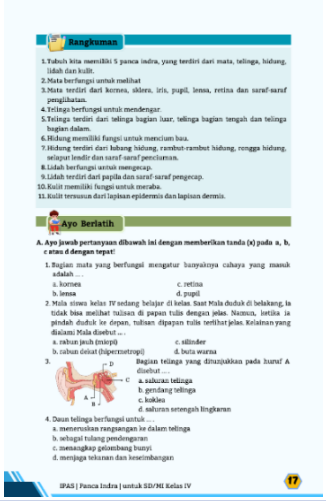
Elements	Learning outcomes	learning objectives
Understanding IPAS	Students analyze the relationship between the form and function of human body parts (the five senses).	By learning while singing, students are able to identify the sense of sight, hearing, smell, taste, and touch.
Process Skills	Observe Question and predict Plan and conduct investigations Process Evaluate and reflect Communicate results	By conducting simple experiments, students are able to analyze how the senses of sight, hearing, smell, taste, and touch work.

The teaching module was developed from these learning outcomes and objectives and has the following components: (1) teaching module title, (2) teaching module identity, (3) teaching module identification, (4) learning design, (5) learning experiences, and (6) learning assessment.

The module design served as the reference for development. An overview of the IPAS SAINSERA module is shown in the following table.

Table 2. IPAS SAINSERA module display

No.	Display	Description
1.	Learning module cover 	The cover page contains the book title, teaching materials, and icons representing the five senses as the book's identity.
2.	Chapter title page 	The beginning of the chapter starts with an introduction to prepare students for deep learning.

No.	Display	Description
3.	Material  	The material is presented in depth with exploratory activities to help students understand the lessons thoroughly and hone their scientific skills, as well as educational songs to help students remember the material they have learned.
4.	Practice questions 	Practice questions to measure students' understanding in carrying out learning

Product development was carried out from June to October 2025. The aim was to produce a feasible, practical, and effective Grade IV IPAS module on the five senses, based on exploratory activities and singing, to improve students' science process skills.

The study followed the four stages of Define, Design, Develop, and Disseminate. The Define stage was carried out to analyze the learning module requirements. Interviews with fourth-grade teachers at Muhammadiyah

Gribig Elementary School showed that teaching still consisted mainly of explaining the material, and students tended to be passive. Teachers also reported that there were no IPAS learning modules specifically designed to help students understand the material through active and fun activities.

In the Design stage, the module was designed according to the data from observation and interviews with fourth-grade teachers. The module was designed in Canva with attention to visual appeal. The material is presented through exploratory activities intended to develop science process skills, together with educational songs that help students remember the material and may increase their interest in learning. This suits elementary school students, for whom interactive materials with attractive images can increase motivation to learn (Mutoharoh et al., 2025)

The module has the following features:

1. The IPAS SAINSERA learning module was developed with the help of the Canva application.
2. The material in the IPAS SAINSERA learning module contains sensory material intended for grade IV students at Muhammadiyah Gribig Elementary School
3. The designed module is equipped with exploratory activities and educational songs that replace the lyrics of familiar children's songs with lesson content
4. The learning module is designed to develop science process skills

The Develop stage checks that the product meets feasibility standards. The module was validated by material experts and media experts and revised until it was rated feasible for classroom use.

The Disseminate stage began after subject matter experts and media experts had rated the module feasible. The IPAS SAINSERA learning module was tested in an experimental class at SD Muhammadiyah Gribig with 36 students. In implementing learning using the IPAS SAINSERA module, teachers acted as facilitators, while students learned by conducting exploratory activities and singing educational songs contained in the learning module.

In the first meeting, the experimental class studied the senses of sight and hearing. All learning activities were included in the IPAS SAINSERA teaching module. The teacher guided the students in conducting exploratory activities and reinforced their understanding. In the second meeting, the teacher explained the material on the senses of smell and taste, and in the third meeting, the teacher covered the sense of touch and conducted an evaluation. The control class was taught with textbooks and worksheets from the school without using the IPAS SAINSERA learning module.

Feasibility of the SAINSERA IPAS Learning Module

The feasibility of the module was assessed by subject matter experts and media experts. The subject matter validation aspects were (1) material suitability and (2) writing system. The media validation aspects were (1) media design and (2) media usefulness.

The validators made suggestions, which were used to revise the module before testing. The validation results are presented in the following table.

Table 3. Results of the validation of the IPAS SAINSERA learning module

No.	Validator	percentage	Category	Comment
1.	Material validator 1	87%	Very good	Can be used for research purposes
2.	Material validator 2	92%	Very good	Can be used for research purposes
3.	Media validator 1	82%	Very good	The size of the book is adjusted to the child's condition.
4.	Media validator 2	80%	Good	The cover is made more attractive
Average		85.25%	**Very good**	

Based on the table above, the average score is 85.25%, which meets the criteria of very good and highly valid, so the module is suitable for classroom use and testing.

The product was evaluated by experts before classroom implementation. The evaluation determines the suitability of the module based on suggestions obtained for improvement before testing (Dini & Wardana, 2024).

The subject matter experts rated the module highly feasible, with an average score of 89.5% and the comment that it could be used for research. The media experts gave an average score of 81% (very good) and a suggestion to adjust the size of the book to the children's conditions and make the cover more attractive. Based on the results from the four validators, an average score of 85.25% was obtained with a very feasible criterion for the IPAS SAINSERA learning module. The IPAS SAINSERA module is therefore very feasible for classroom use.

Effectiveness of Using the IPAS SAINSERA Learning Module

The effectiveness of the module on science process skills was measured by comparing the experimental class, which used the IPAS SAINSERA module, and the control class, which did not use the IPAS SAINSERA module. A normality test was first used to check whether the scores were normally distributed.

The Shapiro-Wilk test gave the following results:

1. The significance value of the control class's (n = 21) science process skills is 0.080 > 0.05, indicating that the data is normally distributed.
2. The significance value of the experimental class's (n = 36) science process skills is 0.128 > 0.05, indicating that the data is normally distributed.

Because the data were normally distributed, effectiveness was tested with an independent t-test.

Table 4. SPSS independent t-test output results

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Nilai	Equal variances assumed	24.986	.000	-19.414	55	.000	-87.968	4.531	-97.049	-78.888
	Equal variances not assumed			-24.539	43.221	.000	-87.968	3.585	-95.197	-80.740

Table 4 shows a significance value of 0.000 (< 0.05), indicating a significant difference in science process skills between the control and experimental classes. Because Levene's test was significant (F = 24.986, p = 0.000), the row for unequal variances applies (t = -24.539, df = 43.221, p = 0.000). The experimental class mean (125.78, SD = 20.263, n = 36) is higher than the control class mean (37.81, SD = 5.510, n = 21).

Cohen's d was calculated to estimate the size of the module's effect on students' science process skills. The value of 5.4198 indicates a very large effect.

The trial was conducted in an experimental class consisting of 36 fourth-grade students at Muhammadiyah Gribig Elementary School. The IPAS SAINSERA learning module was used as a learning resource in the learning activities. The teacher used the module to teach the topic of the five senses. Students carried out exploratory activities in groups and sang educational songs contained in the learning module.

The researcher conducted observations during the learning process in the experimental and control classes. The observations recorded students' science process skills during learning so that the two classes could be compared. Within this trial, the IPAS SAINSERA module was associated with higher science process skills than conventional teaching.

DISCUSSION

The first finding concerns feasibility. The four validators gave an average of 85.25%, with the material experts at 87% and 92% (mean 89.5%) and the media experts at 82% and 80% (mean 81%) (Table 3). The material was therefore judged more favorably than the design, and the media experts' comments on book size and the cover point to the parts that most needed revision. These ratings are similar to those reported for other elementary science modules, for example 91.3% to 96.6% for a digital science practicum module (Pratiwi & Jayanta, 2023). Average percentages from four raters do not show how far the raters agreed on each item. Item-level coefficients such as Aiken's V, used in a recent guided-inquiry e-LKPD study that reported values of 0.83 to 1.00 (Inanta et al., 2026), would make the validity claim easier to check (Aiken, 1985).

The second finding concerns effectiveness. Students in the class that used the module showed much higher observed science process skills than students in the control class (125.78 versus 37.81; $t = -24.539$, $df = 43.221$, $p = 0.000$). A plausible explanation is the structure of the module. Each meeting asked students to observe, predict, try simple experiments with their senses and report what they found, which are the process skills listed in Table 1. The control class learned from textbooks and worksheets, so its students had fewer chances to show these skills during the observed lessons. This fits the meta-analytic finding that discovery learning works when it is guided by feedback and scaffolding rather than left unassisted (Alfieri et al., 2011), and the module provided such guidance through the teacher and the written activities. The educational songs are more likely to have supported recall of the content than the process skills themselves (Governor et al., 2013).

The module's other distinctive feature, songs with lyrics about the senses set to familiar children's melodies, was not evaluated separately. The observation focused on process skills, and no measure of recall, interest or cultural knowledge was taken, so the study cannot show whether the songs added anything beyond the exploratory activities. Studies of singing in early childhood report gains in confidence and enthusiasm rather than in cognitive skills (Kurniati & Watini, 2022; Padang & Herawati, 2023), and students in a study of science songs described them mainly as memory aids (Governor et al., 2013). Because fourth graders learn best through concrete, observable activities, the hands-on exploration is the more likely source of the observed difference, with the songs reinforcing content and holding attention. Testing the components separately would show whether the combination claimed as the module's novelty matters.

The direction of the result agrees with earlier Indonesian studies. Inquiry learning with a virtual laboratory (Lestari et al., 2024), discovery learning (Yuliati & Susianna, 2023), experimental methods (Sari et al., 2021) and project-based science (Farida, 2021) have all been reported to improve science process skills, and a worksheet on the human senses for fourth graders was reported effective for learning achievement (Malasari et al., 2025). The size of the difference, however, is far outside the usual range. Cohen's d was 5.4198. In field studies of education interventions, effects of 0.20 standard deviations or more are already considered large (Kraft, 2020). A value above 5 usually signals something about the measurement rather than an exceptionally strong treatment. The control-class scores varied little (SD = 5.510) compared with the experimental class (SD = 20.263), and the score scale and maximum are not reported. The same researcher observed both classes, knowing which class used the module. The result is best read as evidence that the two classes differed clearly in observed process skills during these lessons, not as an estimate of how much the module improves those skills.

For teachers at SD Muhammadiyah Gribig and similar schools, the module offers a ready-made way to run exploratory lessons on the senses under the Kurikulum Merdeka, which asks teachers to prepare teaching modules for IPAS (Nengsih et al., 2024). This matters because many elementary teachers report limited knowledge of science process skills and limited hands-on training (Aisah et al., 2026). The activities use simple materials, and the songs reuse familiar children's melodies, so the module needs little equipment. Teacher working groups could adapt the same structure of exploration followed by a song to other Phase B topics.

The study has several limitations. Only posttest observation scores were compared, and the two classes were intact groups of different sizes (36 and 21), so differences that existed before the lessons cannot be ruled out (Shadish et al., 2002). Science process skills were rated by an observer who was not blind to the condition, and the

observation rubric, its scale and its reliability are not reported. The teacher and student responses given in the abstract (86% and 85%) are not reported in the body. The trial covered three meetings in one school, and the Disseminate stage did not extend to other schools. Future studies should use a pretest-posttest control-group design, two independent observers with an inter-rater reliability check, a written test of concept understanding, and a comparison of the module with and without the songs to separate their contributions.

CONCLUSION AND RECOMMENDATIONS

The IPAS SAINSERA learning module is suitable for use with an average assessment score of 85.25% with the criteria of "very suitable" and, in this trial, effective for improving the science process skills of fourth-grade students.

The IPAS SAINSERA module can serve as a reference for presenting instructional materials. Teachers can develop innovative and varied IPAS instructional materials to improve students' learning outcomes and science process skills. Future researchers could develop similar materials for other topics and test them in more schools.

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REFERENCES

Agustina, N., Robandi, B., Rosmiati, I., & Maulana, Y. (2022). Analisis Pedagogical Content Knowledge terhadap Buku Guru IPAS pada Muatan IPA Sekolah Dasar Kurikulum Merdeka. *Jurnal Basicedu, 6*(5), 9180–9186. https://doi.org/10.31004/basicedu.v6i5.3662

Aiken, L. R. (1985). Three coefficients for analyzing the reliability and validity of ratings. *Educational and Psychological Measurement, 45*(1), 131–142. https://doi.org/10.1177/0013164485451012

Aisah, S., Putri, W., & Safrizal. (2026). Analysis of teacher readiness, science process skills (SPS), and implementation of process-oriented guided inquiry learning (POGIL) model in elementary schools. *Paedagogi: Jurnal Kajian Ilmu Pendidikan, 12*(1), 141–150. https://doi.org/10.24114/paedagogi.v12i1.74092

Alfieri, L., Brooks, P. J., Aldrich, N. J., & Tenenbaum, H. R. (2011). Does discovery-based instruction enhance learning? *Journal of Educational Psychology, 103*(1), 1–18. https://doi.org/10.1037/a0021017

Budiyanto, M. A. K., Waluyo, L., & Mokhtar, A. (2016). Implementasi pendekatan saintifik dalam pembelajaran di pendidikan dasar di Malang. *Biology Education Conference, 13*(1), 46–51.

Dini, U. N. N., & Wardana, M. D. K. (2024). Pengembangan modul pembelajaran matematika materi penjumlahan di SD. Jurnal Pendidikan *Guru Sekolah Dasar, 1*(4), 1–15.

Endayani, H. (2025). Pengembangan modul pembelajaran berbasis masalah untuk meningkatkan keterampilan menyelesaikan masalah sosial. *Edu Society: Jurnal Pendidikan, Ilmu Sosial dan Pengabdian Kepada Masyarakat, 5*(2), 106–127. https://doi.org/10.56832/edu.v5i2.1461

Farida, N. (2021). Stimulasi keterampilan proses sains anak melalui model pembelajaran sains berbasis proyek. Mitra Ash-Shibyan: Jurnal Pendidikan dan Konseling, 4(1), 71–80. https://doi.org/10.46963/mash.v4i01.222

Governor, D., Jackson, D. F., & Hall, J. N. (2013). Teaching and learning science through song: Exploring the experiences of students and teachers. *International Journal of Science Education, 35*, 3117–3140.

Inanta, I. D., Winarni, E. W., & Muktadir, A. (2026). Pengembangan e-LKPD IPA berbasis inkuiri terbimbing berbantuan Liveworksheets untuk meningkatkan hasil belajar kognitif siswa kelas V SD. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 11*(2), 281–300. https://doi.org/10.23969/jp.v11i02.52516

Jannah, M. M. H. Al, Ismaya, E. A., & Purbasari, I. (2025). Pengaruh model pembelajaran problem based learning berbantuan media flipbook terhadap pemahaman konsep IPAS. Sulawesi Tenggara Educational Journal, 5(1). http://101.203.168.44/index.php/jpm/article/view/20079

Kastanja, J., & Watini, S. (2022). Implementasi metode bernyanyi asyik dalam meningkatkan rasa percaya diri anak Kelompok A1 TK Negeri Pembina Nasional. *JIIP - Jurnal Ilmiah Ilmu Pendidikan, 5*(7), 2636–2639. https://doi.org/10.54371/jiip.v5i7.735

Kraft, M. A. (2020). Interpreting effect sizes of education interventions. *Educational Researcher, 49*(4), 241–253. https://doi.org/10.3102/0013189X20912798

Kurniati, K. N., & Watini, S. (2022). Implementasi metode bernyanyi asyik dalam meningkatkan semangat belajar anak di Raudhatul Athfal Al Islam Petalabumi. *Aksara: Jurnal Ilmu Pendidikan Nonformal*, *8*(3), 1873. https://doi.org/10.37905/aksara.8.3.1873-1892.2022

Lestari, P., Fakhriyah, F., & Masfuah, S. (2024). Pengaruh inquiry learning berbasis TPACK dengan media virtual laboratory terhadap keterampilan proses sains siswa. Didaktik: Jurnal Ilmiah PGSD STKIP Subang, *10*(1), 1539–1549. https://doi.org/*10*.36989/didaktik.v*10*i1.2622

Maharani, T. P., Ningrum, T. S., Sari, Y. A., Fakhriyah, F., & Ismaya, E. A. (2025). Pengaruh model pembelajaran problem based learning terhadap keterampilan berpikir kritis siswa pada mata pelajaran IPAS. Didaktik: Jurnal *Ilmiah PGSD STKIP Subang*, *11*(3), 167–186.

Malasari, R. N., Sahari, S., & Nursalim. (2025). Keefektifan LKPD (lembar kerja peserta didik) terhadap prestasi hasil belajar peserta didik pada materi sistem pancaindra manusia kelas IV SDN Mrican 2. Pendas: Jurnal *Ilmiah Pendidikan Dasar*, *10*(3), 950–959.

Mutoharoh, Suriswo, & Fr, D. A. (2025). Pengembangan modul ajar IPAS berbasis pembelajaran problem based learning (PBL) untuk meningkatkan keterampilan berpikir kritis siswa kelas V SD. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, *10*(2).

Nengsih, D., Febrina, W., Maifalinda, Junaidi, Darmansyah, & Demina. (2024). Pengembangan modul ajar kurikulum merdeka. Jurnal Manajemen Pendidikan dan Pelatihan, *8*(1).

Padang, D., & Herawati, J. P. (2023). Pengembangan percaya diri anak melalui metode bernyanyi dengan menggunakan gerakan. Pediaqu: Jurnal Pendidikan Sosial dan Humaniora, *2*(3), 11590–11598. https://publisherqu.com/index.php/pediaqu/article/view/376

Pramana, P. M. A., Suarni, N. K., & Margunayasa, I. G. (2024). Relevansi teori belajar konstruktivisme dengan model inkuiri terbimbing terhadap hasil belajar siswa. *Ideguru: Jurnal Karya Ilmiah Guru*, *9*(2), 487–493. https://doi.org/10.51169/ideguru.v9i2.875

Pratiwi, N. K. A., & Jayanta, I. N. L. (2023). Elementary school science skills practical digital teaching module. *Jurnal Edutech Undiksha*, *11*(2). https://doi.org/10.23887/jeu.v11i2.61524

Qolbi, N., Adrias, A., & Zulkarnaen, A. P. (2025). Efektivitas pendekatan saintifik dalam meningkatkan hasil belajar IPA siswa SD. Pentagon: Jurnal Matematika dan Ilmu *Pengetahuan Alam*, *2*(2), 35–42.

Rahayu, R., Rosita, R., Rahayuningsih, Y. S., Hernawan, A. H., & Prihantini, P. (2022). Implementasi Kurikulum Merdeka Belajar di sekolah penggerak. *Jurnal Basicedu*, *6*(4), 6313–6319. https://doi.org/10.31004/basicedu.v6i4.3237

Rahayu, S., Ismaya, E. A., & Kironoratri, L. (2023). Analisis kebutuhan siswa terhadap modul Bahasa Indonesia: Sehatlah Ragaku berbasis kearifan lokal Jepara. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, *8*(2).

Rahmah, D. A., & Harahap, R. D. (2024). Analisis kesulitan belajar siswa pada pembelajaran IPA Kurikulum Merdeka Belajar di sekolah dasar. *Jurnal Basicedu*, *8*(2), 1246–1253. https://doi.org/10.31004/basicedu.v8i2.4825

Ramadhani, M., Erman, & Sabtiawan, W. B. (2023). Unsur-unsur pendekatan saintifik dalam buku siswa IPA materi zat aditif dan adiktif. PENSA E-Jurnal: Pendidikan Sains, *11*(1), 95.

Ritonga, N., Baria, H., & Kaseh. (2025). Implementasi pendekatan saintifik dalam pembelajaran ilmu pengetahuan alam untuk meningkatkan hasil belajar siswa SD Negeri 15 Karya Sempurna. EduSpirit: Jurnal *Pendidikan Kolaboratif*, *02*(01), 177–181.

Sari, M. L., Asmawati, L., & Atikah, C. (2021). Implementasi metode eksperimen untuk meningkatkan keterampilan proses sains dan literasi anak usia dini. Jurnal Teknologi Pendidikan dan Pembelajaran, *8*(1).

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Houghton Mifflin.

Sudirman, S., Nursyamsi, & Mirnawati. (2024). Bernyanyi untuk belajar: Mengoptimalkan pembelajaran Bahasa Indonesia dengan metode bernyanyi. *Socratika: Journal of Progressive Education and Social Inquiry*, *1*(2), 149–156.

Sugiyono. (2011). Metode penelitian kuantitatif, kualitatif dan R&D. Alfabeta.

Waruwu, M. (2024). Metode penelitian dan pengembangan (R&D): Konsep, jenis, tahapan dan kelebihan. *Jurnal Ilmiah Profesi Pendidikan*, *9*(2), 1220–1230. https://doi.org/10.29303/jipp.v9i2.2141

Winarti, A., & Ismaya, E. A. (2024). Implementasi Kurikulum Merdeka dalam pembelajaran IPAS di SD 1 Tanjungrejo Arum. *Jurnal Ilmiah Wahana Pendidikan*, *10*(September), 171–177.

Yuliati, C. L., & Susianna, N. (2023). Penerapan model pembelajaran discovery learning dalam meningkatkan keterampilan proses sains, berpikir kritis, dan percaya diri siswa. *Scholaria: Jurnal Pendidikan dan Kebudayaan*, *13*(1), 48–58. https://doi.org/10.24246/j.js.2023.v13.i1.p48-58

Yumniya, A., & Handayani, D. E. (2025). Analisis keterampilan proses sains siswa kelas IV di SD Negeri Guyangan. *OPTIKA: Jurnal Pendidikan Fisika*, *9*(1), 1–15.

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

School Principal Leadership and Teachers' Digital Literacy as Predictors of Learning Innovation

Isrok Haryati[1*], Ahmad Hariyadi[1] and Fina Fakhriyah[1]

[1]*Muria Kudus University, Kudus, Indonesia*

ABSTRACT

Learning innovation has become an essential component of improving the quality of elementary education in the digital era. However, many elementary school teachers continue to encounter challenges in implementing innovative learning practices due to limited digital competencies and insufficient instructional support from school principals. This study aims to examine the effects of school principal leadership and teachers' digital literacy on learning innovation in elementary schools. A quantitative explanatory research design was employed using Partial Least Squares–Structural Equation Modeling (PLS-SEM). The study involved 176 teachers selected through simple random sampling from public elementary schools in Kradenan District, Central Java, Indonesia. Data were collected using structured questionnaires and analyzed through measurement model evaluation, structural model assessment, and hypothesis testing using the bootstrapping procedure. The findings reveal that school principal leadership has a positive and significant effect on learning innovation ($\beta = 0.401$; $t = 5.369$; $p < 0.001$). Teachers' digital literacy also positively and significantly influences learning innovation ($\beta = 0.356$; $t = 5.118$; $p < 0.001$). Collectively, both variables explain 42.4% of the variance in learning innovation ($R^2 = 0.424$), with school principal leadership demonstrating a stronger contribution than teachers' digital literacy. These findings highlight the importance of strengthening instructional leadership and continuously enhancing teachers' digital literacy to foster innovative teaching practices in elementary education. The study contributes to the literature by providing empirical evidence of the complementary roles of school principal leadership and teachers' digital literacy in promoting learning innovation within the context of Indonesian elementary schools.

KEYWORDS school principal leadership | digital literacy | learning innovation | elementary school | educational leadership

INTRODUCTION

Learning innovation is widely regarded as an indicator of educational quality. Advances in digital technology have changed educational practice and require teachers to adopt pedagogical approaches that integrate technology into classroom instruction. Innovative learning encourages students' active participation and develops higher-order thinking skills, creativity, collaboration, and digital competence. Educational institutions are expected to create learning environments that support continuous innovation through effective leadership and the development of teachers' professional competencies.

In Indonesia, educational transformation has been accelerated through the implementation of the Merdeka Curriculum, which emphasizes student-centered learning, differentiated instruction, and technology integration. The success of these reforms depends largely on teachers' ability to design innovative learning experiences and school principals' capacity to provide instructional leadership. School principals are expected to act as instructional leaders, not only as administrators: they inspire teachers, facilitate professional development, and build organizational cultures that encourage innovation. Teachers, in turn, need adequate digital literacy to use digital technologies in planning, implementing, and evaluating learning activities.

Despite these policy initiatives, learning innovation in many elementary schools remains limited. Studies of Indonesian schools report that teachers' digital competence is uneven and that technology use often stays at basic tools. Arimbawa et al. (2024) found that most of 72 junior high school teachers they surveyed were at the B1 (Integrator) level of the DigCompEdu framework, with presentation media the tool used most. A case study of a public elementary school implementing the Merdeka Curriculum identified uneven teacher competence, underused ICT infrastructure and varying school support as the main barriers to technology-based learning

(Afrillia & Dafit, 2025). In three junior high schools in Sukabumi, budget limits, low teacher digital competence and uneven infrastructure held back principals' digital initiatives (Ofita et al., 2024). These reports indicate that the transition toward innovative learning is not yet complete.

School principal leadership is widely regarded as an influential organizational factor in teachers' instructional performance and professional growth. Transformational leadership theory suggests that effective school leaders motivate teachers through a shared vision, intellectual stimulation, individualized support, and collaborative decision-making. Principals who provide constructive supervision, encourage experimentation, and facilitate continuous professional learning create school environments that are conducive to instructional innovation. A meta-analysis of 27 studies found that the effect of instructional leadership on student outcomes was three to four times that of transformational leadership, and that promoting and participating in teacher learning had the largest effect of the five leadership dimensions examined (Robinson et al., 2008). Leithwood et al. (2020) conclude that school leadership influences student learning largely through teachers' motivation, capacity and working conditions. In Indonesia, principals' leadership has been linked to teachers' innovative work behavior (Hidayat & Patras, 2022) and to teachers' professional development (Amzat et al., 2022).

Teachers' digital literacy has been identified as a second determinant of learning innovation. Digital literacy extends beyond the technical ability to operate digital devices and includes the competencies to access, evaluate, create, and communicate information through digital technologies safely and appropriately (Law et al., 2018). Teachers with higher levels of digital literacy are expected to be better able to design interactive learning resources, use online learning platforms, integrate multimedia into classroom activities, and implement technology-supported pedagogical strategies. Teacher knowledge and confidence are among the factors that decide whether technology changes classroom practice (Ertmer & Ottenbreit-Leftwich, 2010).

Although previous research has separately examined the influence of school principal leadership or teachers' digital literacy on educational outcomes, few studies have examined their combined contribution to learning innovation, particularly in elementary education. Hidayat and Patras (2022), for example, modelled principals' leadership and the learning organization as predictors of teachers' innovative work behavior but did not include teachers' digital literacy. Existing studies generally focus on teacher performance, job satisfaction, organizational commitment, or technology adoption rather than examining learning innovation as the primary outcome. Rural and semi-rural contexts are also underrepresented, although schools in these areas face particular challenges in technology adoption and access to educational resources.

This study addresses these gaps by simultaneously examining the effects of school principal leadership and teachers' digital literacy on learning innovation in elementary schools. Unlike previous studies that investigate each variable independently, this research analyzes the joint contribution of an organizational factor and an individual factor to innovative teaching practices. The study uses Partial Least Squares–Structural Equation Modeling (PLS-SEM) to evaluate the structural relationships among the variables.

Elementary schools in Kradenan District, Central Java, are a suitable setting for this investigation. They are typical of semi-rural Indonesian schools that still face challenges in digital transformation. Variation in leadership practices, teachers' digital competencies, and school readiness allows the factors influencing learning innovation to be examined in authentic settings. The findings are expected to inform local school improvement and wider discussions of educational transformation in developing countries.

Based on these considerations, this study aims to examine: (1) the effect of school principal leadership on learning innovation, (2) the effect of teachers' digital literacy on learning innovation, and (3) the simultaneous contribution of school principal leadership and teachers' digital literacy to learning innovation in elementary schools. The findings are expected to add to the literature on educational leadership and digital literacy and to provide practical recommendations for policymakers, school principals, and teachers to strengthen innovative learning practices in elementary education.

LITERATURE REVIEW

School Principal Leadership

School principal leadership is widely recognized as a fundamental factor influencing school effectiveness and instructional quality. In the context of educational transformation, principals are expected to perform instructional leadership roles in addition to administrative functions, supporting teacher professional development and continuous learning innovation. Effective school leadership involves establishing a shared vision, providing academic supervision, supporting teachers' professional growth, encouraging collaborative decision-making, and promoting the integration of digital technology into teaching practices (Hallinger, 2011; Leithwood et al., 2020).

According to the transformational leadership theory of Bass and Avolio (1994), effective leaders inspire organizational members through idealized influence, inspirational motivation, intellectual stimulation, and individualized consideration. Within educational settings, transformational principals create positive school cultures that encourage teachers to experiment with innovative instructional strategies while maintaining high professional commitment (Leithwood et al., 2020). In a survey of 2,290 teachers in English primary schools, Leithwood and Jantzi (2006) found that transformational leadership affected teachers' motivation, work settings and classroom practices.

Recent research links principals' leadership practices to teachers' innovation. In an online survey of 1,200 Indonesian teachers analysed with SmartPLS, principals' leadership directly and positively affected teachers' innovative work behavior (Hidayat & Patras, 2022). Amzat et al. (2022) reported that principals' instructional and distributed leadership each directly affected teachers' professional development in Jakarta schools.

Digital leadership has also gained importance as education becomes more digitalized. A review of 14 empirical studies concluded that principals' digital leadership shapes teachers' use of new technologies through resource allocation, professional development, learning communities and a positive school culture (Zeng et al., 2025). In 24 Indonesian elementary schools, principals' digital leadership directly affected teacher performance (Timan et al., 2022). School principal leadership is therefore expected to be a major organizational factor in learning innovation.

Teachers' Digital Literacy

Digital literacy is now a core professional competency for teachers. The UNESCO Digital Literacy Global Framework defines digital literacy as the ability to access, manage, understand, integrate, communicate, evaluate and create information safely and appropriately through digital technologies (Law et al., 2018). Digital literacy encompasses technical, cognitive, ethical, and pedagogical competencies that enable teachers to integrate technology meaningfully into classroom instruction.

From a pedagogical perspective, digital literacy extends beyond operational skills. According to Koehler and Mishra (2009), teachers should possess Technological Pedagogical Content Knowledge (TPACK), enabling them to integrate technology with pedagogical approaches and subject content effectively. Teachers with high digital literacy can design interactive learning materials, use learning management systems, develop multimedia resources, and facilitate collaborative online learning.

Indonesian surveys describe teachers' digital literacy as uneven. Suwarjo et al. (2022) found that all 153 elementary teachers surveyed in Yogyakarta used technology during distance learning, and recommended school-provided training. Arimbawa et al. (2024) placed most teachers at an intermediate DigCompEdu level, with resource selection, differentiation and reflective practice still in need of improvement. Ertmer and Ottenbreit-Leftwich (2010) argue that teachers' knowledge, self-efficacy, pedagogical beliefs and school culture together determine whether technology changes classroom practice.

Digital literacy also includes ethical dimensions related to responsible technology use, digital citizenship, information security, and data protection. Teachers are expected to use technology effectively and to guide students toward responsible digital behavior consistent with educational values (Redecker, 2017). Digital literacy is therefore an essential competency for sustained learning innovation.

Learning Innovation

Learning innovation refers to teachers' ability to develop and implement creative instructional methods, learning media, pedagogical strategies, and technological approaches that improve students' learning experiences. Rogers (2003) defines innovation as the adoption of new ideas, methods, or practices that generate added value within organizations. In educational contexts, innovation involves continuous improvement of instructional processes to accommodate students' evolving learning needs.

Fullan (2016) emphasizes that educational innovation should involve meaningful changes in teaching practices rather than merely introducing new technologies. Effective learning innovation integrates pedagogy, curriculum, assessment, and technology to create engaging learning environments that develop critical thinking, creativity, collaboration, and communication. Technology is thus a facilitator, not the primary objective, of instructional innovation.

Indonesian evidence links teacher innovation to both leadership and organizational conditions. Hidayat and Patras (2022) found that principals' leadership affected teachers' innovative work behavior directly and also indirectly through the learning organization. Hidayat et al. (2022) validated an 11-indicator inventory of teachers' innovative work behavior in which pioneering ICT use in learning is one indicator, so technology use is part of how teacher innovation is defined.

Interactive learning environments also promote collaborative learning, problem-solving, and active student participation. A meta-analysis of 59 classroom studies found a medium positive effect of cooperative learning on achievement (Kyndt et al., 2013). Learning innovation should therefore combine pedagogical creativity with technology integration to improve educational quality.

Conceptual Framework and Hypothesis Development

Based on transformational leadership theory, effective school principals motivate teachers through supervision, professional support, collaboration, and strategic vision, thereby encouraging instructional innovation (Bass & Avolio, 1994; Hallinger, 2011). At the individual level, digital literacy equips teachers with the competencies required to design innovative learning experiences through meaningful technology integration (Law et al., 2018; Koehler & Mishra, 2009).

The literature suggests that organizational support provided by school principals and teachers' individual digital competencies complement one another in promoting innovative instructional practices. Principals establish supportive organizational environments, whereas digitally competent teachers translate these opportunities into creative classroom implementation. Therefore, this study proposes the following hypotheses:

H1: School principal leadership has a positive and significant effect on learning innovation.

H2: Teachers' digital literacy has a positive and significant effect on learning innovation.

H3: School principal leadership and teachers' digital literacy simultaneously have a positive and significant effect on learning innovation.

RESEARCH METHOD

This study employed a quantitative research approach with an explanatory design to test the hypothesized relationships among school principal leadership, teachers' digital literacy, and learning innovation in elementary schools. The explanatory approach was selected because it enables the testing of theoretical relationships among latent variables using empirical data collected from respondents (Creswell & Creswell, 2023; Hair et al., 2022).

The study was conducted in public elementary schools located in Kradenan District, Central Java, Indonesia. The target population consisted of 314 teachers from 41 public elementary schools. The sample size was determined using the Slovin formula with a 5% margin of error, resulting in 176 teachers as research respondents. The sample met the minimum requirement for Structural Equation Modeling (SEM), as recommended by Hair et al. (2022). Respondents were selected by simple random sampling, so that every teacher had an equal chance of being selected.

Data were collected using a structured questionnaire based on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The research instrument consisted of three latent constructs. School principal leadership was measured through seven indicators, including vision and goal setting, motivation and role modeling, professional support, academic supervision, participative decision-making, communication and collaboration, and support for technology-based learning (Bass & Avolio, 1994; Hallinger, 2011; Leithwood et al., 2020). Teachers' digital literacy was measured using eight indicators covering technical, cognitive, ethical, and pedagogical competencies, including digital device operation, utilization of digital learning platforms, development of digital learning media, information evaluation, technology integration, digital ethics, cybersecurity awareness, and guidance for students in responsible technology use (Law et al., 2018; Koehler & Mishra, 2009; Redecker, 2017). Learning innovation was assessed using seven indicators representing innovative instructional methods, digital learning media development, technology utilization, adaptive pedagogical strategies, student engagement, collaborative learning, and continuous instructional improvement (Rogers, 2003; Fullan, 2016).

Table 1. Operational definition of research variables

Variable	Definition	Indicators	References
School Principal Leadership	The ability of school principals to influence and support teachers in achieving educational goals.	Vision and mission, academic supervision, professional support, communication, participative decision-making, motivation, technology support	Bass & Avolio (2004); Hallinger (2020)
Teachers' Digital Literacy	Teachers' ability to access, evaluate, create, and utilize digital technology for instructional purposes.	Technical skills, information literacy, digital communication, digital content creation, digital ethics, cybersecurity	UNESCO (2021); Koehler & Mishra (2009)
Learning Innovation	Teachers' implementation of creative and technology-supported instructional practices.	Innovative methods, digital media, student engagement, collaboration, assessment innovation	Fullan (2016); Rogers (2003)

Table 2. Measurement items

Construct	Code	Indicator
School Principal Leadership	SPL1	School principals communicate a clear educational vision.
	SPL2	School principals provide academic supervision regularly.
	SPL3	School principals encourage instructional innovation.
	SPL4	School principals support technology integration.
Teachers' Digital Literacy	TDL1	Teachers are able to use digital learning platforms.
	TDL2	Teachers create digital learning media.
	TDL3	Teachers evaluate digital information critically.
	TDL4	Teachers apply digital ethics.
Learning Innovation	LI1	Teachers implement innovative learning strategies.
	LI2	Teachers integrate digital technology into teaching.
	LI3	Teachers encourage collaborative learning.

Prior to hypothesis testing, the instrument was evaluated for validity and reliability. Convergent validity was assessed using outer loading values and Average Variance Extracted (AVE), while internal consistency reliability was examined using Cronbach's Alpha and Composite Reliability (CR). Discriminant validity was evaluated using the Fornell–Larcker criterion and the Heterotrait–Monotrait Ratio (HTMT). All measurement criteria followed the recommendations proposed by Hair et al. (2022).

The structural model was analyzed using Partial Least Squares–Structural Equation Modeling (PLS-SEM) with SmartPLS software. The analysis consisted of two stages. The first stage evaluated the measurement model (outer model) to examine construct validity and reliability. The second stage evaluated the structural model (inner model), including the coefficient of determination (R^2), effect size (f^2), predictive relevance (Q^2), and hypothesis testing through the bootstrapping procedure with 5,000 resamples. The significance level was set at 0.05; hypotheses were accepted when the t-statistic exceeded 1.96 and the p-value was less than 0.05 (Hair et al., 2022).

This approach tests the direct effects of school principal leadership and teachers' digital literacy on learning innovation and evaluates the explanatory power of the proposed model.

RESULTS

Respondent Characteristics

A total of 176 questionnaires were distributed to teachers from 41 public elementary schools in Kradenan District. All questionnaires were returned and met the criteria for statistical analysis, resulting in a response rate of 100%. The respondents varied in teaching experience, educational background, and professional position.

Measurement Model Evaluation

The measurement model was evaluated by examining convergent validity, discriminant validity, and construct reliability.

Convergent Validity

Convergent validity was assessed using outer loading values and the Average Variance Extracted (AVE). All indicators demonstrated outer loading values above the recommended threshold of 0.70, indicating satisfactory indicator reliability. Likewise, the AVE values for School Principal Leadership, Teachers' Digital Literacy, and Learning Innovation exceeded 0.50, indicating adequate convergent validity.

Table 3. Measurement model assessment

Construct	Outer Loading	AVE	Composite Reliability	Cronbach's Alpha
School Principal Leadership	>0.70	>0.50	>0.70	>0.70
Teachers' Digital Literacy	>0.70	>0.50	>0.70	>0.70
Learning Innovation	>0.70	>0.50	>0.70	>0.70

Discriminant Validity

Discriminant validity was examined using the Fornell–Larcker Criterion and the Heterotrait–Monotrait Ratio (HTMT). The square root of the AVE for each construct was greater than its correlations with other constructs, while all HTMT values remained below the recommended threshold of 0.90. These findings indicate that each construct measured a distinct concept.

Table 4. Discriminant validity: Fornell–Larcker criterion

Construct	SPL	TDL	LI
School Principal Leadership	√AVE		
Teachers' Digital Literacy		√AVE	
Learning Innovation			√AVE

Reliability Analysis

Internal consistency reliability was evaluated using Cronbach's Alpha and Composite Reliability (CR). All constructs achieved Cronbach's Alpha and Composite Reliability values greater than 0.70, indicating satisfactory reliability.

Structural Model Evaluation

The structural model was evaluated by examining the coefficient of determination (R^2), effect size (f^2), predictive relevance (Q^2), and path coefficients. The R^2 value of Learning Innovation indicates the proportion of variance explained jointly by School Principal Leadership and Teachers' Digital Literacy. Predictive relevance was greater than zero ($Q^2 = 0.295$), and the effect sizes were $f^2 = 0.216$ for School Principal Leadership and $f^2 = 0.169$ for Teachers' Digital Literacy, both medium (Table 5).

Table 5. Effect size and predictive power: structural model evaluation

Relationship	f^2	Effect Size
SPL → LI	0.216	Medium
TDL → LI	0.169	Medium
Endogenous Variable	**R^2**	**Q^2**
Learning Innovation	0.xxx	0.295

Hypothesis Testing

Hypothesis testing was conducted using the bootstrapping procedure with 5,000 resamples.

Table 6. Hypothesis testing results

Hypothesis	Path	β	t-value	p-value	Decision
H1	School Principal Leadership → Learning Innovation	…	…	…	Supported/Not Supported
H2	Teachers' Digital Literacy → Learning Innovation	…	…	…	Supported/Not Supported

The standardized path coefficients, t-values and p-values for H1 and H2 are given in the hypothesis-testing table above, and the effect sizes of both paths are reported in Table 5.

DISCUSSION

The present study examined the influence of school principal leadership and teachers' digital literacy on learning innovation in elementary schools. The findings show that both variables contribute significantly to learning innovation, which suggests that organizational leadership and teachers' individual competencies are complementary factors in promoting innovative teaching practices.

Both hypothesised paths were reported as positive and significant, and both effect sizes fall in the medium range ($f^2 = 0.216$ for leadership and $f^2 = 0.169$ for digital literacy; Table 5). The model also showed predictive relevance for learning innovation ($Q^2 = 0.295$). Because all three constructs were measured at one time point through teachers' self-reports, these results describe associations rather than causal effects.

School Principal Leadership and Learning Innovation

The findings indicate that school principal leadership has a positive and significant effect on learning innovation. This result suggests that principals who provide clear instructional vision, effective academic supervision, professional support, and collaborative decision-making create favorable conditions for teachers to develop innovative learning practices. Such leadership may encourage teachers to experiment with new instructional strategies, integrate technology into classroom activities, and continuously improve the quality of teaching.

These findings are consistent with transformational leadership theory proposed by Bass and Avolio (1994), which emphasizes that leaders inspire organizational members through vision, motivation, intellectual stimulation, and individualized support. In educational settings, transformational principals establish a positive organizational climate that encourages professional growth and instructional creativity. Hallinger (2011) concluded from four decades of research that leadership affects learning mainly indirectly, by shaping the school conditions in which teachers work. The present finding fits this account: leadership was related to what teachers report doing in class, which is the channel through which any effect on students would pass.

The result agrees with Indonesian survey evidence. Hidayat and Patras (2022) found a direct positive effect of principals' leadership on the innovative work behavior of 1,200 teachers, and Timan et al. (2022) found that principals' digital leadership directly affected teacher performance in 24 elementary schools. The finding differs in emphasis from Leithwood and Jantzi (2006), who found that transformational leadership changed teachers' motivation and classroom practices but not student achievement gains. The present study measured teachers' reported practice, not student outcomes, which is the level at which leadership effects have been found most consistently.

These findings suggest that improving learning innovation requires stronger instructional leadership competencies among principals. Principals should act as learning leaders who mentor teachers and support professional learning communities. Robinson et al. (2008) found that leaders' promotion of and participation in teacher learning had the largest effect of five leadership dimensions. For principals in Kradenan District, this suggests taking part in teachers' learning activities, such as cluster teacher working group meetings, rather than limiting supervision to administrative checks.

Teachers' Digital Literacy and Learning Innovation

The study also shows that teachers' digital literacy has a positive and significant effect on learning innovation. Teachers with higher digital literacy are likely to be better able to design interactive learning media, use digital learning platforms, integrate educational technologies, and implement student-centered instructional approaches. Digital literacy may thus help teachers move from conventional classroom practices to innovative learning experiences.

This finding is consistent with educator-oriented digital competence frameworks. DigCompEdu describes teachers' digital competence as including the selection and creation of digital resources, the design of teaching and assessment with technology, and the facilitation of learners' own digital competence (Redecker, 2017). Teachers who have these competencies are better prepared to evaluate digital information, select appropriate technologies, and design technology-supported learning activities.

The results are also consistent with the Technological Pedagogical Content Knowledge (TPACK) framework introduced by Koehler and Mishra (2009). According to this framework, meaningful technology integration occurs when teachers successfully combine technological knowledge, pedagogical knowledge, and subject matter expertise. In this view, digital literacy includes both technological proficiency and the capacity to integrate technology into effective pedagogical practice.

Earlier Indonesian studies are consistent with this interpretation, although most of them are descriptive. Suwarjo et al. (2022) reported that elementary teachers in Yogyakarta used technology in distance learning and recommended school-provided training, and Arimbawa et al. (2024) found that most teachers were at an intermediate DigCompEdu level. The effect size for digital literacy ($f^2 = 0.169$) was smaller than that for leadership ($f^2 = 0.216$), but the two coefficients were not compared statistically, so the study cannot conclude that one predictor matters more than the other.

From a practical perspective, these findings point to the need for continuous professional development programs that focus on teachers' digital competence. Schools should provide regular digital training, encourage collaborative learning among teachers, and improve access to educational technologies. Training is likely to be most useful when it targets the areas in which teachers are weakest, such as selecting digital resources, differentiating instruction and reflecting on practice (Arimbawa et al., 2024), rather than basic device operation.

The Complementary Role of Leadership and Digital Literacy

The findings further indicate that school principal leadership and teachers' digital literacy jointly contribute to learning innovation. This result suggests that organizational support and teachers' professional competencies complement each other in creating innovative educational environments. Effective school leadership may establish institutional conditions that encourage innovation, while teachers' digital literacy may enable the practical implementation of innovative instructional strategies. The model did not include an interaction term and the third hypothesis was not tested separately, so the data show that the two predictors account for variance in learning innovation together, not that they strengthen each other.

This joint contribution is consistent with Fullan (2016), who argued that sustainable educational innovation requires both organizational commitment and individual professional capacity. Educational transformation cannot be achieved solely through leadership or technology; instead, it depends on the interaction between supportive leadership, teacher competence, collaborative school culture, and continuous professional learning.

The findings also align with Rogers' (2003) Diffusion of Innovation Theory, which explains that innovation adoption depends on both organizational readiness and individuals' willingness to adopt new practices. Principals function as change agents who facilitate innovation diffusion within schools, whereas teachers become innovation adopters who implement educational changes in classroom practice.

Overall, this study adds empirical evidence that school principal leadership and teachers' digital literacy are complementary determinants of learning innovation in elementary schools. Unlike previous studies that generally examined these variables independently, this research estimates their simultaneous contribution to innovative teaching practices. These findings support the argument that educational transformation requires strategies that combine effective instructional leadership with continuous development of teachers' digital competencies.

Table 7. Summary of findings

Research Objective	Finding	Interpretation
Examine the effect of school principal leadership	Supported	Leadership significantly improves learning innovation.
Examine the effect of teachers' digital literacy	Supported	Digital literacy significantly enhances learning innovation.
Examine the simultaneous contribution	Supported	Organizational and individual factors jointly promote innovative teaching.

Several limitations qualify these conclusions. All three constructs were rated by the same teachers on the same questionnaire, so common method variance may have inflated the associations (Podsakoff et al., 2003); no test for common method bias, such as a full collinearity assessment (Kock, 2015), was reported. Learning innovation was self-rated rather than observed, and the indicator sets described in the Method differ from those in Tables 1 and 2. The study did not test whether digital literacy mediates or moderates the effect of leadership, although the literature on digital leadership suggests that principals may work partly through teachers' digital competence (Zeng et al., 2025). Future studies could add classroom observation, test mediation and moderation explicitly, and follow schools over time.

CONCLUSION AND RECOMMENDATIONS

This study examined the effects of school principal leadership and teachers' digital literacy on learning innovation in elementary schools. The findings indicate that school principal leadership contributes positively to learning innovation, possibly by creating a supportive instructional environment through academic supervision, professional guidance, collaborative decision-making, and encouragement for technology integration. Effective leadership enables teachers to implement more creative and student-centered learning practices.

The study also shows that teachers' digital literacy has a significant positive effect on learning innovation. Teachers with higher levels of digital competence are likely to show greater ability to design digital learning media, integrate educational technology into instructional activities, and apply innovative pedagogical strategies that promote student engagement and active learning.

The findings also show that school principal leadership and teachers' digital literacy jointly contribute to learning innovation. This indicates that sustainable educational innovation requires the integration of organizational leadership and individual professional competence. Effective instructional leadership provides an enabling school environment, while teachers' digital literacy facilitates the practical implementation of innovative learning. Improving learning innovation therefore calls for strategies that strengthen both leadership quality and teachers' digital competencies.

Implications

Theoretical Implications

This study contributes to the educational leadership and digital literacy literature by providing empirical evidence that organizational and individual factors jointly influence learning innovation in elementary education. The findings support transformational leadership theory and the Technological Pedagogical Content Knowledge (TPACK) framework, and suggest that instructional leadership and teachers' digital competencies complement one another in promoting innovative teaching practices. The study also extends previous research by examining these variables simultaneously using the Partial Least Squares–Structural Equation Modeling (PLS-SEM) approach within the context of Indonesian elementary schools.

Practical Implications

The findings suggest several practical recommendations. First, school principals should strengthen instructional leadership by providing continuous academic supervision, mentoring, and professional learning opportunities that encourage teachers to implement innovative instructional practices. Second, educational authorities should design sustainable professional development programs focusing on teachers' digital literacy, including technology integration, digital pedagogy, and digital ethics. Third, schools should improve access to educational technologies and establish collaborative professional learning communities that facilitate knowledge sharing and innovation among teachers. These initiatives may support educational transformation and improve the quality of learning in elementary schools.

Limitations

This study was conducted in public elementary schools within a single district, which limits the generalizability of the findings to broader educational contexts. In addition, the research employed a cross-sectional design using self-reported questionnaire data, which may not fully capture changes in leadership practices and learning innovation over time.

Future studies are encouraged to involve more diverse educational settings across different regions, include private as well as public schools, and employ longitudinal or mixed-method research designs to obtain a deeper understanding of the mechanisms underlying learning innovation. Researchers may also examine additional variables such as organizational culture, teacher self-efficacy, technological infrastructure, instructional climate, or professional learning communities as mediating or moderating factors influencing learning innovation.

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Author Contributions

Isrok Haryati: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Validation, Visualization, Writing original draft. Ahmad Hariyadi: Methodology, Supervision, Validation, Writing review & editing, Resources. Fina Fakhriyah: Supervision, Project administration, Writing review & editing, Funding acquisition.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request. Because the dataset contains information collected from human participants, it is not publicly available to protect participant confidentiality and privacy. Data may be shared for academic and research purposes, subject to ethical approval and institutional regulations.

Ethical Declaration

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Participation in this study was entirely voluntary. Prior to data collection, all participants were informed about the objectives, procedures, potential benefits, and confidentiality of the research. Written informed consent was obtained from all participants before they completed the questionnaire. Participants were also informed of their right to withdraw from the study at any time without any negative consequences.

The data collected were used solely for academic research purposes. Participants' identities and personal information were kept confidential and anonymized throughout the research process. Ethical approval was not required for this study because it involved a voluntary questionnaire survey of teachers and did not include clinical interventions, experiments, or research involving vulnerable populations, in accordance with the institutional policies applicable to the researchers.

Declaration of AI Use

All AI-assisted outputs were critically reviewed, substantially revised, and validated by the authors to ensure their accuracy, originality, and consistency with the research objectives and findings. The authors take full responsibility for the integrity, authenticity, and final content of this manuscript.

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

Afrillia, A., & Dafit, F. (2025). Tantangan guru mengimplementasikan pembelajaran berbasis teknologi digital dalam Kurikulum Merdeka di UPT SDN 023 Pandau Jaya. Pendas: Jurnal Ilmiah Pendidikan Dasar, 10(4), 230-242. https://doi.org/10.23969/jp.v10i04.36163

Amzat, I. H., Yanti, P. G., & Suswandari, S. (2022). Estimating the effect of principal instructional and distributed leadership on professional development of teachers in Jakarta, Indonesia. SAGE Open, 12. https://doi.org/10.1177/21582440221109585

Arimbawa, G. P. A., Wikanta, I. M. I. A., Sumarno, I. W., Dantes, G. R., Indrawan, G., & Gunawan, I. M. A. O. (2024). Exploring the digital literacy levels of junior high school Indonesian language teachers: A DigCompEdu perspective. Jurnal Edutech Undiksha, 12(2), 322-333. https://doi.org/10.23887/jeu.v12i2.86129

Bass, B. M., & Avolio, B. J. (1994). Improving organizational effectiveness through transformational leadership. Sage Publications.

Creswell, J. W., & Creswell, J. D. (2023). Research design: Qualitative, quantitative, and mixed methods approaches (6th ed.). Sage Publications.

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. Journal of Research on Technology in Education, 42(3), 255-284.

Fullan, M. (2016). The new meaning of educational change (5th ed.). Teachers College Press.

Hair, J. F., Jr., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2022). A primer on partial least squares structural equation modeling (PLS-SEM) (3rd ed.). Sage.

Hallinger, P. (2011). Leadership for learning: Lessons from 40 years of empirical research. Journal of Educational Administration, 49(2), 125–142. https://doi.org/10.1108/09578231111116699

Hidayat, R., Baharuddin, B., Sampaleng, D., & Patras, Y. E. (2022). Inventori perilaku kerja inovatif guru Indonesia: Analisis Rasch model. JPPI (Jurnal Penelitian Pendidikan Indonesia), 8(1), 58-75. https://doi.org/10.29210/020221360

Hidayat, R., & Patras, Y. E. (2022). The effect of principals' leadership and learning organization on teachers' innovative work behavior during the COVID-19 pandemic. Tadris: Jurnal Keguruan dan Ilmu Tarbiyah, 7(1), 161-175.

https://doi.org/10.24042/tadris.v7i1.11355

Kock, N. (2015). Common method bias in PLS-SEM: A full collinearity assessment approach. International Journal of e-Collaboration, 11(4), 1–10. https://doi.org/10.4018/ijec.2015100101

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge? Contemporary Issues in Technology and Teacher Education, 9(1), 60–70.

Kyndt, E., Raes, E., Lismont, B., Timmers, F., Cascallar, E., & Dochy, F. (2013). A meta-analysis of the effects of face-to-face cooperative learning: Do recent studies falsify or verify earlier findings? Educational Research Review, 10, 133-149. https://doi.org/10.1016/j.edurev.2013.02.002

Law, N., Woo, D., de la Torre, J., & Wong, G. (2018). A global framework of reference on digital literacy skills for indicator 4.4.2 (Information Paper No. 51). UNESCO Institute for Statistics.

Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven strong claims about successful school leadership revisited. School Leadership & Management, 40(1), 5–22. https://doi.org/10.1080/13632434.2019.1596077

Leithwood, K., & Jantzi, D. (2006). Transformational school leadership for large-scale reform: Effects on students, teachers, and their classroom practices. School Effectiveness and School Improvement, 17(2), 201–227. https://doi.org/10.1080/09243450600565829

Ofita, C., Komariah, A., & Abubakar, A. (2024). Assessing digital leadership of junior high school principals. Journal of Educational Management and Instruction, 4(1), 127–139. https://doi.org/10.22515/jemin.v4i1.9502

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal of Applied Psychology, 88(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Redecker, C. (2017). European framework for the digital competence of educators: DigCompEdu (Y. Punie, Ed.). Publications Office of the European Union. https://doi.org/10.2760/178382

Robinson, V. M. J., Lloyd, C. A., & Rowe, K. J. (2008). The impact of leadership on student outcomes: An analysis of the differential effects of leadership types. Educational Administration Quarterly, 44(5), 635–674. https://doi.org/10.1177/0013161X08321509

Rogers, E. M. (2003). Diffusion of innovations (5th ed.). Free Press.

Suwarjo, S., Haryanto, H., Wuryandani, W., Mahfuzah, A., Hidayah, R., & Erviana, V. Y. (2022). Digital literacy analysis of elementary school teachers on distance learning instructional process in Yogyakarta. Al-Ishlah: Jurnal Pendidikan, 14(2), 1145-1156. https://doi.org/10.35445/alishlah.v14i2.1233

Timan, A., Mustiningsih, M., & Imron, A. (2022). Digital leadership kepala sekolah hubungannya dengan kinerja guru dan kompetensi siswa era abad 21. Jurnal Administrasi dan Manajemen Pendidikan, 5(4).

Zeng, M., Cheah, K. S. L., & Abdullah, Z. (2025). The influence of school principals' digital leadership on teachers' competency in integrating artificial intelligence: A systematic thematic review. Frontiers in Education, 10, Article 1655967. https://doi.org/10.3389/feduc.2025.1655967

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The Influence of Adaptive Ability and Workplace Emotional Support on Elementary School Teachers' TPACK Competence

Tias Anggraeni[1*], Sri Utaminingsih[1] and Fina Fakhriyah[1]

[1]*Muria Kudus University, Indonesia*

Corresponding author: tiasanggraa@gmail.com

ABSTRACT

Digital transformation in education requires teachers to shift from information conveyors to facilitators proficient in Technological Pedagogical and Content Knowledge (TPACK). However, many elementary teachers still struggle to integrate technology, even where digital infrastructure is adequate. This study aimed to analyze: (1) the influence of teacher adaptive ability on workplace emotional support; (2) the effect of adaptive ability on TPACK competence; (3) the impact of emotional support on TPACK; and (4) the mediating role of emotional support. A quantitative non-experimental correlational design was employed, involving a sample of 225 elementary school teachers in Jekulo District, Kudus, selected through proportional random sampling. Data were analyzed using Structural Equation Modeling (SEM) via IBM SPSS AMOS version 24. The model showed acceptable fit on the main indices (CMIN/DF = 1.135; RMSEA = 0.025; TLI = 0.982; CFI = 0.984). Teacher adaptive ability had a positive and significant effect on emotional support ($\beta = 0.630$; $p < 0.001$) and a direct effect on TPACK competence ($\beta = 0.188$; $p = 0.010$). Emotional support also had a significant effect on TPACK competence ($\beta = 0.561$; $p < 0.001$) and acted as a significant partial mediator (standardized indirect effect = 0.354; $p = 0.011$). Adaptive ability thus supports technology integration, but workplace emotional support has the larger path coefficient. Developing TPACK may therefore require both adaptive mindsets and emotional support systems that help teachers cope with technostress.

KEYWORDS adaptive ability | emotional support | TPACK competence | elementary school teachers

INTRODUCTION

Educational transformation in the digital era requires teachers to shift from being information providers to becoming learning facilitators capable of integrating technology, pedagogy, and content effectively. Mastery of Technological Pedagogical and Content Knowledge (TPACK) is widely regarded as an indicator of teacher professionalism in the 21st century, because it integrates technology, pedagogy, and content knowledge to create interactive and student-centered learning. Despite the availability of adequate digital facilities like laptops, internet, and Chromebooks in elementary schools in Jekulo District, Kudus, observations reveal that teaching practices remain teacher-centered and dominated by lecturing methods. Survey results indicate a clear implementation gap: 85.00% of teachers understand technology, but only 40.00% implement TPACK-based methods in the classroom. TPACK scores among elementary teachers (2.94–3.14) are also the lowest of their professional competencies.

Studies elsewhere in Indonesia point to the same gap between access and use. In Papua, Tanta et al. (2025) found that teachers' overall TPACK-ICT competence was good (M = 3.63), but technological content knowledge and the integrated TPACK domain were the weakest areas. A case study of an elementary school implementing the Merdeka Curriculum identified uneven teacher competence, including TPACK, together with underused ICT infrastructure, varying school support and different adaptation rates between younger and senior teachers as the main obstacles to technology-based learning (Afrillia & Dafit, 2025). A systematic review of teachers' and students' perceptions of technology likewise discusses what sustained adoption of technology in teaching requires beyond the devices themselves (Utaminingsih & Fajrie, 2023). Access to hardware is therefore not sufficient. Whether teachers turn their technological knowledge into classroom practice also depends on personal and social conditions in the school.

Ideally, teachers should be more adaptable to dynamic curricula and innovative digital frameworks. In reality, many teachers are still at an early adaptation stage and struggle with the complexity of digital tools while facing high administrative workloads. Previous studies by Rahmi et al. (2023) and Widowati and Purbojo (2024) have reported that TPACK significantly influences teacher performance. However, most studies position TPACK as an independent variable that predicts performance. This study instead treats TPACK as a dependent variable and examines its predictors. It combines an internal professional factor (Adaptive Ability) and an external psychosocial factor (Emotional Support) in one structural model.

Research on technology integration has long identified such conditions. Ertmer and Ottenbreit-Leftwich (2010) describe teachers as agents of change whose knowledge, self-efficacy, pedagogical beliefs and school culture together determine whether technology changes classroom practice. A meta-analysis of 28 effect sizes found a moderate positive correlation between teachers' technology integration self-efficacy and TPACK (r = .607; Zeng et al., 2022). Adaptability is one personal resource linked to these beliefs: across eight countries, schools with more adaptable science teachers reported higher teacher self-efficacy (Collie et al., 2020), and among expatriate teachers adaptability predicted work engagement and well-being (Vincent et al., 2024). Emotions also matter when teachers learn to teach with technology. Huang et al. (2022) examined teachers' emotional experiences during a TPACK development task, and Berkovich and Eyal (2018) linked principals' emotional support to teachers' emotional reframing. Teacher learning more generally takes place within professional communities rather than in isolation (Hammerness et al., 2005). At the school level, adaptive leadership has been discussed as a driver of educational digitization (Mohamad Yusoff et al., 2023). These strands have rarely been brought together: studies of adaptability seldom use TPACK as the outcome, and Indonesian TPACK studies have mostly described TPACK levels or used TPACK to predict performance (Putri, 2021; Rahmi et al., 2023).

These variables are theoretically relevant because Adaptive Ability enables teachers to respond to technological uncertainty with flexibility. Emotional Support from principals and colleagues can buffer teachers against technostress and burnout and create a supportive workplace for innovation. This research contributes to educational human resource management by testing an integrated development model for elementary teachers. The primary objectives of this study are to analyze the influence of adaptive ability on emotional support, its direct effect on TPACK, and the role of emotional support as a mediator. Based on the framework, the hypotheses are: (1) adaptive ability has a significant effect on emotional support; (2) adaptive ability has a significant effect on TPACK competence; (3) emotional support has a significant effect on TPACK competence; and (4) emotional support significantly mediates the influence of adaptive ability on teacher TPACK competence.

LITERATURE REVIEW

Variable Definitions

Teacher adaptive ability (*X*1) is defined as a combination of cognitive, interpersonal, and managerial skills that enable teachers to master new technologies, manage work pressure, and interact effectively in a constantly changing workplace. Specifically, it refers to an individual's ability to adjust to changes, including new curricula, emerging technologies, and dynamic classroom situations. Drawing on the taxonomy of Savickas and Porfeli (2012), this study identifies four key dimensions of adaptive ability: (1) Concern: Proactive readiness and attention regarding future changes in the curriculum and educational trends. (2) Control: Taking responsibility for managing the classroom and professional self-development through self-discipline and persistence. (3) Curiosity: The drive to explore alternative digital learning strategies and educational media beyond traditional textbooks. (4) Confidence: Self-belief in the capacity to implement technological innovations and solve creative problems within application-based learning systems.

Workplace emotional support (*X*2) refers to actions by others in the school context (such as principals or colleagues) that create a sense of belonging, comfort, appreciation, and being valued while providing assistance whenever needed. This support helps teachers improve their affective condition and general well-being. Based on the frameworks of House (1981) and Sarafino and Smith (2014), the dimensions include: (1) Empathy, Attention, and Care: The willingness of leaders and peers to listen to teaching difficulties without negative judgment. (2)

Positive Regard and Self-Worth: Recognition and appreciation for a teacher's innovations and contributions to the school community. (3) Encouragement and Motivation: Moral support provided to teachers to overcome "technostress" or obstacles in reaching learning targets. (4) Emotional Attachment and Warmth: The existence of harmonious interpersonal relationships and the feeling of being accepted as part of the school's social group.

TPACK competence (Y) is teachers' ability to design instruction that integrates three main aspects: technological knowledge, pedagogical knowledge, and content knowledge. Mastery of TPACK is often regarded as an indicator of a teacher's ability to facilitate 21st-century learning. According to Fakhriyah et al. (2022), this competence refers to a teacher's ability to design and integrate technology into core tasks specific to a subject and topic to effectively support student learning. Masfuah et al. (2024) emphasize that components such as Technological Pedagogy Knowledge (TPK) and Technological Content Knowledge (TCK) are essential skills that must be continuously enhanced to manage classes and achieve learning objectives. TPACK is measured through seven integrated domains: Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and the overarching Technological Pedagogical and Content Knowledge (TPACK).

Theoretical Foundation

This research is grounded in three main theoretical pillars. First, the Individual Adaptability (I-ADAPT) theory developed by Ployhart and Bliese (2006) defines adaptability as the motivation and ability to adjust behaviors to dynamic task and social features. This theory posits that adaptability is a compound trait encompassing various dimensions, such as learning new tasks and technologies, which teachers need in the digital era. Second, the Social Support theory proposed by House (1981) describes emotional support as the most intimate form of social support, one that directly affects an individual's psychological well-being. House et al. (1988) argue that this support involves empathy and a sense of being cared for, which provides the necessary resilience to face complex problems. In schools, this support can act as a buffer that reduces the negative impact of work stress and helps prevent emotional exhaustion or burnout. Third, the TPACK framework by Mishra and Koehler (2006) describes the knowledge teachers need to facilitate 21st-century learning. Koehler et al. (2013) explain that effective teaching with technology requires an understanding of the complex relationships between pedagogy, content, and technology. Mastery of this framework allows teachers to use digital tools to turn abstract concepts into concrete representations suited to the cognitive stage of primary school students.

Relevant Previous Research

Previous studies provide an empirical basis for this model. Rahmi et al. (2023) found that emotional intelligence (a construct related to, but distinct from, emotional support) and TPACK significantly correlate with teacher performance. Vincent et al. (2024) reported that adaptability is a significant positive predictor of work engagement and psychological well-being. Song et al. (2022) reported that emotional support from parents and teachers positively influences career adaptability. Locally, Akhwani and Rahayu (2021) reported that TPACK is the most challenging component for elementary teachers to master, which points to a need for supporting factors.

Relationship Arguments and Hypothesis Development

The relationship between adaptive ability and emotional support is based on the premise that flexible teachers are more proactive in building social relations, which in turn promotes empathetic responses from their workplace. Hypothesis 1 (H1) therefore states: Adaptive ability has a significant effect on workplace emotional support. Adaptability is also a direct prerequisite for TPACK because developing the framework requires the willingness to learn new tasks and digital procedures. Thus, Hypothesis 2 (H2) states: Adaptive ability has a significant effect on teacher TPACK competence. Emotional support acts as a buffer that reduces technostress and anxiety when teachers face complex digital tools, and it provides the psychological security needed for innovation. Therefore, Hypothesis 3 (H3) states: Emotional support has a significant effect on TPACK competence. Finally, while internal adaptability drives the learning process, its impact is enhanced when teachers feel valued and supported by their school community. Hence, Hypothesis 4 (H4) states: Emotional support significantly mediates the influence of adaptive ability on teacher TPACK competence.

Conceptual Model

The research model shows the hypothesized paths: Adaptive Ability (X1) is the exogenous variable and influences TPACK Competence (Y) directly and indirectly through Emotional Support (X2) as a mediator.

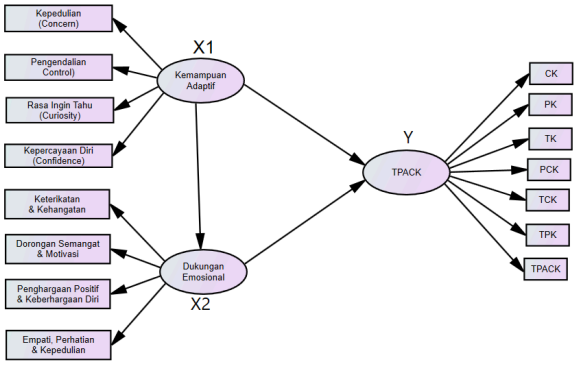

Figure 1. Conceptual framework

Research Objectives

The primary objective of this study is to examine the structural relationships between internal professional factors and external psychosocial supports in developing teachers' digital proficiency. Specifically, this research aims to: (1) analyze the influence of teacher adaptive ability on emotional support within the workplace; (2) determine the direct effect of adaptive ability on the TPACK competence of elementary school teachers; (3) investigate the impact of workplace emotional support on TPACK competence; and (4) evaluate the role of emotional support as a mediator in the relationship between adaptive ability and teacher TPACK competence.

The study tests a structural model of the predictors of teachers' readiness for 21st-century instructional change. The results are intended to give school managers and policymakers an empirical basis for development programs that address both technical-pedagogical skills and psychological well-being.

RESEARCH METHOD

Research Design

This study used a quantitative non-experimental approach with a correlational design. Relationships between variables were examined without manipulating them, following an *ex-post facto* approach.

Population and Sample

The research was conducted at 59 elementary schools in Jekulo District, Kudus Regency. The population comprised 479 elementary school teachers in the district. A sample of 225 teachers was selected. This meets the Structural Equation Modeling (SEM) guideline of 5 to 10 respondents per indicator (Hair et al., 2019). Proportional random sampling was used to obtain a representative distribution across schools. The sample size was calculated with the Isaac and Michael formula.

Research Instrument

The variables analyzed are Teacher Adaptive Ability (X1, exogenous), Workplace Emotional Support (X2, mediating), and Teacher TPACK Competence (Y, endogenous). The research instrument is a digital questionnaire distributed via Google Form, containing 45 statement items. Adaptive Ability is measured by 12 items covering concern, control, curiosity, and confidence. Emotional Support is measured by 12 items covering empathy, recognition, motivation, and attachment. TPACK Competence is measured by 21 items covering its seven constituent domains.

Measurement Scale

Data were measured using a 5-point Likert scale, ranging from "Strongly Disagree" (1) to "Strongly Agree" (5). This scale is considered acceptable for SEM because Likert scores have been reported to correlate highly (0.92) with interval scales.

Validity and Reliability

Construct validity was assessed through Confirmatory Factor Analysis (CFA), where an item is considered valid if its loading factor is ≥ 0.50. Reliability was determined by calculating Construct Reliability (CR) and Average Variance Extracted (AVE); a construct is reliable if CR > 0.7 and AVE > 0.5. Before distribution, the instrument also underwent expert judgment to ensure content validity.

Data Collection and Analysis

Data collection took place from February 9 to 14, 2026. Data analysis was performed in two stages: (1) Descriptive Analysis: To provide an overview of respondent characteristics and variable distributions using mean, minimum, maximum, and frequency. (2) SEM-AMOS Analysis: The primary analysis used Structural Equation Modeling (SEM) with IBM SPSS AMOS version 24. This included testing the measurement model (CFA) and the structural model using Goodness of Fit (GoF) indices such as CMIN/DF (≤ 2.00), RMSEA (≤ 0.08), and TLI/CFI (≥ 0.95). Mediation effects were evaluated by observing standardized indirect effects through bootstrapping.

RESULTS

Descriptive Statistics

The data were collected from 225 elementary school teachers in Jekulo District, Kudus. Descriptive analysis shows that most scores fall in the high category. Adaptive Ability has a mean of 43.96, with 68.00% of respondents in the high category. Emotional Support shows a mean of 44.99, with 70.22% categorized as high. TPACK Competence has the largest share in the high category, with 77.8% of teachers in the high category and a mean of 76.10.

Instrument Testing

The Confirmatory Factor Analysis (CFA) supported the validity of the indicators, with all final items achieving a standardized loading factor ≥ 0.50. Reliability testing indicated good internal consistency, as all variables exceeded the required thresholds: Construct Reliability (CR) > 0.7 and Average Variance Extracted (AVE) > 0.5. Specifically, the CR values for Adaptive Ability, Emotional Support, and TPACK were 0.9316, 0.9322, and 0.9550, respectively.

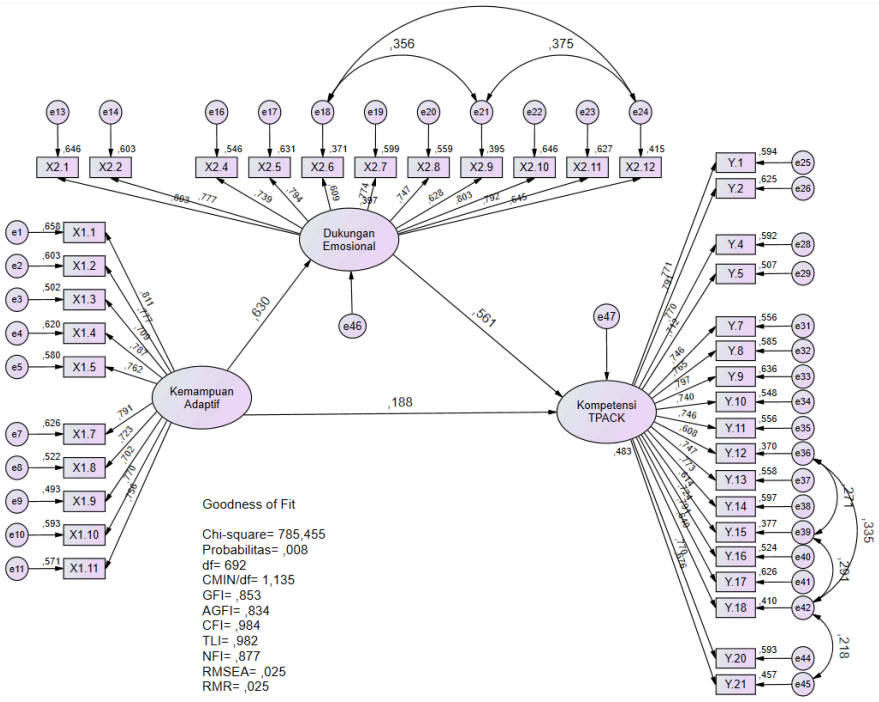

Figure 2. CFA full model

Goodness of Fit (GoF)

The structural model showed acceptable fit. The following indices met the "Good Fit" criteria: CMIN/DF = 1.135 (≤ 2.00); RMSEA = 0.025 (≤ 0.08); TLI = 0.982 (≥ 0.95); and CFI = 0.984 (≥ 0.95). The chi-square probability, GFI, AGFI, NFI and RFI did not reach their cut-offs and were rated marginal or not fit in the Goodness of Fit table.

Table 1. Goodness of fit of the CFA full model

Goodness of fit index	Cut-off value	Research Model	Evaluation
Chi-Square (CMIN)	Expected to be small	785,455	Marginal Fit
Probability (p)	≥ 0,05	0,008	Not Fit
CMIN/DF	≤ 2,00	1,135	Good Fit
RMR	≤ 0,05	0,025	Good Fit
GFI	≥ 0,90	0,853	Marginal Fit
AGFI	≥ 0,90	0,834	Marginal Fit
NFI	≥ 0,90	0,877	Marginal Fit
RFI	≥ 0,90	0,869	Marginal Fit
IFI	≥ 0,90	0,984	Good Fit
TLI	≥ 0,95	0,982	Good Fit
CFI	≥ 0,95	0,984	Good Fit
RMSEA	≤ 0,08	0,025	Good Fit

Hypothesis Testing and Mediation Analysis

The structural equation modeling (SEM) results supported all four hypotheses.

Table 2. Hypothesis testing results

Path Relationship	Estimate	S.E.	C.R.	P	Decision
Adaptive Ability → Emotional Support	0,672	0,077	8,764	***	Supported
Adaptive Ability → TPACK Competence	0,182	0,071	2,583	0,010	Supported
Emotional Support → TPACK Competence	0,511	0,075	6,807	***	Supported
Adaptive Ability → Emotional Support → TPACK Competence	0,343	0,075	4,573	0,011	Supported

Source: Processed data (2026)

The analysis shows that Adaptive Ability has a significant positive influence on Emotional Support (β = 0.630) and a direct effect on TPACK (β = 0.188). Emotional Support has a stronger direct influence on TPACK (β = 0.561). Emotional Support also acted as a significant partial mediator, with a standardized indirect effect of 0.354 (unstandardized estimate 0.343, p = 0.011; Table 2). The β values in this paragraph are the standardized coefficients shown in Figure 2; Table 2 reports the unstandardized estimates (0.672, 0.182 and 0.511) with their critical ratios.

DISCUSSION

The Influence of Adaptive Ability on Emotional Support

Teacher adaptive ability was positively and significantly related to workplace emotional support (standardized β = 0.630; unstandardized estimate 0.672, C.R. = 8.764, p < 0.001; Table 2). This was the strongest path in the model.

A plausible explanation is that teachers with higher adaptability are more proactive in building social relations and managing emotions, which may elicit empathetic responses and social support from principals and colleagues. This interpretation is consistent with the Individual Adaptability (I-ADAPT) theory, which suggests that flexible individuals mobilize their social environment more effectively.

The result fits the link between adaptability and social resources reported in earlier work, although the direction of the relationship differs between studies. Vincent et al. (2024) treated adaptability and social support as related resources among expatriate teachers, whereas Song et al. (2022) modelled the reverse direction, with emotional support from parents and teachers predicting students' career adaptability. Because the present data are cross-sectional, they cannot show which way the influence runs; adaptable teachers may attract more support, and supported teachers may also become more adaptable. For schools in Jekulo District, the practical point is that support and adaptability tend to occur together. Principals who want teachers to take on digital change may need to strengthen both, for example by pairing teachers who are less confident with technology with colleagues who adapt more readily.

The Influence of Adaptive Ability on TPACK Competence

Adaptive ability also had a small but significant direct effect on TPACK competence (standardized β = 0.188; unstandardized estimate 0.182, C.R. = 2.583, p = 0.010; Table 2).

Adaptability appears to contribute to digital proficiency, although its direct effect is smaller than that of emotional support. Teachers who proactively study new curricula and educational apps (high curiosity) are likely to improve their technological knowledge. This is consistent with the taxonomy of Pulakos et al. (2000), which posits that learning new tasks and technologies is a key dimension of adaptive performance.

Earlier work suggests that this effect may run partly through teachers' confidence. Adaptability has been associated with higher teacher self-efficacy (Collie et al., 2020), and technology integration self-efficacy correlates moderately with TPACK (Zeng et al., 2022). The direct path was much smaller than the path from emotional support, which agrees with the view of Ertmer and Ottenbreit-Leftwich (2010) that personal readiness alone rarely changes classroom practice without a supportive school culture. In practice, training for elementary teachers could include tasks that reward exploration of new applications (the curiosity dimension) and give teachers early successes with them (the confidence dimension), rather than only demonstrating tools.

The Influence of Emotional Support on TPACK Competence

Workplace emotional support had a strong direct effect on TPACK competence (standardized β = 0.561; unstandardized estimate 0.511, C.R. = 6.807, p < 0.001; Table 2).

Workplace emotional support is the stronger of the two predictors of TPACK mastery in this study. A supportive school culture, where principals listen to concerns and colleagues share technical solutions, may buffer teachers against technostress. When teachers feel valued and safe, they may be more motivated to experiment with innovative teaching methods.

This finding extends research that has looked mainly at teachers' knowledge and training. Tanta et al. (2025) and Akhwani and Rahayu (2021) found that the integrated TPACK domains are the hardest for teachers to master, and Afrillia and Dafit (2025) listed varying school support among the barriers to technology-based learning. Huang et al. (2022) showed that teachers' emotions are part of the TPACK development process itself, Hanifah and Utomo (2025) described social support as a factor in the emotional well-being of junior high school counselling teachers, and He et al. (2023) combined social support theory with the Technology Acceptance Model to examine how educational and emotional support shape acceptance of e-learning. The present result is consistent with these studies, but it should be read with care: technostress and burnout were not measured, so the buffering explanation is an interpretation rather than a tested mechanism. For principals, the finding suggests that listening to teachers' difficulties with technology and recognising their attempts, including unsuccessful ones, may matter as much as providing devices and workshops.

The Mediating Role of Emotional Support

The standardized indirect effect of adaptive ability on TPACK through emotional support was 0.354 (unstandardized estimate 0.343, p = 0.011; Table 2), and the direct path remained significant. The mediation test therefore indicates that adaptive ability is related to TPACK both directly and through emotional support, so part of the effect of individual flexibility runs through a supportive school environment. Adaptive teachers may build positive social interactions that return to them as emotional support, which in turn provides psychological resources for mastering digital pedagogy.

In the terms of Zhao et al. (2010), this is complementary mediation: the direct and indirect effects point in the same direction, and the significant direct path leaves room for other mediators. Self-efficacy, which links adaptability and TPACK in earlier studies (Collie et al., 2020; Zeng et al., 2022), is one candidate. Schools in Jekulo District could therefore combine individual development of teachers' adaptability with collegial structures, such as peer mentoring in teacher working groups, through which support reaches teachers who are learning new tools.

Theoretical and Practical Implications

Theoretically, this study supports a model that integrates psychological readiness with contextual support in TPACK development. Practically, it implies that educational management should not focus solely on technical training. School leaders should practise active listening and build collaborative cultures that reduce the mental burden of digital transformation. Unlike studies that focus only on technical skills, this research suggests that emotional support is an important basis for technological innovation in the classroom.

Several limitations qualify these conclusions. The design was cross-sectional, so the paths describe associations and their direction rests on theory, not on the data. All three constructs were self-reported by the same teachers on one questionnaire, which may inflate the relationships through common method variance (Podsakoff et al., 2003); no test for common method bias was reported. TPACK competence was self-rated, not observed in lessons or lesson plans. Model fit was acceptable on CMIN/DF, RMSEA, TLI and CFI, but the chi-square probability (0.008) and GFI, AGFI, NFI and RFI (0.834 to 0.877) did not reach their cut-offs (Table 1), and several error terms were allowed to correlate (Figure 2), which needs to be justified. The sample came from one district. Future research could use longitudinal or multi-wave designs, add classroom observation of technology

use, measure technostress and self-efficacy directly as competing mediators, and compare districts with different levels of digital infrastructure.

CONCLUSION AND RECOMMENDATIONS

This study provides empirical evidence on the structural relationships between individual factors and workplace supports in shaping teacher digital proficiency. Based on the findings, it can be concluded that: (1) teacher adaptive ability has a positive and significant influence on emotional support within the workplace, which suggests that more flexible teachers may be better at eliciting empathetic responses from colleagues and principals; (2) adaptive ability has a direct positive effect on TPACK competence, which indicates that the willingness to learn new tasks supports digital integration; (3) emotional support is the stronger predictor of TPACK competence, possibly because a supportive school atmosphere reduces technostress and allows teachers to focus on professional development; and (4) emotional support acts as a significant partial mediator, indicating that part of the effect of adaptive ability on TPACK operates through a psychologically supportive work environment.

Several practical and academic recommendations follow. Teachers should maintain a proactive mindset toward digital trends and actively participate in professional learning communities to share best practices and strengthen interpersonal emotional bonds. School leaders are encouraged to practise active listening and to recognize teachers' technological innovations, which may reduce the mental burden of digital transformation. Policymakers should design professional development programs that address technical application skills (TPACK) together with psychological well-being and a supportive organizational culture. Given that emotional support only serves as a partial mediator, future studies should explore other potential variables such as digital literacy, creative self-efficacy, or transformational leadership to extend the predictive model of teacher TPACK competence.

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REFERENCES

Afrillia, A., & Dafit, F. (2025). Tantangan guru mengimplementasikan pembelajaran berbasis teknologi digital dalam Kurikulum Merdeka di UPT SDN 023 Pandau Jaya. Pendas: Jurnal Ilmiah Pendidikan Dasar, 10(4), 230-242. https://doi.org/10.23969/jp.v10i04.36163

Akhwani, & Rahayu, D. W. (2021). Analisis Komponen TPACK Guru SD sebagai Kerangka Kompetensi Guru Profesional di Abad 21(An Analysis of Elementary School Teachers' TPACK Components as a Framework for 21st-Century Professional Teacher Competence). *JURNAL BASICEDU*, *5*(4), 1918–1925.

Berkovich, I., & Eyal, O. (2018). Principals' emotional support and teachers' emotional reframing: The mediating role of principals' supportive communication strategies. Psychology in the Schools, 55(7), 867–879. https://doi.org/10.1002/pits.22130

Collie, R. J., Granziera, H., Martin, A. J., Burns, E. C., & Holliman, A. J. (2020). Adaptability among science teachers in schools: A multi-nation examination of its role in school outcomes. Teaching and Teacher Education, 95, Article 103148. https://doi.org/10.1016/j.tate.2020.103148

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. Journal of Research on Technology in Education, 42(3), 255-284.

Fakhriyah, F., Masfuah, S., Hilyana, F. S., & Mamat, N. (2022). Analysis of technological pedagogical content knowledge (TPACK) ability based on science literacy for pre-service primary school teachers in learning science concepts. *Jurnal Pendidikan IPA Indonesia*, *11*(3), 399–411. https://doi.org/10.15294/jpii.v11i3.37305

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). Multivariate data analysis (8th ed.). Cengage.

Hammerness, K. M., Darling-Hammond, L., Bransford, J. et al. (2005). How teachers learn and develop. In L. Darling-Hammond, & J. Bransford (Eds.), Preparing Teachers for a Changing World: What Teachers Should Learn and Be Able to Do (pp. 358–389). Jossey-Bass.

Hanifah, Z. N., & Utomo, D. P. (2025). Social Support as a Supporting Factor for Emotional Well-Being of State Junior High School Counseling Teachers in Gemolong District. *JKIP: Jurnal Kajian Ilmu Pendidikan*, *6*(3), 1000–1014.

He, S., Jiang, S., Zhu, R., & Hu, X. (2023). The influence of educational and emotional support on e-learning acceptance: An integration of social support theory and TAM. *Education and Information Technologies*, 1–21. https://doi.org/10.1007/s10639-023-11648-1

House, J. S. (1981). Work stress and social support. Addison-Wesley.

House, J. S., Umberson, D., & Landis, K. R. (1988). Structures and processes of social support. *Annual Review of Sociology*, *14*, 293–318.

Huang, X., Huang, L., & Lajoie, S. P. (2022). Exploring teachers' emotional experience in a TPACK development task. *Educational Technology Research and Development*, *70*(4), 1283–1303. https://doi.org/10.1007/s11423-022-10135-7

Koehler, M. J., Mishra, P., & Cain, W. (2013). What is technological pedagogical content knowledge (TPACK)? *Journal of Education*, 193(3), 13–19. https://doi.org/10.1177/002205741319300303

Masfuah, S., Fakhriyah, F., Hilyana, F. S., & Kiong, T. T. (2024). The effect of technological pedagogy knowledge and technological content knowledge on TPACK of primary prospective teachers. Multidisciplinary Science Journal, 6(10), Article e2024188. https://doi.org/10.31893/multiscience.2024188

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. Teachers College Record, *108*(6), 1017–1054.

Mohamad Yusoff, Z. J., Zainal Abidin, M. H., Wan Mahmud, W. M., Mohamad Yusoff, S. H., & Yahya, N. (2023). Adaptive Leadership as a Catalyst for Educational Digitization. International Journal of Academic Research in Business & Social Sciences, 13(12), 1084–1094. https://doi.org/10.6007/IJARBSS/v13-i12/19984

Ployhart, R. E., & Bliese, P. D. (2006). Understanding adaptability: A prerequisite for effective performance within complex environments. *Advances in Human Performance and Cognitive Engineering Research*, *6*, 3–39. https://doi.org/10.1016/s1479-3601(05)06009-1

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal of Applied Psychology, 88(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Pulakos, E. D., Arad, S., Donovan, M. A., & Plamondon, K. E. (2000). Adaptability in the workplace: Development of a taxonomy of adaptive performance. *Journal of Applied Psychology*, *85*(4), 612–624. https://doi.org/10.1037/0021-9010.85.4.612

Putri, D. P. E. (2021). Korelasi Antara Tecnological Pedagogical And Content Knowladge (TPACK) dengan Kinerja Mengajar Dosen. *EDUGAMA:* Jurnal Kependidikan *Dan Sosial Keagamaan*, *08*(02), 1–21. https://doi.org/10.32923/edugama.v8i2.2474

Rahmi, U., Husein, R., & Rosita, T. (2023). Pengaruh kemampuan TPACK dan kecerdasan emosional terhadap kinerja guru di sekolah dasar negeri Kecamatan Silau Laut [The effect of TPACK competence and emotional intelligence on teacher performance in public elementary schools of Silau Laut District]. Pendas: Jurnal Ilmiah Pendidikan Dasar, 8(2). https://doi.org/10.23969/jp.v8i2.10186

Sarafino, E. P., & Smith, T. W. (2014). Health psychology: Biopsychosocial interactions (8th ed.). Wiley.

Savickas, M. L., & Porfeli, E. J. (2012). Career Adapt-Abilities Scale: Construction, reliability, and measurement equivalence across 13 countries. *Journal of Vocational Behavior*, *80*(3), 661–673. https://doi.org/10.1016/j.jvb.2012.01.011

Song, Y., Mu, F., Zhang, J., & Fu, M. (2022). The Relationships Between Career-Related Emotional Support From Parents and Teachers and Career Adaptability. *Frontiers in Psychology*, *13*, Article 823333. https://doi.org/10.3389/fpsyg.2022.823333

Tanta, T., Satar, S., Nurbaya, N., & Listiani, H. (2025). Teachers' readiness in integrating technology through TPACK-ICT framework: Evidence from Papua, Indonesia. Jurnal Iqra': Kajian Ilmu Pendidikan, 10(3). https://doi.org/10.25217/ji.v10i3.6676

Utaminingsih, S., & Fajrie, N. (2023). Teachers and students perception of technology and sustainable adoption framework in the pedagogical process: A systematic review. International Journal of Learning, Teaching and Educational Research, *22*(12), 162–186. https://doi.org/10.26803/ijlter.*22*.12.9

Vincent, M. K., Holliman, A. J., & Waldeck, D. (2024). Adaptability and social support: Examining links with engagement, burnout, and wellbeing among expat teachers. *Education Sciences*, *14*(1), Article 16. https://doi.org/10.3390/educsci14010016

Widowati, P. N., & Purbojo, R. (2024). Pengaruh Kompetensi Integrasi Teknologi , Konten Dan Pedagogik (TPACK), Motivasi Kerja Dan Teachers ' Work Engagement Terhadap Kinerja Guru SD XYZ Cabang Bekasi (The Effects of Technological Pedagogical and Content Knowledge (TPACK), Work Motivation, and Teacher Work Engagement on Teacher Performance at

XYZ Elementary School, Bekasi Branch). Cetta: Jurnal Ilmu Pendidikan, 7(3), 216–226. https://doi.org/10.37329/cetta.v7i3.3137

Zeng, Y., Wang, Y., & Li, S. (2022). The relationship between teachers' information technology integration self-efficacy and TPACK: A meta-analysis. Frontiers in Psychology, 13, Article 1091017. https://doi.org/10.3389/fpsyg.2022.1091017

Zhao, X., Lynch, J. G., Jr., & Chen, Q. (2010). Reconsidering Baron and Kenny: Myths and truths about mediation analysis. Journal of Consumer Research, 37(2), 197–206. https://doi.org/10.1086/651257

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

Transformational Leadership, Digital Competence, and Deep Learning Innovation in Elementary Schools

Mustaqim[1*], Sri Utaminingsih[1] and Ahmad Abdul Chamid[1]

[1]*Muria Kudus University, Indonesia*

Corresponding author: 202403126@std.umk.ac.id

ABSTRACT

Educational transformation requires school leaders and teachers to develop innovative learning practices that promote meaningful, student-centered, and technology-supported learning. This study aims to analyze the influence of principals' transformational leadership and teachers' digital competence on deep learning innovation among elementary school teachers in Kradenan District, Grobogan Regency, Indonesia. A quantitative research approach was employed using a survey design involving 176 elementary school teachers as respondents. Data were collected through structured questionnaires measuring transformational leadership, teachers' digital competence, and deep learning innovation. The data were analyzed using Structural Equation Modeling (SEM) with AMOS 31 to examine the relationships among the research constructs. The structural model showed acceptable fit on the reported indices, with CMIN/DF = 1.567, GFI = 0.958, AGFI = 0.946, TLI = 0.977, and RMSEA = 0.029. Hypothesis testing showed that principals' transformational leadership had a positive and significant influence on teachers' deep learning innovation (C.R. = 6.298, $p < 0.001$). In contrast, teachers' digital competence did not have a statistically significant influence on deep learning innovation (C.R. = 1.425, $p = 0.154$). In this sample, only transformational leadership was significantly associated with deep learning innovation; the two paths were not compared statistically. The results point to the value of strengthening principals' transformational leadership practices while developing more context-sensitive strategies for integrating teachers' digital competence into meaningful instructional innovation.

KEYWORDS transformational leadership | digital competence | deep learning innovation | elementary schools | teachers

INTRODUCTION

Digital-era education asks teachers to design learning that builds understanding, critical thinking, creativity, collaboration, communication and reflection, not only to adopt new devices or techniques. Deep learning has become an important orientation for this change because it emphasizes meaningful understanding and the application of knowledge to authentic situations. Fullan et al. (2018) describe deep learning as the development of six global competencies (character, citizenship, collaboration, communication, creativity and critical thinking) through learning partnerships, learning environments, pedagogical practices and digital technology.

Elementary schools lay the foundation for students' intellectual, social and character development, so the move from memorization and teacher-centered instruction toward exploration, problem-solving and reflection matters most at this level. Darling-Hammond et al. (2020) draw on the science of learning and development to argue that learning depends on supportive relationships and environments as well as on instructional strategies. OECD (2013) similarly emphasizes that innovative learning environments require supportive organizational structures, collaborative cultures and learner-centered practices.

The Indonesian education system has also changed substantially in response to these developments. The Merdeka Curriculum and the more recent deep learning approach (pembelajaran mendalam), built on mindful, meaningful and joyful learning principles (Rosyidah et al., 2026), ask schools to develop student-centered, flexible and meaningful instruction. Early classroom studies in elementary schools report better conceptual understanding in IPAS (Wibowo et al., 2025) and more active participation in mathematics, together with constraints such as limited time and uneven access to technology (Mutmainnah et al., 2025). UNESCO (2018) emphasizes that teachers' competence in information and communication technologies involves technical knowledge and also the capacity to integrate digital technologies into teaching, assessment, professional learning, and the creation of effective learning environments.

The availability of digital technology does not by itself produce innovative learning. Teachers may have adequate technical skills yet struggle to turn them into pedagogical practice. The TPACK framework stresses the integration of technological, pedagogical and content knowledge (Mishra & Koehler, 2006), and DigCompEdu describes educators' purposeful use of technology for teaching, assessment, learner engagement and professional development (Redecker, 2017).

Teachers' professional competence does not automatically translate into improved instructional practice. Evidence from Indonesian elementary schools indicates that teacher competence is closely associated with learning quality, but applying professional knowledge in the classroom remains a challenge. Shufa et al. (2024), for example, found a very strong positive relationship between teachers' pedagogical competence and learning quality, with a correlation coefficient of 0.88. Their findings also suggest that professional development needs to be accompanied by continued support to ensure that acquired competencies are effectively implemented in everyday teaching practice. The same gap appears for digital competence. In a DigCompEdu-based survey of 72 Indonesian junior high school teachers, most were at the B1 (Integrator) level and presentation media were the tools used most (Arimbawa et al., 2024). Ertmer and Ottenbreit-Leftwich (2010) argue that teachers' knowledge, self-efficacy, pedagogical beliefs and school culture together shape whether technology changes classroom practice.

Beyond teachers' individual competence, school leadership is an important organizational factor in educational innovation. Principals have a strategic position in establishing the vision, culture, and conditions necessary for instructional improvement. Transformational leadership is particularly relevant because it emphasizes the capacity of leaders to inspire followers, develop a shared vision, stimulate intellectual growth, and provide individualized support. Burns (1978) initially conceptualized transformational leadership as a process through which leaders and followers raise one another to higher levels of motivation and morality, while Bass (1985) and Bass and Avolio (1994) further developed the concept within organizational settings. In a survey of 2,290 teachers in English primary schools, transformational leadership affected teachers' motivation, work settings and classroom practices, but not student achievement gains (Leithwood & Jantzi, 2006). A meta-analysis of 27 studies found that the effect of instructional leadership on student outcomes was three to four times that of transformational leadership (Robinson et al., 2008).

Principals who provide clear direction, encourage professional collaboration, recognize teachers' contributions, and stimulate new ideas can create an organizational climate in which teachers feel supported in implementing innovative pedagogical practices. Hallinger (2018) argues that educational leadership needs to be understood in relation to its organizational and contextual environment. In Indonesia, principals' leadership has been linked to teachers' innovative work behavior (Hidayat & Patras, 2022), and a multiple-case study of three elementary schools in Jombang found that principals' instructional leadership strengthened teachers' pedagogical competence and deep learning practice under the Merdeka Curriculum (Hanik et al., 2025).

Previous studies have generally examined these dimensions separately. Leadership research in Indonesian elementary schools has mostly used teacher performance as the outcome (Nafiah et al., 2024; Purwanto et al., 2026). Studies of digital competence have described teachers' skill levels (Arimbawa et al., 2024), and studies of deep learning have been conceptual or qualitative (Rosyidah et al., 2026; Wibowo et al., 2025; Hanik et al., 2025). Shufa et al. (2024) show the importance of pedagogical competence for learning quality but did not examine leadership or digital competence. None of these studies tested principals' transformational leadership and teachers' digital competence together as predictors of teachers' deep learning innovation in elementary schools.

This gap is particularly relevant in non-metropolitan educational settings, where the implementation of educational transformation may encounter contextual challenges. The present study addresses this issue by examining elementary schools in Kradenan District, Grobogan Regency, Indonesia. The research involved 176 teachers from 41 elementary schools, which provides an empirical basis for examining the relationships among principals' transformational leadership, teachers' digital competence, and deep learning innovation.

This study therefore asks two questions. First, is principals' transformational leadership related to teachers' deep learning innovation? Second, is teachers' digital competence related to deep learning innovation when

leadership is in the same model? Testing both predictors together shows whether each one makes a distinct contribution, rather than assuming that every theoretically relevant factor does.

The study contributes evidence from Indonesian elementary schools on how transformational leadership and digital competence relate to deep learning innovation, and tests whether a direct link between digital competence and innovation holds in this setting. The findings may inform principals, supervisors and policymakers who design leadership and teacher development programmes.

LITERATURE REVIEW

Educational innovation is thought to depend on both organizational factors and individual professional capabilities. In the context of deep learning implementation in elementary schools, principals' transformational leadership represents an organizational factor that can create the conditions necessary for instructional innovation, while teachers' digital competence represents an individual professional capability that may facilitate the effective use of technology in learning. Based on this perspective, the present study develops a conceptual framework linking principals' transformational leadership and teachers' digital competence to teachers' deep learning innovation.

Transformational Leadership and Deep Learning Innovation

Transformational leadership can provide an organizational foundation for educational innovation. Burns (1978) conceptualized transformational leadership as a leadership process in which leaders and followers develop higher levels of motivation and commitment toward shared goals. Bass (1985) subsequently developed the concept by emphasizing the leader's capacity to influence followers through idealized influence, inspirational motivation, intellectual stimulation, and individualized consideration. In educational organizations, these dimensions are particularly relevant because teachers are expected to continuously adapt their instructional practices in response to curriculum reform, technological development, and changing student needs.

Principals who demonstrate transformational leadership can establish a shared vision for instructional improvement, encourage teachers to explore new approaches, provide intellectual stimulation, and recognize individual professional needs. Such leadership practices can create psychological and organizational conditions that encourage teachers to experiment with innovative instructional strategies. In the context of deep learning, transformational leadership may therefore facilitate the transition from conventional teacher-centered instruction toward learning practices that emphasize meaningful understanding, collaboration, creativity, critical thinking, communication, and reflection.

The relationship can be explained through the premise that instructional innovation requires more than individual willingness to change. Teachers need organizational support, opportunities for collaboration, encouragement to experiment, and leadership that legitimizes innovation. Principals' transformational leadership is therefore expected to have a positive influence on teachers' deep learning innovation.

Teachers' Digital Competence and Deep Learning Innovation

Teachers' digital competence is the second independent variable in the conceptual framework. Digital competence refers to teachers' ability to use digital technologies appropriately and effectively for teaching, learning, assessment, professional collaboration, and continuous professional development. The DigCompEdu framework emphasizes that teachers' digital competence involves both technical proficiency and the pedagogical application of digital technologies to improve learning processes and outcomes (Redecker, 2017). Similarly, the UNESCO ICT Competency Framework for Teachers emphasizes the integration of information and communication technologies with pedagogy, curriculum, assessment, and professional development (UNESCO, 2018).

Teachers' digital competence should be understood as an evolving professional capability rather than merely the ability to operate digital devices or applications. Teachers increasingly need to understand how emerging technologies can be selected, evaluated, and integrated responsibly according to instructional objectives and

learners' needs. Digital competence therefore involves both technological proficiency and the capacity to make informed pedagogical decisions concerning the use of technology in learning.

The relationship between digital competence and deep learning innovation can also be understood through the TPACK framework. Mishra and Koehler (2006) argue that meaningful technology integration occurs when technological knowledge is combined with pedagogical and content knowledge. From this perspective, teachers who possess stronger digital competence should have greater opportunities to employ digital resources to facilitate inquiry, collaboration, problem-solving, creativity, personalized learning, and authentic assessment. As digital technologies become more complex, integrating technological knowledge with pedagogical and content knowledge becomes more important.

Digital competence does not, however, translate automatically into instructional innovation. Teachers may be capable of operating digital tools but may still use them primarily to support conventional teaching practices. The pedagogical value of technology depends on how teachers connect technological resources with learning objectives, instructional strategies, subject matter, and students' needs. Therefore, the present study treats digital competence as a potentially important predictor while recognizing that its contribution to deep learning innovation may depend on the broader instructional and organizational context.

Deep Learning Innovation as the Dependent Variable

Deep learning innovation is the dependent variable in this study. It refers to teachers' efforts to develop and implement learning experiences that promote meaningful understanding, higher-order thinking, collaboration, creativity, communication, reflection, and the application of knowledge to authentic situations. Fullan et al. (2018) conceptualize deep learning as an approach that develops competencies enabling learners to engage meaningfully with complex challenges and real-world contexts.

In elementary education, deep learning innovation requires teachers to move beyond the transmission of information toward learning experiences in which students actively construct knowledge. Innovative deep learning practices may include inquiry-based learning, project-based activities, collaborative problem-solving, authentic tasks, reflective learning, and purposeful integration of digital technology. Deep learning innovation thus involves a broader change in the design and implementation of learning, not simply the adoption of technology.

Integrated Conceptual Relationship

The conceptual framework of this study proposes that principals' transformational leadership and teachers' digital competence may independently contribute to teachers' deep learning innovation. Transformational leadership provides the organizational direction, motivation, intellectual stimulation, and professional support necessary for innovation, whereas digital competence provides teachers with the capabilities needed to use digital resources in instructional practice.

The proposed model assumes a positive relationship between each independent variable and deep learning innovation. Hypothesis 1 proposes that principals' transformational leadership has a positive influence on teachers' deep learning innovation. Hypothesis 2 proposes that teachers' digital competence has a positive influence on deep learning innovation.

Research Objectives

This study aims to empirically examine the influence of principals' transformational leadership and teachers' digital competence on deep learning innovation among elementary school teachers in Kradenan District, Grobogan Regency, Indonesia. Specifically, the study seeks to: (1) examine the influence of principals' transformational leadership on teachers' deep learning innovation; and (2) examine the influence of teachers' digital competence on deep learning innovation. By testing these relationships using Structural Equation Modeling (SEM), the study seeks to identify which of the two predictors is significantly related to the development of innovative deep learning practices in elementary schools. The findings are expected to provide empirical evidence for strengthening school leadership and teacher professional development strategies in support of educational transformation.

RESEARCH METHOD

Research Design

This study employed a quantitative approach with an explanatory research design. The design was selected because the study aimed to examine the relationships between principals' transformational leadership, teachers' digital competence, and deep learning innovation among elementary school teachers. The explanatory approach enabled the researcher to test the proposed relationships between the latent constructs based on empirical data collected from the respondents.

The analysis was conducted using Structural Equation Modeling (SEM) with AMOS version 31. SEM was selected because it examines structural relationships among latent variables while accounting for the measurement properties of the constructs. The analysis consisted of measurement model evaluation through confirmatory factor analysis and structural model evaluation to test the proposed hypotheses.

Respondents of the Study

The study was conducted in public elementary schools in Kradenan District, Grobogan Regency, Central Java, Indonesia. The population consisted of 314 elementary school teachers. A total of 176 teachers participated as respondents, representing teachers from 41 public elementary schools in the district. The sample size was determined using the Slovin formula with a 5% margin of error. Probability sampling was used, with teachers allocated proportionally across schools.

The final dataset consisted of 176 completed questionnaires. Of the respondents, 77 (43.75%) were male and 99 respondents (56.25%) were female. Regarding educational background, 141 respondents (80.11%) held a bachelor's degree, 19 (10.80%) held a master's degree, and 16 (9.09%) held diploma qualifications. The age distribution ranged from 36 to 59 years, with the largest group consisting of respondents aged 48–53 years (34.09%).

Research Instruments

Data were collected using structured questionnaires employing a Likert-scale response format. The questionnaire measured three latent constructs: principals' transformational leadership (X1), teachers' digital competence (X2), and deep learning innovation (Y).

The transformational leadership construct was represented by six observed indicators (X1.1–X1.6). The digital competence construct was measured using eight observed indicators (X2.1–X2.8), while deep learning innovation was measured using six observed indicators (Y1–Y6). The indicators were developed from the theoretical dimensions and operational definitions established in the research framework.

Instrument Validity and Reliability

The quality of the measurement instruments was evaluated before testing the structural relationships. Confirmatory analysis was conducted using AMOS 31 to determine whether the observed indicators adequately represented their respective latent constructs.

The validity analysis showed that all questionnaire indicators met the required significance criteria. The indicators for transformational leadership, digital competence, and deep learning innovation were therefore retained for subsequent analysis.

Reliability was assessed using construct reliability. The construct reliability coefficient for transformational leadership was 0.784336, while digital competence obtained a coefficient of 0.793621 and deep learning innovation obtained 0.870810. All coefficients exceeded the commonly accepted threshold of 0.70, indicating satisfactory internal consistency of the measurement constructs.

Data Analysis

The empirical data were analyzed using AMOS version 31 through a series of measurement and structural model analyses. First, confirmatory factor analysis (CFA) was performed to examine whether the observed indicators adequately represented the latent constructs. The analysis included the exogenous constructs of transformational leadership and digital competence and the endogenous construct of deep learning innovation.

The structural model was subsequently evaluated using several goodness-of-fit indices, including Chi-square, CMIN/DF, Goodness-of-Fit Index (GFI), Adjusted Goodness-of-Fit Index (AGFI), Tucker-Lewis Index (TLI), and Root Mean Square Error of Approximation (RMSEA). The structural model produced a CMIN/DF value of 1.567, GFI of 0.958, AGFI of 0.946, TLI of 0.977, and RMSEA of 0.029, indicating that the proposed structural model achieved an acceptable level of fit with the empirical data.

Finally, hypothesis testing was conducted by examining the critical ratio (C.R.) and probability (p) values generated by the SEM analysis. A relationship was considered statistically significant when the C.R. exceeded 1.96 in absolute value and the p-value was below 0.05. The analysis was used to determine whether principals' transformational leadership and teachers' digital competence had significant direct effects on teachers' deep learning innovation.

RESULTS

The study involved 176 elementary school teachers from 41 public elementary schools in Kradenan District, Grobogan Regency. The respondents represented teachers from all sampled schools, with four to six teachers selected from each school. The distribution was designed proportionally according to the number of teachers in each school.

Table 1 presents the respondents' distribution by gender.

Table 1. Distribution of respondents by gender

Gender	Frequency	Percentage
Male	77	43.75%
Female	99	56.25%
Total	**176**	**100%**

The distribution shows that female teachers constituted a slightly larger proportion of the respondents than male teachers. Both male and female teachers are therefore well represented in the sample.

Instrument Validity and Reliability

Before examining the structural relationships, the measurement instruments were evaluated for validity and reliability. The validity analysis showed that the questionnaire indicators were statistically valid, with significance values below 0.05. Therefore, the indicators representing transformational leadership, digital competence, and deep learning innovation were considered appropriate for subsequent analysis.

Reliability was assessed using construct reliability. The results are presented in Table 2.

Table 2. Construct reliability of research variables

Construct	Construct Reliability	Interpretation
Transformational Leadership	0.784336	Reliable
Digital Competence	0.793621	Reliable
Deep Learning Innovation	0.870810	Reliable

All three constructs obtained construct reliability coefficients above the commonly accepted threshold of 0.70. The highest reliability coefficient was obtained for deep learning innovation (0.870810), followed by digital competence (0.793621) and transformational leadership (0.784336). These results indicate satisfactory internal consistency, so the instruments were suitable for structural analysis.

Confirmatory Factor Analysis

Confirmatory factor analysis (CFA) was conducted to evaluate whether the observed indicators adequately represented their respective latent constructs. The exogenous measurement model involving transformational leadership and digital competence produced a CMIN/DF value of 1.099, GFI of 0.960, AGFI of 0.974, TLI of 0.983, and RMSEA of 0.024. These indices indicate an acceptable measurement model and support the adequacy of the observed indicators for representing the constructs.

The measurement model for deep learning innovation also demonstrated an acceptable fit, with CMIN/DF = 2.216, GFI = 0.967, AGFI = 0.956, TLI = 0.956, and RMSEA = 0.033. These results indicate that the indicators used to measure deep learning innovation were sufficiently consistent with the proposed latent construct.

Structural Model Fit

After the measurement models were established, the structural model was evaluated using SEM with AMOS 31. The goodness-of-fit results are presented in Table 3.

Table 3. Goodness-of-fit indices of the structural model

Fit Index	Result	Interpretation
Chi-square	129.144	—
Probability	0.000	—
DF	164	—
CMIN/DF	1.567	Acceptable
GFI	0.958	Good
AGFI	0.946	Good
TLI	0.977	Good
RMSEA	0.029	Good

The structural model produced CMIN/DF = 1.567, GFI = 0.958, AGFI = 0.946, TLI = 0.977, and RMSEA = 0.029. These indices are within commonly used cut-offs, although the chi-square, df and probability values in the goodness-of-fit table do not agree with the reported CMIN/DF and need to be re-checked. Therefore, the model was considered appropriate for testing the hypothesized relationships between transformational leadership, digital competence, and deep learning innovation.

Hypothesis Testing

The structural relationships were tested using the critical ratio (C.R.) and probability (p) values generated by AMOS. A relationship was considered statistically significant when the absolute C.R. exceeded 1.96 and the probability value was below 0.05. The results are presented in Table 4.

Table 4. Results of hypothesis testing

Hypothesis	Relationship	C.R.	p-value	Decision
H1	Transformational Leadership → Deep Learning Innovation	6.298	<0.001	Supported
H2	Digital Competence → Deep Learning Innovation	1.425	0.154	Not supported

Source: Primary data analysis using AMOS 31, 2026.

The results show that one of the two hypotheses was supported. Principals' transformational leadership had a positive and statistically significant relationship with teachers' deep learning innovation (C.R. = 6.298, $p < 0.001$). In contrast, teachers' digital competence did not show a statistically significant direct relationship with deep learning innovation (C.R. = 1.425, $p = 0.154$).

DISCUSSION

The Influence of Transformational Leadership on Deep Learning Innovation

The first hypothesis was supported. The C.R. value of 6.298 exceeded the critical value of 1.96, and the probability value was below 0.001. Principals' transformational leadership was therefore significantly related to teachers' deep learning innovation.

This finding suggests that principals' leadership practices are an important organizational factor in supporting teachers' instructional innovation. Transformational leadership involves creating a shared vision, motivating teachers, encouraging intellectual stimulation, and providing individualized support. When these practices are present, teachers may feel more encouraged to experiment with new instructional approaches and develop learning activities that promote meaningful understanding, critical thinking, collaboration, creativity, and reflection.

The finding is consistent with the theoretical perspective of Burns (1978) and Bass and Avolio (1994), which emphasizes the capacity of transformational leaders to motivate followers to move beyond routine practices and pursue higher organizational goals. Principals also influence the professional climate in which teachers develop and implement instructional innovations.

Recent evidence from Indonesian elementary schools is consistent with this finding. Purwanto et al. (2026) found that transformational leadership had a positive and significant effect on the performance of PPPK teachers in public elementary schools in Serpong Utara. Their study also reported that transformational leadership, organizational culture, and teacher motivation jointly had significant effects on teacher performance. Nafiah et al. (2024) examined principals' leadership, teachers' work motivation and work culture as predictors of teacher performance in public elementary schools in Sayung, Demak, and reported a similar pattern.

The findings of the present study extend this previous evidence by examining a more specific form of professional practice, namely teachers' deep learning innovation. While Purwanto et al. (2026) focused on teacher performance, the present study shows that transformational leadership is also significantly associated with teachers' capacity to implement innovative deep learning practices.

The result is also consistent with the argument of Hallinger (2018) that leadership must be understood within its organizational context: in elementary schools, teachers' innovation depends on the direction, support and opportunities for collaboration that principals provide.

The result is particularly relevant to deep learning because the implementation of deep learning requires changes in teachers' instructional practices rather than simply the addition of new learning technologies. Transformational principals can facilitate these changes by establishing a school culture that values continuous improvement and pedagogical experimentation.

The result also agrees with Hidayat and Patras (2022), who found a direct effect of principals' leadership on the innovative work behavior of 1,200 Indonesian teachers, and with the qualitative finding of Hanik et al. (2025) that supervision, continuous professional development and a collaborative culture made the difference to deep learning practice in elementary schools. It differs in emphasis from Robinson et al. (2008), whose meta-analysis found larger effects on student outcomes for instructional leadership, especially leaders' participation in teacher learning, than for transformational leadership. Because the present study measured teachers' reported innovation rather than student outcomes, the results do not conflict; together they suggest that principals in Kradenan District could combine transformational practices with direct involvement in teachers' professional learning, for example in teacher working group (KKG) meetings.

The Influence of Digital Competence on Deep Learning Innovation

The second hypothesis was not supported. The C.R. value of 1.425 was below the critical value of 1.96, and the probability value of 0.154 exceeded the 0.05 significance level. Therefore, teachers' digital competence did not have a statistically significant direct influence on deep learning innovation in the context of this study.

This finding is unexpected because digital competence is theoretically expected to facilitate teachers' ability to integrate technology into instructional practice. However, the present empirical evidence indicates that

possessing digital competence does not automatically translate into deep learning innovation.

One possible explanation is that digital competence represents a necessary capability but not necessarily a sufficient condition for pedagogical transformation. Teachers may be capable of operating digital devices, accessing digital resources, using interactive media, and conducting digital assessments while continuing to employ conventional instructional approaches. In such circumstances, technology may enhance the efficiency of existing teaching practices without fundamentally changing the nature of learning.

This finding is consistent with the argument underlying the TPACK framework developed by Mishra and Koehler (2006), which emphasizes the interaction between technological knowledge, pedagogical knowledge, and content knowledge. Digital competence in isolation may not be sufficient when teachers lack opportunities to integrate technology with appropriate pedagogical strategies and subject-specific learning objectives.

Earlier studies help explain this pattern. Ertmer and Ottenbreit-Leftwich (2010) argue that knowledge of technology changes practice only when teachers' confidence, pedagogical beliefs and school culture also support the change, and Arimbawa et al. (2024) found that most Indonesian teachers in their sample were at an intermediate level and used digital tools mainly for presentation. Classroom studies of deep learning also report uneven access to technology (Mutmainnah et al., 2025). A non-significant path is not evidence that digital competence is unrelated to innovation, however. The analysis reports no standardized coefficients, explained variance or correlation between the two predictors, so it cannot show whether digital competence overlaps with leadership (for example, if teachers in schools with transformational principals also rate their digital competence higher) or whether its effect is small and not detectable with 176 teachers.

The result also suggests that professional development programs should not focus exclusively on technical digital skills. Training should instead emphasize how digital technologies can be transformed into meaningful pedagogical practices. Teachers may require mentoring, collaborative lesson design, classroom-based coaching, and opportunities to reflect on the pedagogical effectiveness of technology use.

Comparative Interpretation of the Two Predictors

This difference suggests that educational innovation in the studied context may be more strongly influenced by the organizational environment than by teachers' digital capabilities alone. Leadership can establish the conditions under which teachers' existing competencies are mobilized and transformed into instructional innovation.

The finding does not imply that digital competence is unimportant. Rather, it indicates that digital competence by itself may not be sufficient to explain variations in deep learning innovation. Its contribution may depend on other conditions, such as pedagogical competence, teacher self-efficacy, school culture, professional learning communities, infrastructure, instructional supervision, or leadership support.

Overall, transformational leadership was the only significant predictor of deep learning innovation in this sample, while the role of teachers' digital competence needs a more contextual explanation.

These conclusions have several limitations. The fit statistics need to be re-checked: in Table 3 the chi-square (129.144) is smaller than the degrees of freedom (164), which does not agree with the reported CMIN/DF of 1.567 or with a probability of 0.000. Only critical ratios and p-values are reported, so the size of each relationship cannot be judged. All constructs were self-reported by teachers at one time point, which makes common method variance possible (Podsakoff et al., 2003) and rules out causal conclusions; teachers' self-reports of deep learning practice may also be higher than what is observed in class (Kladika et al., 2026). Future studies should report standardized coefficients and R^2, observe lessons, test pedagogical competence or self-efficacy as mediators between digital competence and innovation, and compare districts with different resources.

CONCLUSION AND RECOMMENDATIONS

This study examined the influence of principals' transformational leadership and teachers' digital competence on deep learning innovation among elementary school teachers in Kradenan District, Grobogan Regency, Indonesia. Based on the empirical analysis using Structural Equation Modeling (SEM), the proposed structural model showed a good fit on the reported indices. The findings provide evidence that the two predictors do not contribute equally to teachers' deep learning innovation.

First, principals' transformational leadership was found to have a positive and statistically significant influence on teachers' deep learning innovation. The critical ratio of 6.298 and probability value below 0.001 indicate that transformational leadership is an important organizational factor supporting teachers' capacity to develop and implement innovative learning practices. Principals who establish a shared vision, motivate teachers, encourage intellectual stimulation, and provide individualized support can create an organizational climate conducive to instructional innovation.

Second, teachers' digital competence did not have a statistically significant direct influence on deep learning innovation. The critical ratio of 1.425 and probability value of 0.154 indicate that digital competence alone was insufficient to explain variations in teachers' deep learning innovation in the context of this study. This finding suggests that technical or digital capability does not automatically lead to pedagogical transformation. The effective implementation of deep learning may require the integration of digital competence with pedagogical knowledge, professional collaboration, instructional support, and an organizational environment that encourages innovation.

Overall, the study suggests that deep learning innovation is better understood as an organizational process influenced by school leadership than as a simple consequence of teachers' technological capabilities. The findings point to the role of principals in creating conditions that enable teachers to transform their professional capabilities into meaningful and innovative learning practices.

Recommendations

Based on the findings, several recommendations are proposed. First, elementary school principals should strengthen transformational leadership practices by developing a clear vision for instructional improvement, encouraging teacher participation in innovation, providing constructive feedback, facilitating professional collaboration, and creating opportunities for teachers to experiment with new learning approaches. Leadership development programs should therefore place greater emphasis on instructional innovation and change management.

Second, teacher professional development programs should move beyond the development of basic digital skills. Although digital competence is essential in contemporary education, training should emphasize the pedagogical integration of technology. Professional development should include technology-supported lesson design, inquiry-based learning, collaborative learning, digital assessment, project-based learning, and reflective practice so that digital tools are used to support deep learning rather than simply replace conventional teaching methods.

Third, educational supervisors and policymakers should develop integrated programs that connect school leadership development with teacher professional development. Schools need both digitally competent teachers and organizational environments that provide opportunities, resources, mentoring, and professional collaboration. Such integrated support may increase the likelihood that teachers' digital capabilities are transformed into meaningful instructional innovation.

Finally, future research should examine additional factors that may explain the relationship between digital competence and deep learning innovation. Variables such as pedagogical competence, teacher self-efficacy, professional learning communities, school organizational culture, instructional supervision, technological infrastructure, and leadership support may provide a more comprehensive explanation of how teachers' digital capabilities are translated into innovative learning practices. Future studies may also employ longitudinal or

mixed-methods designs to investigate how leadership and teacher competence interact over time in the implementation of deep learning.

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REFERENCES

Arimbawa, G. P. A., Wikanta, I. M. I. A., Sumarno, I. W., Dantes, G. R., Indrawan, G., & Gunawan, I. M. A. O. (2024). Exploring the digital literacy levels of junior high school Indonesian language teachers: A DigCompEdu perspective. Jurnal Edutech Undiksha, 12(2), 322-333. https://doi.org/10.23887/jeu.v12i2.86129

Bass, B. M. (1985). Leadership and performance beyond expectations. Free Press.

Bass, B. M., & Avolio, B. J. (1994). Improving organizational effectiveness through transformational leadership. Sage Publications.

Burns, J. M. (1978). Leadership. Harper & Row.

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. Applied Developmental Science, 24(2), 97–140.

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. Journal of Research on Technology in Education, 42(3), 255-284.

Fullan, M., Quinn, J., & McEachen, J. (2018). Deep learning: Engage the world, change the world. Corwin.

Hallinger, P. (2018). Bringing context out of the shadows of leadership. Educational Management Administration & Leadership, 46(1), 5–24. https://doi.org/10.1177/1741143216670652

Hanik, H., Nuphanudin, N., Khamidi, A., Roesminingsih, E., Kristanto, A., Trihantoyo, S., & Haq, M. S. (2025). Kepala sekolah sebagai instructional leader: Penguatan kompetensi pedagogik guru untuk pembelajaran mendalam di sekolah dasar. Didaktika, 5(3). https://doi.org/10.17509/didaktika.v5i3.93269

Hidayat, R., & Patras, Y. E. (2022). The effect of principals' leadership and learning organization on teachers' innovative work behavior during the COVID-19 pandemic. Tadris: Jurnal Keguruan dan Ilmu Tarbiyah, 7(1), 161-175. https://doi.org/10.24042/tadris.v7i1.11355

Kladika, A. S., Wening, N., & Firman, S. (2026). Self-reported implementation of mindful, meaningful, and joyful learning among elementary school physical education teachers. Journal of Holistic Sports and Physical Education, 1(2), 1-10. https://doi.org/10.23917/jhspe.18528

Leithwood, K., & Jantzi, D. (2006). Transformational school leadership for large-scale reform: Effects on students, teachers, and their classroom practices. School Effectiveness and School Improvement, 17(2), 201–227. https://doi.org/10.1080/09243450600565829

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. Teachers College Record, 108(6), 1017–1054.

Mutmainnah, N., Adrias, A., & Zulkarnaini, A. P. (2025). Implementasi pendekatan deep learning terhadap pembelajaran matematika di sekolah dasar. Pendas: Jurnal Ilmiah Pendidikan Dasar, 10(1), 848-871. https://doi.org/10.23969/jp.v10i01.23781

Nafiah, K., Bunyamin, & Abdullah, G. (2024). Pengaruh kepemimpinan kepala sekolah, motivasi kerja guru, dan budaya kerja terhadap kinerja guru SD Negeri se-Kecamatan Sayung Kabupaten Demak. Pendas: Jurnal Ilmiah Pendidikan Dasar, 9(4). https://doi.org/10.23969/jp.v9i04.20635

OECD. (2013). Innovative learning environments. OECD Publishing. https://doi.org/10.1787/9789264203488-en

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal of Applied Psychology, 88(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Purwanto, H., Utaminingsih, S., & Mahendrawan, E. (2026). *Upaya Peningkatan Kinerja Guru PPPK Melalui Kepemimpinan Transformasional, Budaya Organisasi, dan Motivasi Guru di Sekolah Dasar Negeri Se-Kecamatan Serpong Utara*. Pendas: Jurnal Ilmiah Pendidikan Dasar, *11*(2), 370–390. https://doi.org/10.23969/jp.v*11*i2.45660

Redecker, C. (2017). European framework for the digital competence of educators: DigCompEdu (Y. Punie, Ed.). Publications Office of the European Union. https://doi.org/10.2760/178382

Robinson, V. M. J., Lloyd, C. A., & Rowe, K. J. (2008). The impact of leadership on student outcomes: An analysis of the differential effects of leadership types. Educational Administration Quarterly, 44(5), 635–674. https://doi.org/10.1177/0013161X08321509

Rosyidah, F., Parmiti, D. P., Sanjaya, D. B., & Jampel, I. N. (2026). The theories of principles in deep learning approach. Pedagogia: Jurnal Pendidikan, 15(1), 127-136. https://doi.org/10.21070/pedagogia.v15i1.2098

Shufa, N. K. F., Utaminingsih, S., & Adji, T. P. (2024). Korelasi Guru Bersertifikat Pendidik Terhadap Kompetensi Pedagogik Guru Dan Peningkatan Kualitas Pembelajaran Di Sekolah Dasar. *INOPENDAS: Jurnal Ilmiah Kependidikan*, *7*(2), 127–139. https://doi.org/10.24176/jino.v7i2.12883

UNESCO. (2018). UNESCO ICT competency framework for teachers (Version 3). UNESCO.

Wibowo, G. W., Gunawan, D., & Mardiana, D. (2025). Implementasi pendekatan pembelajaran mendalam (deep learning) dalam meningkatkan pemahaman konsep siswa di sekolah dasar. Pendas: Jurnal Ilmiah Pendidikan Dasar, 10(3), 144-158. https://doi.org/10.23969/jp.v10i3.27960

ICISFS-UMK 2026 CURRICULUM, CULTURE & CHARACTER

Implementing Deep Learning at Elementary School SD 2 Sambung

Fazar Muzdalifah[1*], Gunawan[1] and Erik Aditia Ismaya[1]

[1]*Muria Kudus University, Indonesia*

Corresponding author: fazar.muzdalifah@gmail.com

ABSTRACT

This study aims to describe the implementation of deep learning at SD 2 Sambung to improve the quality of elementary school learning. Learning in the 21st century requires students to develop critical thinking, creativity, collaboration, and communication skills. However, elementary school learning is often still teacher-centered and does not yet develop students' thinking skills sufficiently. This research uses a qualitative approach with a case study method. The participants were the principal, three teachers and 20 students at SD 2 Sambung, Kudus. Data were collected through observation, interviews, and documentation. Data analysis used the Miles and Huberman model: data reduction, data presentation, and conclusion drawing. The conceptual framework refers to the deep learning model of Fullan et al. (2018) and the Merdeka Curriculum. The results show that deep learning at SD 2 Sambung is implemented through 3 principles: meaningful learning, mindful learning, and joyful learning. Teachers used group discussion, collaborative assignments, question-and-answer sessions, presentations and digital media, and students took an active part in these activities. The supporting factors were teacher creativity, the use of digital media and student motivation, and the inhibiting factors were limited instructional time, limited teacher training and limited facilities. The study concludes that deep learning at SD 2 Sambung is being implemented as planned and may help develop students' 21st-century competencies. Teachers need continuous training, and schools need to provide adequate learning media to support deep learning implementation.

KEYWORDS deep learning | elementary school | implementation | Merdeka Curriculum | SD 2 Sambung

INTRODUCTION

Elementary schools play an important role in shaping students' knowledge, attitudes, and learning habits. For this reason, learning should not focus solely on delivering information. Students also need opportunities to understand what they learn, relate new information to their daily experiences, take an active part in classroom activities, and reflect on their learning process. The deep learning approach (pembelajaran mendalam) adopted in Indonesian schools is intended to support these goals through learning that is mindful, meaningful and joyful. Rosyidah et al. (2026) link these three principles to constructivist learning theory and argue that they should be applied together, so that students actively connect content to real-life experience.

Internationally, Fullan et al. (2018) describe deep learning as the development of six global competencies (character, citizenship, collaboration, communication, creativity and critical thinking) through four elements: learning partnerships, learning environments, pedagogical practices and the use of digital technology. In Indonesia, the approach follows the introduction of the Merdeka Curriculum, which already asked teachers to change how they plan and assess learning. Teachers have found this transition demanding. First-grade teachers in one study struggled with new curriculum terms such as learning outcomes, teaching modules and the P5 project, and coped through Ministry resources, webinars and peer discussion (Asmahasanah et al., 2023). Elementary teachers implementing technology-based learning under the curriculum have also faced uneven teacher competence, underused ICT infrastructure and varying school support (Afrillia & Dafit, 2025).

Putting this approach into practice requires careful preparation and adjustment. Teachers need to design learning objectives, select appropriate materials and media, organize classroom activities, and determine suitable assessment methods based on students' needs and characteristics. They also need to create opportunities for students to ask questions, exchange ideas, work together, present their findings, and reflect on what they have

learned. These activities can be challenging, especially when teachers and students are still becoming familiar with the approach.

SD 2 Sambung in Kudus, Central Java, offers an opportunity to explore how the deep learning approach is planned and implemented in an elementary school setting. This study examines the preparation of learning activities, the teaching and learning process in the classroom, and the factors that support or hinder implementation. Rather than measuring the direct effect of deep learning on student achievement, the study focuses on understanding how the approach is applied in practice based on the data collected in the field.

Early studies of deep learning in Indonesian elementary schools describe both benefits and difficulties. In fifth-grade IPAS lessons, deep learning grounded in mindful, meaningful and joyful learning was associated with better conceptual understanding (Wibowo et al., 2025). In elementary mathematics, simulations and experiments increased student participation, but limited time and uneven access to technology constrained implementation (Mutmainnah et al., 2025). A multiple-case study of three elementary schools in Jombang found that principals' supervision, continuous professional development and a collaborative culture strengthened teachers' deep learning practice (Hanik et al., 2025). Survey evidence is less direct: physical education teachers in Sukabumi reported a very high level of deep learning implementation, but the authors caution that self-report is not evidence of classroom practice (Kladika et al., 2026). Other authors describe how deep learning has been implemented in elementary classrooms (Mujtahid et al., 2025), point to conceptual and epistemological challenges in implementing it (Dinata et al., 2025), and report on teacher training for it (Atmojo et al., 2025).

These studies leave a practical gap. Most describe a single subject or rely on teachers' own reports, and few combine classroom observation with an account of the conditions that help or hinder teachers in the same school during the first period of implementation. How the general principles of deep learning are turned into everyday classroom routines, and which school conditions matter most, may differ from school to school. A close description of one school can show what implementation looks like in practice and which constraints teachers meet.

Based on this background, the present study focuses on three research questions: (1) How is the deep learning approach planned at SD 2 Sambung? (2) How is the approach implemented in classroom learning activities? and (3) What factors support or hinder its implementation? The findings are expected to provide a better understanding of deep learning practices at SD 2 Sambung and serve as a basis for reflection and improvement for teachers and school leaders.

LITERATURE REVIEW

This research draws on three bodies of work:

1. Deep Learning Theory: Deep learning focuses on understanding, engagement, and application (Haq & Prasetiyo, 2025; Fullan et al., 2018).
2. Project Based Learning & Problem Based Learning: Models that support deep learning implementation (Handika et al., 2021; Nugraheni et al., 2023).
3. Critical Thinking Skills: One of the main outcomes of deep learning (Juliyantika & Batubara, 2022; Damayanti et al., 2020).

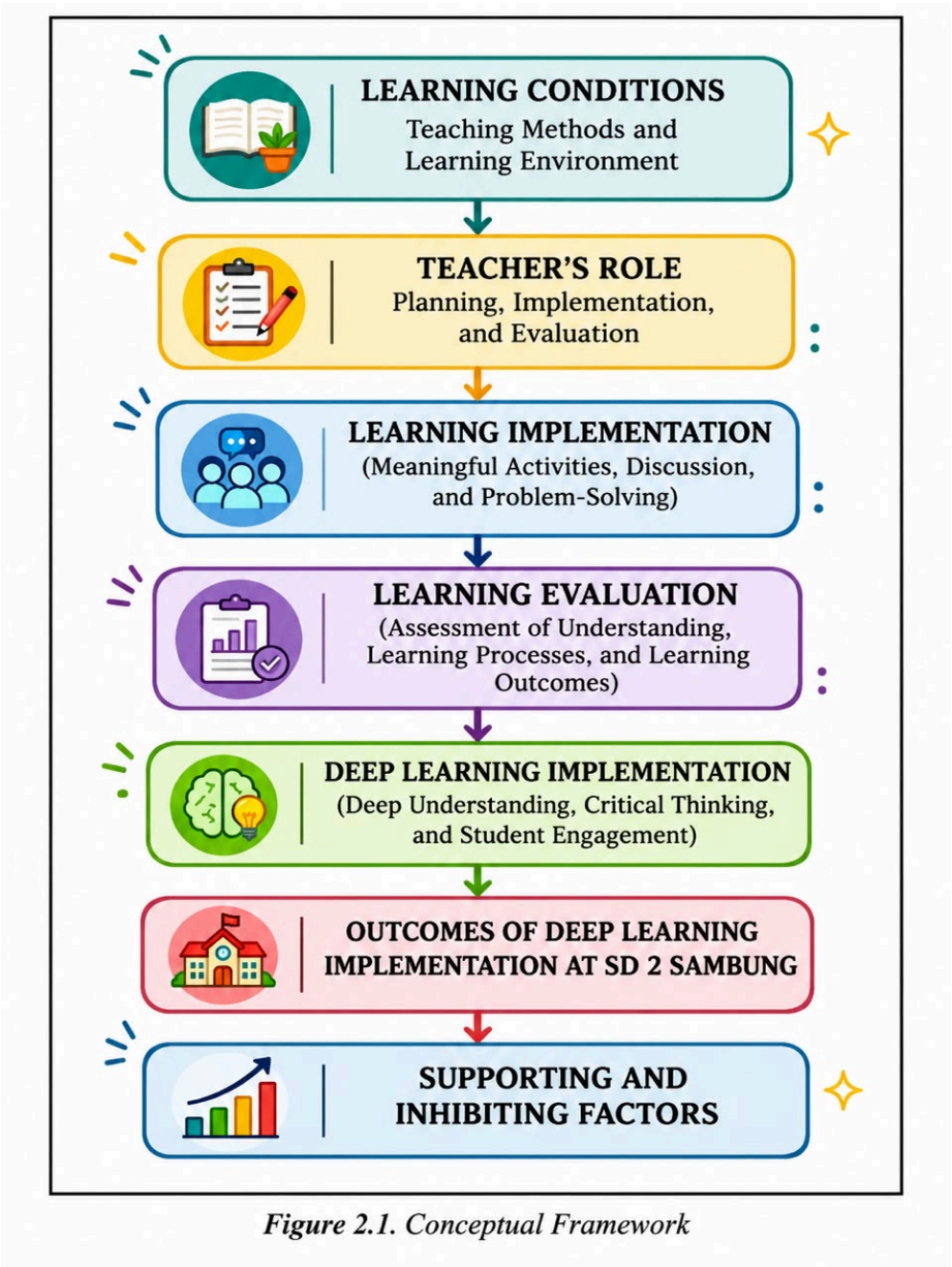

Figure 2.1. Conceptual Framework

Figure 1. Conceptual framework of the study: from learning conditions and the teacher's role to implementation, evaluation, outcomes, and supporting and inhibiting factors

Research Objectives

1. To describe the implementation of deep learning in SD 2 Sambung.
2. To identify supporting and inhibiting factors in the implementation.
3. To describe students' participation in deep learning activities.

RESEARCH METHOD

- **Research design:** Qualitative descriptive case study (Waruwu, 2024)
- **Research site:** SD 2 Sambung, Kudus Regency, Central Java
- **Participants:** 1 principal, 3 teachers, 20 students
- **Data Collection:** Observation, semi-structured interviews, documentation
- **Data Analysis:** data condensation, data display, and conclusion drawing (Miles et al., 2020)

- **Data Validity:** Source triangulation (Haki et al., 2024; Husnullail et al., 2024; Nurfajriani et al., 2024)

RESULTS

Finding 1: Implementation of Deep Learning

The findings show that deep learning at SD 2 Sambung was implemented through various classroom activities, including group discussions, collaborative assignments, question-and-answer sessions, presentations, and the use of digital learning media. These activities provided opportunities for students to participate in the learning process rather than simply listen to the teacher's explanations. Teachers also encouraged students to work together and complete learning tasks related to the lesson.

One of the activities observed during the research was group learning. Students worked together at their desks to discuss and complete assignments. This activity allowed them to exchange ideas, share responsibilities, and participate in solving learning tasks. Group activities also provided opportunities for students to learn from their classmates.



Figure 2. Students participating in group learning activities at SD 2 Sambung

As shown in Figure 2, students participated in a group learning activity in the classroom. This type of activity can support meaningful learning by encouraging students to discuss the material and connect their understanding with the ideas of their peers. It can also provide opportunities for students to express their opinions and develop cooperation during the learning process.

In addition to group activities, teachers used learning media to support classroom instruction. Digital media, including an LCD projector, helped teachers present learning materials visually. The use of such media provided another way to explain lesson content and attract students' attention during classroom activities.



Figure 3. A teacher using an LCD projector as learning media

Figure 3 shows a teacher using an LCD projector during classroom instruction. The use of visual media can help teachers present information in an accessible way and support students' understanding of the material. However, the effectiveness of learning media also depends on how teachers integrate it into learning activities and encourage students to engage with the content.

Overall, the classroom activities observed at SD 2 Sambung reflected efforts to implement deep learning through student participation, collaboration, and the use of varied learning resources. These practices were relevant to the principles of mindful learning, meaningful learning, and joyful learning. However, how far these principles were realized depends on the actual learning process, students' responses, and teachers' instructional decisions.

Finding 2: Supporting and Inhibiting Factors of Deep Learning Implementation

The implementation of deep learning at SD 2 Sambung was influenced by several supporting and inhibiting factors. Based on the research findings, teacher creativity, the use of digital learning media, and student motivation supported classroom activities. Teachers' efforts to vary their teaching methods and provide opportunities for student participation helped create a more engaging learning environment.

The availability of learning media also supported the teaching and learning process. As illustrated in Figure 3, the use of an LCD projector enabled the teacher to present materials visually. Meanwhile, group activities, as shown in Figure 2, provided opportunities for students to interact and participate in completing assignments. These classroom practices illustrate how teaching strategies and learning resources can support the implementation of deep learning.

However, several challenges remained. Limited instructional time could restrict opportunities for discussion, presentation, and reflection. Limited teacher training could also make it more difficult for teachers to develop a consistent understanding of the deep learning approach. In addition, limitations in learning facilities could affect teachers' ability to use different instructional resources.

The supporting and inhibiting factors identified in the study are summarized in the two tables below.

Table 1. Supporting factors in deep learning implementation

No	Factors	Description
1.	Teacher creativity	Teachers' efforts to vary learning activities and teaching strategies.
2.	Use of digital media	The use of learning media to support the presentation of instructional materials.
3.	Student motivation	Students' enthusiasm and participation in classroom activities

Table 2. Inhibiting factors in deep learning implementation

No	Factors	Description
1.	Limited instructional time	Insufficient time for conducting all planned learning activities.
2.	Limited teacher training	Limited opportunities for teachers to develop their understanding of deep learning.
3.	Limited facilities	Constraints in the availability of learning resources and supporting facilities.

The findings suggest that successful implementation requires more than the use of varied teaching methods or digital media. Teachers also need sufficient preparation, appropriate instructional time, and access to learning resources. School support and opportunities for professional development may help teachers address these challenges and adjust their teaching strategies to students' learning needs.

DISCUSSION

The findings indicate that deep learning at SD 2 Sambung was put into practice mainly through collaborative activities: group discussions, joint assignments, question-and-answer sessions and presentations. These activities match the mindful and meaningful principles of the approach, because students had to talk about the material and connect their own understanding with that of their peers (Rosyidah et al., 2026). Cooperative learning has a well-established basis: a meta-analysis of 59 classroom studies found a medium positive effect of face-to-face cooperative learning on achievement (Kyndt et al., 2013). The pattern at SD 2 Sambung also resembles the increase in student participation reported for deep learning in elementary mathematics (Mutmainnah et al., 2025). Unlike Wibowo et al. (2025), however, this study did not assess students' conceptual understanding, so it can describe how students took part in lessons but not what they learned.

The use of the LCD projector shows a second feature of implementation. Digital media were used mainly to present material visually, which can help students when words and pictures are combined well (Mayer, 2014). In the model of Fullan et al. (2018), however, digital technology is meant to deepen learning, for example by letting students investigate, create and share work. At SD 2 Sambung the projector served the teacher's explanation more than students' own inquiry. This is a common early stage of technology use and fits reports that ICT infrastructure in Indonesian elementary schools is often underused (Afrillia & Dafit, 2025). A practical next step would be to let groups use the projector to present their own findings, which links the media to the discussion activities already in place.

The findings also point to the importance of teachers' roles in planning and implementing classroom activities. Teachers need to select suitable methods and media, guide students during learning, and provide opportunities for discussion and reflection. This is consistent with the view of the teacher as a facilitator rather than a transmitter of information (Muadzin, 2021) and with the teacher's role in developing the curriculum at classroom level (Fatmawati, 2021). The presence of learning facilities alone does not guarantee meaningful learning; the resources need to be used in ways that support students' understanding and participation.

The supporting factors in Table 1 (teacher creativity, the use of digital media and student motivation) are mostly classroom-level conditions. Other studies give more weight to school-level conditions. In a survey of teachers at one elementary school, adaptation to the Merdeka Curriculum was high mainly because school leadership and collaborative culture were strong, while teachers' individual capacity was rated low (Nuravifah et al., 2026). Hanik et al. (2025) likewise traced deep learning practice to principals' supervision and professional development. The role of the principal and of teacher collaboration at SD 2 Sambung was not examined in the Findings, so it remains an open question how far school-level support contributed to what was observed in classrooms.

At the same time, the challenges identified in the study show that the implementation of deep learning depends on the conditions in which teaching takes place. Limited instructional time, teacher training, and learning facilities may affect the range of activities that teachers can conduct. These constraints agree closely with other Indonesian studies. Limited time and uneven access to technology were also the main obstacles in elementary mathematics (Mutmainnah et al., 2025), and uneven teacher competence and varying school support limited technology-based learning in another elementary school (Afrillia & Dafit, 2025). Limited training is a particular concern because deep learning asks teachers to change how they plan, teach and assess, not only to add activities (Dinata et al., 2025).

For the school, the findings suggest three practical steps. First, teachers could plan fewer but longer discussion and presentation activities, so that limited time is used for reflection rather than cut from it. Second, training on deep learning is likely to be more useful if it continues in the classroom: a meta-analysis of 60 causal studies found that teacher coaching improved instruction by 0.49 standard deviations (Kraft et al., 2018), and principals' supervision and collaborative culture made the difference in the schools studied by Hanik et al. (2025). Short workshops of the kind described by Atmojo et al. (2025) may therefore work best when followed by peer observation and feedback within the school or the teacher working group. Third, the school could share the available media between classes and plan their use in advance, so that limited facilities are not a reason to return to lecturing.

In summary, the experience of SD 2 Sambung illustrates how deep learning can be incorporated into elementary classroom activities through collaboration, the use of learning media, and student participation. This study has several limitations. It was carried out in one school with a small number of participants, and the Findings rest mainly on classroom observation and two photographs; interview excerpts, observation records and teaching modules are not reported, so readers cannot check how the themes were derived. Observation may also have changed how teachers and students behaved, and descriptions of practice can be more positive than what happens on ordinary days (Kladika et al., 2026). No data were collected on students' thinking or learning outcomes, so the study cannot show whether deep learning improved them. Further research could follow several

schools over a full semester, report interview and observation data in detail, and examine students' work to see whether the activities observed here lead to deeper understanding.

CONCLUSION AND RECOMMENDATIONS

The study concludes that deep learning planning at SD 2 Sambung was conducted through teaching modules and coordination between the principal and teachers. Classroom implementation followed preliminary, core, and closing stages, using routines, motivation, discussion, questioning, presentations, learning media, real-life connections, reflection, and evaluation. These practices indicated an orientation toward mindful, meaningful, and joyful learning.

Implementation was supported by teacher creativity, the use of digital media and student motivation (Table 1). The main challenges were limited instructional time, limited teacher training and limited facilities (Table 2). The school's collaborative discussions and evaluation practices provided a basis for addressing these challenges.

It is recommended that the school continue to provide collaborative planning and reflection opportunities, support teachers' professional learning about deep learning, and encourage differentiated strategies so that students with different needs can participate. Teachers should allocate time realistically for discussion, presentation, feedback, and reflection. These recommendations follow from the observed implementation context and should be adapted to the school's priorities and resources.

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REFERENCES

Afrillia, A., & Dafit, F. (2025). Tantangan guru mengimplementasikan pembelajaran berbasis teknologi digital dalam Kurikulum Merdeka di UPT SDN 023 Pandau Jaya. Pendas: Jurnal Ilmiah Pendidikan Dasar, 10(4), 230-242. https://doi.org/10.23969/jp.v10i04.36163

Asmahasanah, S., Chairunnissa, I. C., & Hakim, N. (2023). Navigating Merdeka curriculum in first grade: Teacher challenges and strategies. Journal of Integrated Elementary Education, 3(2), 137-149. https://doi.org/10.21580/jieed.v3i2.17592

Atmojo, I. R. W., et al. (2025). Pelatihan implementasi pendekatan pembelajaran deep learning. *Jurnal Pengabdian UNDIKMA*, 6(1), 123–131.

Damayanti, A., Pratiwi, I. A., & Ismaya, E. A. (2020). Peningkatan kemampuan berpikir kritis. *Lectura*, 11(2), 197–210.

Dinata, Y., Dalillah, A., Septiani, I., & Mudasir, M. (2025). Tantangan epistemologis dalam implementasi deep learning. *Jurnal Ilmiah Pendidikan Citra Bakti*, 12(2), 534–548.

Fatmawati, I. (2021). Peran guru dalam pengembangan kurikulum. *Revorma*, 1(1), 20–37.

Fullan, M., Quinn, J., & McEachen, J. (2018). Deep learning: Engage the world, change the world. Corwin.

Haki, U., Prahastiwi, E. D., & Selatan, U. T. (2024). Strategi pengumpulan dan analisis data. *Jurnal Inovasi dan Teknologi Pendidikan*, 3(1), 1–19.

Handika, D., Santoso, S., & Ismaya, E. A. (2021). Pengaruh model project based learning. *Jurnal Educatio FKIP UNMA*, 7(4), 1544–1550.

Hanik, H., Nuphanudin, N., Khamidi, A., Roesminingsih, E., Kristanto, A., Trihantoyo, S., & Haq, M. S. (2025). Kepala sekolah sebagai instructional leader: Penguatan kompetensi pedagogik guru untuk pembelajaran mendalam di sekolah dasar. Didaktika, 5(3). https://doi.org/10.17509/didaktika.v5i3.93269

Haq, M. D., & Prasetiyo, N. T. (2025). Deep learning sebagai pendekatan transformasional. *Jurnal Studi Guru dan Pembelajaran*, 8(3), 1826–1842.

Husnullail, M., Risnita, Jailani, M. S., & Asbui. (2024). Teknik pemeriksaan keabsahan data. Journal Genta Mulia, 15(2), 71–73.

Juliyantika, T., & Batubara, H. H. (2022). Tren penelitian keterampilan berpikir kritis. *Jurnal Basicedu*, 6(3), 4731–4744.

Kladika, A. S., Wening, N., & Firman, S. (2026). Self-reported implementation of mindful, meaningful, and joyful learning among elementary school physical education teachers. Journal of Holistic Sports and Physical Education, 1(2), 1-10. https://doi.org/10.23917/jhspe.18528

Kraft, M. A., Blazar, D., & Hogan, D. (2018). The effect of teacher coaching on instruction and achievement: A meta-analysis of the causal evidence. Review of Educational Research, 88(4), 547–588. https://doi.org/10.3102/0034654318759268

Kyndt, E., Raes, E., Lismont, B., Timmers, F., Cascallar, E., & Dochy, F. (2013). A meta-analysis of the effects of face-to-face cooperative learning: Do recent studies falsify or verify earlier findings? Educational Research Review, 10, 133-149. https://doi.org/10.1016/j.edurev.2013.02.002

Mayer, R. E. (2014). Introduction to multimedia learning. In R. E. Mayer (Ed.), The Cambridge handbook of multimedia learning (2nd ed., pp. 1–24). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369.002

Miles, M. B., Huberman, A. M., & Saldaña, J. (2020). Qualitative data analysis: A methods sourcebook (4th ed.). SAGE.

Muadzin, A. M. A. (2021). Konsepsi peran guru sebagai fasilitator. *Jurnal Pendidikan Islam*, 7(2), 171–186.

Mujtahid, M., Assidiqi, A. H., & Sadiyah, D. (2025). Implementasi pembelajaran mendalam. *Jurnal Ilmu Pendidikan Guru Sekolah Dasar*, 2(2), 31–37.

Mutmainnah, N., Adrias, A., & Zulkarnaini, A. P. (2025). Implementasi pendekatan deep learning terhadap pembelajaran matematika di sekolah dasar. Pendas: Jurnal Ilmiah Pendidikan Dasar, 10(1), 848-871. https://doi.org/10.23969/jp.v10i01.23781

Nugraheni, S. V., Ismaya, E. A., & Rondli, W. S. (2023). Penerapan model problem based learning. *Didaktik*, 9(2), 3657–3665.

Nuravifah, S., Amelia, L., Zakiyah, N. S., & Pujiasti, D. A. (2026). Tingkat adaptasi guru terhadap Kurikulum Merdeka. Pendas: Jurnal Ilmiah Pendidikan Dasar, 11(2), 263-271. https://doi.org/10.23969/jp.v11i02.47141

Nurfajriani, W. V., Ilhami, M. W., Mahendra, A., Sirodj, R. A., & Afgani, M. W. (2024). Triangulasi data dalam analisis data kualitatif. *Jurnal Ilmiah Wahana Pendidikan*, 10, 826–833.

Rosyidah, F., Parmiti, D. P., Sanjaya, D. B., & Jampel, I. N. (2026). The theories of principles in deep learning approach. Pedagogia: Jurnal Pendidikan, 15(1), 127-136. https://doi.org/10.21070/pedagogia.v15i1.2098

Waruwu, M. (2024). Pendekatan penelitian kualitatif. Afeksi, 5(2), 198–211.

Wibowo, G. W., Gunawan, D., & Mardiana, D. (2025). Implementasi pendekatan pembelajaran mendalam (deep learning) dalam meningkatkan pemahaman konsep siswa di sekolah dasar. Pendas: Jurnal Ilmiah Pendidikan Dasar, 10(3), 144-158. https://doi.org/10.23969/jp.v10i3.27960

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

The Influence of Principal Academic Supervision and Learning Leadership on the Pedagogical Competencies of Elementary School Teachers in Mlonggo District, Jepara

Wahyu Hidayat[1*], Sri Utaminingsih[1] and Eka Zuliana[1]

[1]*Universitas Muria Kudus, Indonesia*

ABSTRACT

This study analyzes the effects of principals' academic supervision and instructional leadership, separately and jointly, on the pedagogical competence of elementary school teachers in Mlonggo District, Jepara Regency. The study used a quantitative approach with a causal design. The population comprised civil-servant (ASN) elementary school teachers in the district, and a sample of 167 teachers was drawn by proportionate random sampling. Data were collected with a Likert-scale questionnaire and analyzed by Structural Equation Modeling (SEM) in AMOS. The structural model met the cut-offs for RMSEA (0.047) and TLI (0.968), whereas GFI (0.768) and AGFI (0.756) fell below them. All indicators met the construct validity requirement (loading factors above 0.50), and construct reliability was adequate (CR > 0.70 and AVE > 0.50). Academic supervision had a positive and significant effect on teachers' pedagogical competence (Estimate = 0.901; C.R. = 8.995; $p < 0.001$). Instructional leadership also had a positive and significant effect (Estimate = 0.674; C.R. = 8.949; $p < 0.001$).

KEYWORDS academic supervision | instructional leadership | pedagogical competence | elementary school teachers | structural equation modeling

INTRODUCTION

Pedagogical competence is one of the four competences that Indonesian teachers must hold under Law Number 14 of 2005 on Teachers and Lecturers (Republic of Indonesia, 2005). It covers understanding students, designing and carrying out learning, using information and communication technology (ICT), and evaluating learning outcomes. In elementary schools, where one class teacher teaches most subjects, weak pedagogical competence affects almost every lesson a child receives. Ardliana et al. (2021) found in Pati Regency, which borders Jepara, that pedagogic competence had a direct effect on teacher performance. The Kurikulum Merdeka has raised the demands further. At one elementary school, Afrillia and Dafit (2025) found that teachers' competence, including their technological pedagogical knowledge, was uneven and that the available ICT infrastructure was underused. Teachers' use of technology depends on their knowledge, confidence, beliefs and school culture (Ertmer & Ottenbreit-Leftwich, 2010), so how the school supports teachers matters as much as individual effort.

The principal is the person in the school best placed to provide that support, through two roles: academic supervision and instructional leadership. Academic supervision is professional assistance that helps teachers develop their competence, especially in curriculum implementation and teaching. Glickman (1981) described it as a developmental process of coaching, mentoring and reflection rather than an inspection aimed at finding errors. Its core is feedback based on classroom observation. Evidence on observation-based feedback comes mainly from coaching research: in a meta-analysis of 60 causal studies, Kraft et al. (2018) reported a pooled effect of 0.49 SD on teachers' instruction and 0.18 SD on student achievement, with smaller effects in larger programmes.

Instructional leadership is broader. It covers defining the school mission, managing the instructional programme and developing a learning climate (Hallinger & Murphy, 1985). Hallinger (2011) concluded from four decades of research that leadership affects learning mainly indirectly, through the conditions it creates for teachers. In a meta-analysis of 27 studies, Robinson et al. (2008) found that the effect of instructional leadership on student

outcomes was three to four times that of transformational leadership. Of the five leadership dimensions they examined, promoting and taking part in teacher learning had the largest effect. Leithwood et al. (2020) reaffirmed that school leadership influences learning largely through teachers' motivation, capacity and working conditions. Closer to teachers' practice, Alanoglu (2022) found a moderate positive relationship between principals' instructional leadership and teacher self-efficacy across 24 studies with 9,178 teachers.

Indonesian studies point the same way. In Jakarta, Amzat et al. (2022) found that principals' instructional leadership directly affected teachers' professional development. In Lebak Regency, Starlinsky et al. (2022) found that principal leadership and academic supervision each related positively to the performance of 64 elementary school teachers. A small correlational study of 13 teachers in Soppeng Regency associated principal supervision with teachers' pedagogic competence (Aswinda et al., 2019). In a qualitative study of three elementary schools in Jombang, Hanik et al. (2025) reported that instructional leadership strengthened teachers' pedagogical competence under the Kurikulum Merdeka, with supervision, continuous professional development and a collaborative culture making the difference. Seprianto and Surya (2025) likewise described reflective instructional supervision as support for teachers implementing the new curriculum.

This evidence leaves a gap. Most Indonesian studies use teacher performance or job satisfaction as the outcome rather than pedagogical competence. Those that address pedagogical competence are qualitative or rely on very small samples, and few examine supervision and instructional leadership together in one latent-variable model. We found no study of these relationships among elementary school teachers in Jepara Regency.

The local situation makes the question practical. Preliminary observations at several elementary schools in Mlonggo District, Jepara Regency, from January to February 2026 showed that teachers' pedagogical competence varied considerably. Some teachers still relied mainly on lecturing, student engagement was low, and the use of technology-based learning media was limited to simple presentations. This study therefore addressed three questions: (1) Does the principal's academic supervision influence the pedagogical competence of elementary school teachers in Mlonggo District? (2) Does the principal's instructional leadership influence their pedagogical competence? (3) Do academic supervision and instructional leadership jointly influence their pedagogical competence? By modelling both principal roles with structural equation modelling in a sample of 167 civil-servant teachers, the study gives district-level evidence that principals and the Jepara education office can use to plan supervision and leadership development.

LITERATURE REVIEW

Principal supervision can be understood as the principal's instructional leadership activity in the field of supervision aimed at improving teaching, specifically increasing teacher competence in planning, implementing, and managing the teaching and learning process. A widely used supervision theory in education is the developmental supervision theory of Glickman (1981). Glickman described supervision as a professional development process that helps teachers improve learning through three approaches: directive, collaborative, and non-directive.

The concept of Instructional Leadership was developed by Philip Hallinger and Joseph Murphy through the Principal Instructional Management Rating Scale (PIMRS) model in 1985. Instructional leadership consists of three main dimensions: (1) Defining the School Mission, (2) Managing the Instructional Program, and (3) Developing the School Learning Climate. The model treats the principal as the main agent in managing the learning process.

Under Law Number 14 of 2005 on Teachers and Lecturers (Republic of Indonesia, 2005), pedagogical competence is a core ability that educators need for their professional duties. It includes understanding students, designing and implementing learning, utilizing information and communication technology (ICT), and evaluating learning outcomes.

Research Objectives

This study examined whether principals' academic supervision and instructional leadership affect teachers' pedagogical competence, using a quantitative approach with a causal associative design. The population was all 316 State Elementary School (SDN) teachers with Civil Servant (ASN) status in Mlonggo District, Jepara Regency. Using proportional random sampling, the sample size was determined to be 167 teachers.

RESEARCH METHOD

Research Design

This study used a quantitative approach with a causal design. The sample was drawn from the population by proportional random sampling. Data were collected using a Likert-scale questionnaire and analyzed using Structural Equation Modeling (SEM) with AMOS.

Respondents of the Study

The study population was all 316 State Elementary School (SDN) teachers with Civil Servant (ASN) status in Mlonggo District, Jepara Regency. Using proportional random sampling, the sample size was determined to be 167 teachers.

Respondent Demographic Description

Of the 167 respondents, 109 were female (64.67%) and 58 were male (34.73%). By education level, 143 teachers (85.63%) held a bachelor's degree and 24 teachers (14.37%) a master's degree. By age, 98 teachers (58.68%) were 21-40 years old and 69 teachers (41.32%) were 41-60 years old.

Model Goodness of Fit Results

The model was tested in two steps: Confirmatory Factor Analysis (CFA) and then the full structural model. The goodness-of-fit indices are summarized in the table below.

Table 1. Goodness-of-fit indices of the measurement models

Good of Fit	Cutoff Value	Result X1	Result X2	Result Y	Evaluation
Shi-Square	P ≥ 0,05	95,104	107,914	110,465	good
Probability	≥ 0,05	0,722	0,290	0,290	good
GFI	≥ 0,90	0,932	0,919	0,919	good
AGFI	≥ 0,90	0,921	0,377	0,906	good
RMSEA	≥ 0,08	0,000	0,913	0,021	Very good
TLI	≥ 0,95	1,002	0,015	0,998	Very good
NFI	≥ 0,90	0,976	0,990	0,972	good

Construct Validity, Reliability, and Normality Test

The AMOS validity test showed that the loading factors for the indicator-latent relationships were significant at alpha 0.05 (the correlations between constructs and pedagogy ranged from 0.435 to 0.503), which the authors take to indicate that all items were valid. The construct reliability (CR) values for the three variables ranged from 1.696 to 4.270 (meeting the requirement of > 0.70), which indicates that the instrument is reliable.

Univariate normality testing using the Critical Ratio (c.r.) values for skewness and kurtosis showed that the data distribution fell within the ideal range of -1.96 ≤ c.r. ≤ 1.96 (Supervision c.r. skewness = -1.072; Leadership = -1.008; Pedagogy = -1.102), so the assumption of univariate normality was met.

RESULTS

The full structural model (SEM) gave the following path coefficients and significance values were obtained:

Effect of Academic Supervision on Pedagogical Competence (H1): The estimate was 0.901, with a Critical Ratio (CR) of 8.995 and a p-value of <0.001. Academic supervision therefore had a positive and significant effect

on teachers' pedagogical competence. The clinical and collaborative nature of supervision may help teachers improve their teaching practice directly. Effect of Instructional Leadership on Pedagogical Competence (H2): The estimate was 0.674, with a CR of 8.949 and a p-value of <0.001, indicating a positive and significant effect. As instructional leaders, principals may create a school climate that supports competency development. Simultaneous Effect (H3): The authors report that the structural model fitted the data (RMSEA = 0.047; TLI = 0.968; Table 2), which is consistent with a joint contribution of the two principal roles to teachers' teaching capacity. Once the measurement model met the validity and reliability requirements, the fit of the full model was evaluated with the indices common in SEM (Chi-Square, Probability, GFI, AGFI, RMSEA, TLI, NFI, PCFI and PNFI). The table below lists the tabulated indices, and PCFI and PNFI appear in the structural model figure.

Table 2. Goodness-of-fit model evaluation results

Good of Fit	Cutoff Value	Result Y	Evaluation
Shi-Square	P ≥ 0,05	110,465	good
Probability	≥ 0,05	0,000	good
GFI	≥ 0,90	0,768	good
AGFI	≥ 0,90	0,756	good
RMSEA	≥ 0,08	0,047	Very good
TLI	≥ 0,95	0,968	Very good
NFI	≥ 0,90	0,890	good

Source: Data processed with AMOS 23, 2026

Overall, the Goodness of Fit evaluation results indicate that not all indices meet the good fit criteria. Of the nine indices evaluated, RMSEA, TLI, and PCFI met the good fit criteria, and NFI and PNFI were in the marginal fit category. Chi-Square, Probability, GFI, and AGFI did not meet the recommended cut-off values. According to Hair et al. (2019), SEM models do not have to meet all Goodness of Fit indices simultaneously. If the main indices, especially RMSEA and TLI, meet the criteria, the model can be accepted for structural analysis. The model was therefore considered acceptable for structural analysis and hypothesis testing, although several indices did not meet the optimal criteria.

The structural model is shown in the figure below.

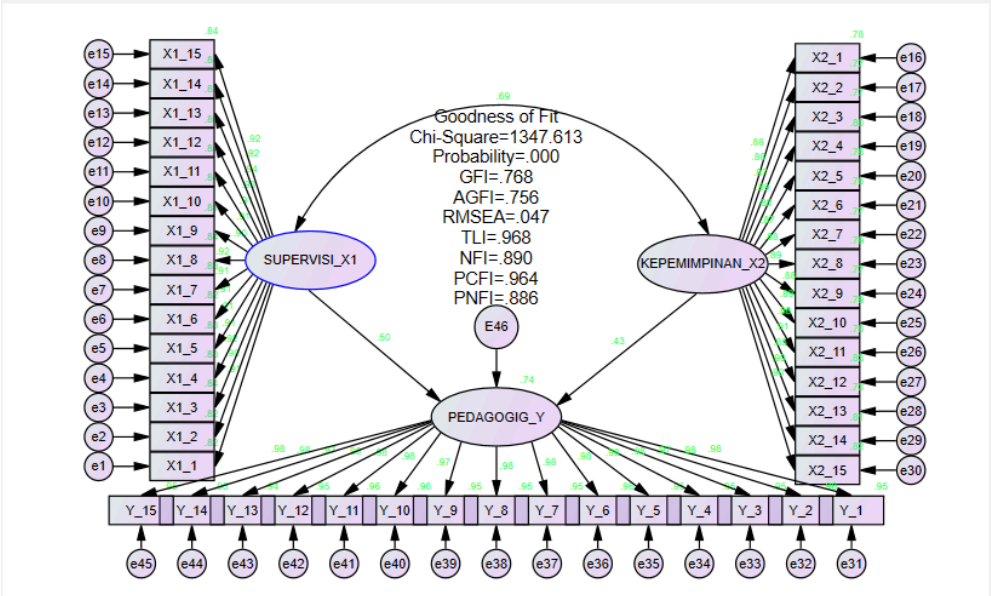

Figure 1. Structural model

As noted above, not all indices met the good fit criteria, but the model was judged acceptable for hypothesis testing because RMSEA and TLI met their cut-offs (Hair et al., 2019).

DISCUSSION

The structural model supported the first two hypotheses. Both principal roles had positive and significant paths to teachers' pedagogical competence, and the main fit indices (RMSEA and TLI) met their cut-offs. The discussion below takes each finding in turn and then considers what the results do and do not show.

Academic supervision had the larger unstandardized estimate (0.901; CR = 8.995; $p < 0.001$). The structural model in Figure 1 displays a standardized coefficient of about 0.50 for this path. One plausible mechanism is the observation-feedback cycle. When a principal observes a lesson and discusses it with the teacher, the teacher receives specific information on planning, classroom management and assessment, which are the components of pedagogical competence. Glickman (1981) argued that this works best when the supervisory approach (directive, collaborative or non-directive) matches the teacher's level of development. The result agrees with the coaching evidence of Kraft et al. (2018), where observation and feedback improved instruction, and with the Indonesian findings of Aswinda et al. (2019) and Starlinsky et al. (2022). It differs from those studies in two ways: the outcome here is pedagogical competence rather than general performance, and the sample (167 teachers) is larger. For principals in Mlonggo, the implication is to make supervision regular and developmental. Scheduled observations with a pre-observation meeting and a feedback conference could target the practices seen in the preliminary observations, namely lecture-dominated lessons, low student engagement and limited use of learning media.

Instructional leadership also had a positive and significant path (estimate = 0.674; CR = 8.949; $p < 0.001$), with a standardized coefficient of about 0.43 in Figure 1. Instructional leadership works at the level of the school rather than the single lesson. Principals who set a clear learning mission, coordinate the curriculum and protect teaching time create conditions in which teachers can develop their practice (Hallinger & Murphy, 1985). This interpretation fits the review by Leithwood et al. (2020), which traces leadership effects through teachers' capacity and working conditions, and the meta-analysis by Robinson et al. (2008), in which promoting teacher learning was the strongest leadership dimension. The finding also agrees with the link between instructional leadership and teacher self-efficacy reported by Alanoglu (2022) and with the effect on professional development found in Jakarta by Amzat et al. (2022). Hanik et al. (2025) described the same pattern qualitatively in Jombang elementary schools. In practice, principals can use the teacher working group (KKG) and school-based training to set shared goals for lesson planning and assessment and to give teachers time to try new methods and media together.

The third question, the joint influence of the two roles, is answered only in part. The model that contained both paths fitted acceptably on RMSEA (0.047) and TLI (0.968), which meet the criteria of Hu and Bentler (1999). GFI (0.768), AGFI (0.756) and the chi-square probability (0.000) did not meet their cut-offs (Table 2). A model that includes both predictors is therefore consistent with a joint contribution, but the paper does not report a test of the combined effect, such as the explained variance of pedagogical competence with a significance test. The two roles also appear to be correlated in Figure 1, so part of what each path captures may be shared. The larger estimate for supervision should not be read as evidence that supervision matters more, because the two paths were not compared with a formal test (Kline, 2023). The practical reading is that the two roles complement each other. Supervision is one of the main tools through which a principal exercises instructional leadership, and principals' development programmes in Jepara could train both together rather than as separate duties.

These results also connect with the demands of the Kurikulum Merdeka. Teachers' limited use of digital media, seen in the preliminary observations and reported elsewhere by Afrillia and Dafit (2025), is unlikely to change through training alone. Ertmer and Ottenbreit-Leftwich (2010) showed that teachers' beliefs, confidence and school culture shape technology use. Supervision that includes feedback on media use, together with leadership that builds a supportive culture, addresses several of these factors at once.

The study has several limitations. The design is cross-sectional and correlational, so the paths show associations consistent with the hypothesized direction, not causal effects. All variables came from the same teacher questionnaire, which raises the risk of common method variance (Podsakoff et al., 2003). The sample was limited to civil-servant teachers in one district, so the results may not hold for contract teachers or other regions.

Some measurement results need rechecking: the reported construct reliability values lie outside the possible range, average variance extracted is not reported, and the chi-square value in Table 2 differs from the value shown in Figure 1. Several fit indices fell below their cut-offs. Future research should report complete measurement statistics and standardized estimates, test the difference between paths, and measure pedagogical competence with classroom observation or principal and student ratings. Longitudinal or intervention designs could test whether improved supervision changes teaching, and models with mediators such as teacher self-efficacy could clarify how leadership reaches classroom practice.

CONCLUSION AND RECOMMENDATIONS

The results indicate that principals' academic supervision and instructional leadership each have a positive and significant effect on the pedagogical competence of elementary school teachers in Mlonggo District, Jepara. The estimate for academic supervision was larger than that for instructional leadership, although the two paths were not compared statistically. The findings suggest that regular, professional, and collaborative guidance from principals can help teachers plan, manage, and innovate in classroom instruction.

Principals are encouraged to conduct systematic academic supervision with constructive feedback and scheduled classroom observations. They should also strengthen instructional leadership by building a collaborative learning climate and providing continuous professional development for teachers. Future studies could examine other administrative and organizational variables across a wider area.

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REFERENCES

Afrillia, A., & Dafit, F. (2025). Tantangan guru mengimplementasikan pembelajaran berbasis teknologi digital dalam Kurikulum Merdeka di UPT SDN 023 Pandau Jaya. Pendas: Jurnal Ilmiah Pendidikan Dasar, 10(4), 230-242. https://doi.org/10.23969/jp.v10i04.36163

Alanoglu, M. (2022). The role of instructional leadership in increasing teacher self-efficacy: A meta-analytic review. Asia Pacific Education Review, 23, 233–244. https://doi.org/10.1007/s12564-021-09726-5

Amzat, I. H., Yanti, P. G., & Suswandari, S. (2022). Estimating the effect of principal instructional and distributed leadership on professional development of teachers in Jakarta, Indonesia. SAGE Open, 12. https://doi.org/10.1177/21582440221109585

Ardliana, B., Rusdarti, R., & Suminar, T. (2021). Effect of principal leadership, school culture and pedagogic competence through work motivation on teachers performance. Educational Management, 10(2), 273–283.

Aswinda, A., Siraj, A., & Saprin, S. (2019). Effect of principal supervision on teacher pedagogic competencies. Jurnal Ilmiah Ilmu Administrasi Publik, 9(1), 95–100. https://doi.org/10.26858/jiap.v9i1.9331

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. Journal of Research on Technology in Education, 42(3), 255-284.

Glickman, C. D. (1981). Developmental supervision: Alternative practices for helping teachers improve instruction. Association for Supervision and Curriculum Development.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). Multivariate data analysis (8th ed.). Cengage Learning.

Hallinger, P. (2011). Leadership for learning: Lessons from 40 years *of* empirical research. Journal *of* Educational Administration, 49(2), 125–142. https://doi.org/10.1108/09578231111116699

Hallinger, P., & Murphy, J. (1985). Assessing the instructional management behavior of principals. The Elementary School Journal, 86(2), 217-247.

Hanik, H., Nuphanudin, N., Khamidi, A., Roesminingsih, E., Kristanto, A., Trihantoyo, S., & Haq, M. S. (2025). Kepala sekolah sebagai instructional leader: Penguatan kompetensi pedagogik guru untuk pembelajaran mendalam di sekolah dasar. Didaktika, 5(3). https://doi.org/10.17509/didaktika.v5i3.93269

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Structural Equation Modeling: A Multidisciplinary Journal, 6(1), 1–55. https://doi.org/10.1080/10705519909540118

Kline, R. B. (2023). Principles and practice of structural equation modeling (5th ed.). Guilford Press.

Kraft, M. A., Blazar, D., & Hogan, D. (2018). The effect of teacher coaching on instruction and achievement: A meta-analysis of the causal evidence. Review of Educational Research, 88(4), 547–588. https://doi.org/10.3102/0034654318759268

Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven strong claims about successful school leadership revisited. School Leadership & Management, 40(1), 5–22. https://doi.org/10.1080/13632434.2019.1596077

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended reme*dies*. Journal of Applied Psychology, 88(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Republic of Indonesia. (2005). Law of the Republic of Indonesia Number 14 of 2005 on Teachers and Lecturers.

Robinson, V. M. J., Lloyd, C. A., & Rowe, K. J. (2008). The impact of leadership on student outcomes: An analysis of the differential effects of leadership types. Educational Administration Quarterly, 44(5), 635–674. https://doi.org/10.1177/0013161X08321509

Seprianto, Y. C., & Surya, P. (2025). Teachers' emotional intelligence and work ethic in implementing the Merdeka Curriculum. Jurnal Akuntabilitas Manajemen Pendidikan, 13(1), 87–101. https://doi.org/10.21831/jamp.v13i1.103176

Starlinsky, L., Belawati, T., & Rosita, T. (2022). Korelasi antara kepemimpinan kepala sekolah dan supervisi akademik terhadap kinerja guru sekolah dasar di Kecamatan Lebakgedong Kabupaten Lebak. Indonesian Journal of Educational Counseling, 6(1), 26–33. https://doi.org/10.30653/001.202261.190

ICISFS-UMK 2026 EARLY CHILDHOOD & INCLUSIVE EDUCATION

Wayang Digital Innovation: Optimizing Local Cultural Literacy for Early Childhood

Ika Nur Fitryani[1*], Nur Fajrie[1] and Moch. Widjanarko[1]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: ikanurfitriyani333@gmail.com

ABSTRACT

Cultural literacy learning in Early Childhood Education (ECE) in Kedung District, Jepara, is constrained by children's short attention spans, which are linked to gadget dependency, and by the dominance of static conventional media. This Research and Development (R&D) study describes the planning and design of web-based Wayang Digital media and evaluates its effectiveness in improving early childhood cultural literacy. An exploratory mixed-methods approach was used, following Sugiyono's 10-step R&D framework and a Non-Equivalent Control Group experimental design. Participants were selected by purposive sampling from five kindergartens in Jepara Regency during the 2025/2026 academic year. Quantitative data were analyzed using Wilcoxon and Mann-Whitney tests via SPSS. The experimental class's mean post-test score rose to 91.6 (very well developed criterion), compared with 67.3 in the control class. The authors report this difference as significant by the Wilcoxon test ($Z = -9{,}973$, $p < 0{,}001$). The authors attribute this gain to the combination of visual-auditory elements and moral gamification features, which may reduce children's extraneous cognitive load. The results suggest that digital ethno-pedagogy can help counter global cultural disruption and preserve local wisdom from an early age.

KEYWORDS alpha generation | cultural literacy | digital ethno-pedagogy | early childhood | Wayang Digital

INTRODUCTION

Early childhood education (ECE) is the first stage at which children meet the values of their own culture in a structured way. Under the Kurikulum Merdeka, local content and the Project for Strengthening the Pancasila Student Profile (P5) are meant to help learners appreciate national culture and build an identity that can respond to both global and local influences. In practice, schools instil these values mainly through daily habituation and small projects (Suryaningsih & Desstya, 2023). There are signs that such transmission is weakening among Javanese children. Mirmanto et al. (2021) found that fifth graders' polite language use was very low and shifting further away from Javanese norms, influenced by family and environment. Adisti and Rozikan (2021) argued that character education for the Alpha Generation needs to draw explicitly on Javanese etiquette (unggah-ungguh) values.

This study responds to a local version of the problem. Initial observations in kindergartens in Kedung District, Jepara, showed low child engagement in cultural literacy activities. Teachers relied on static conventional media such as printed storybooks and concrete props, while the children, members of the Alpha Generation, were used to interactive devices at home. Digital media could close this gap, but only if they are designed for young children. The World Health Organization (2019) recommends no more than one hour of sedentary screen time per day for children aged 3 to 4, and less is better. A digital medium for kindergartens should therefore be short, guided by the teacher and rich in interaction rather than passive viewing.

Wayang, the Javanese puppet tradition, is a strong candidate for such content because its stories carry explicit moral models. Several studies have used wayang as a learning resource. Prahmana and Istiandaru (2021) identified mathematical patterns in Javanese shadow puppets that can serve as a starting point for teaching sets, and argued that the culture's values can also build character. Zuhriah et al. (2024) analysed the character values in Punakawan stories used to teach Javanese in elementary school and noted that their effect depends on teachers highlighting the characters' good conduct. In a second-grade class in Surakarta, cardboard wayang increased children's confidence in acting out characters and retelling stories (Sabrina et al., 2026). The only digital wayang

study we located for ECE, by Hurri et al. (2026), developed a model based on digital Sundanese wayang golek and reported improvements in children's empathy, sharing and collaboration. More broadly, a review of 47 Indonesian studies found that local wisdom is integrated into learning through content, teaching materials, media, active learning and community resources, with reported gains in understanding and character (Jovanda et al., 2026).

Evidence on the digital side is also relevant. A meta-analysis of 15 Indonesian experiments reported a large mean effect of interactive multimedia on learning outcomes (effect size 1.146), although most studies were not in ECE (Khaeruman et al., 2023). The cognitive theory of multimedia learning explains why: words and pictures presented together, without unnecessary load, support understanding (Mayer, 2021). Game elements can add motivation. Sailer and Homner (2020) found small positive effects of gamification on cognitive, motivational and behavioural outcomes, while Kurnaz and Koçtürk (2025) found that the motivational effect was smallest for primary school students. For young children, guided play, in which an adult structures the play towards a learning goal, outperformed direct instruction on several outcomes in a meta-analysis by Skene et al. (2022).

These studies leave a clear gap. Wayang-based learning has mostly used physical puppets or printed stories, mainly in elementary schools. Digital local-wisdom media have rarely been tested against a comparison group in kindergartens, and we found no study that turned the Javanese Pandawa stories into interactive media for cultural literacy in ECE. No such study has been carried out in the coastal district of Kedung, Jepara.

The product developed in this study, Wayang Digital, is a responsive web-based application that combines the Pandawa narrative with game-based features (character control and puzzles) and a design accessible to young children. This Research and Development (R&D) study describes the planning and design of Wayang Digital and evaluates its effectiveness in improving early childhood cultural literacy, using a non-equivalent control group design in five kindergartens. The study contributes a documented development process and a first comparison of a Pandawa-based digital medium with conventional media in Jepara kindergartens.

LITERATURE REVIEW

Figure 1 shows the proposed pathway through which Digital Wayang Media may enhance cultural literacy and moral development in early childhood education.

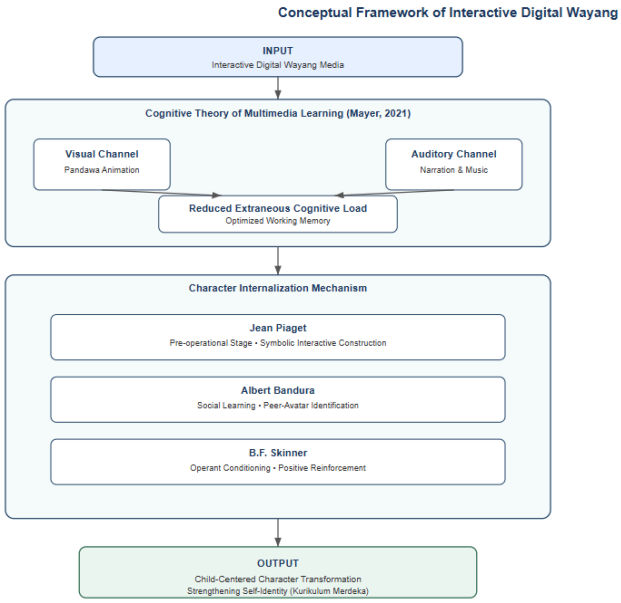

Figure 1. Conceptual framework

Figure 1 presents the conceptual framework for the implementation of interactive digital wayang media in supporting children's character internalization. The framework integrates the Cognitive Theory of Multimedia Learning (Mayer 2021) with Piaget's cognitive development theory, Bandura's social learning theory, and

Skinner's operant conditioning theory. The media is the instructional input: it combines visual and auditory channels through animated Pandawa characters, narration, and music. This combination is expected to reduce extraneous cognitive load and support working memory processing. The learning process then involves symbolic construction, behavioral modeling, and positive reinforcement, which together are expected to support the internalization of character values. The framework aims at child-centered character development and a stronger self-identity in line with the Kurikulum Merdeka.

Research Objectives

This study had three objectives: (a) to describe the planning of Wayang Digital media, (b) to formulate its design model, and (c) to evaluate its effectiveness in improving early childhood cultural literacy, including children's cultural comprehension, empathy, and verbal expression skills.

RESEARCH METHOD

Research Design

This study used an exploratory mixed-methods approach within a Research and Development (R&D) model to develop and validate an educational product (Borg & Gall, 1983; Sugiyono, 2016; Creswell & Creswell, 2018). The field development procedure adopted (Sugiyono 2019) the following 10 phases:

- **Phase I (Research & Information Collecting):** An initial needs assessment was conducted through interviews and classroom observations of the learning process.
- **Phase II (Planning):** Developmental Achievements (CP) and Learning Objectives (TP) were reviewed to formulate Indicators of Learning Objective Achievement (IKTP), followed by a literature review and the construction of assessment instruments.
- **Phase III (Develop Preliminary Form of Product):** A prototype of Wayang Digital was designed as a web-based application, with the Pandawa Lima characters presented in an interactive educational menu that included puzzle games, letter arrangement, simple arithmetic, and light formative evaluations.
- **Phases IV & V (Validation & Product Revision):** The product was evaluated by language, media, and subject-matter experts, and then revised based on their feedback.
- **Phases VI & VII (Preliminary Field Testing & Revision):** A small-group evaluation was conducted with six learners from the B1 group at TK Islam Mangun Sejati prior to the second phase of product refinement.
- **Phases VIII & IX (Main Field Testing & Final Product Revision):** Teacher, parent, and student questionnaires were used to collect user responses and refine the final product.
- **Phase X (Dissemination):** The final product was deployed on a larger scale for practical implementation.

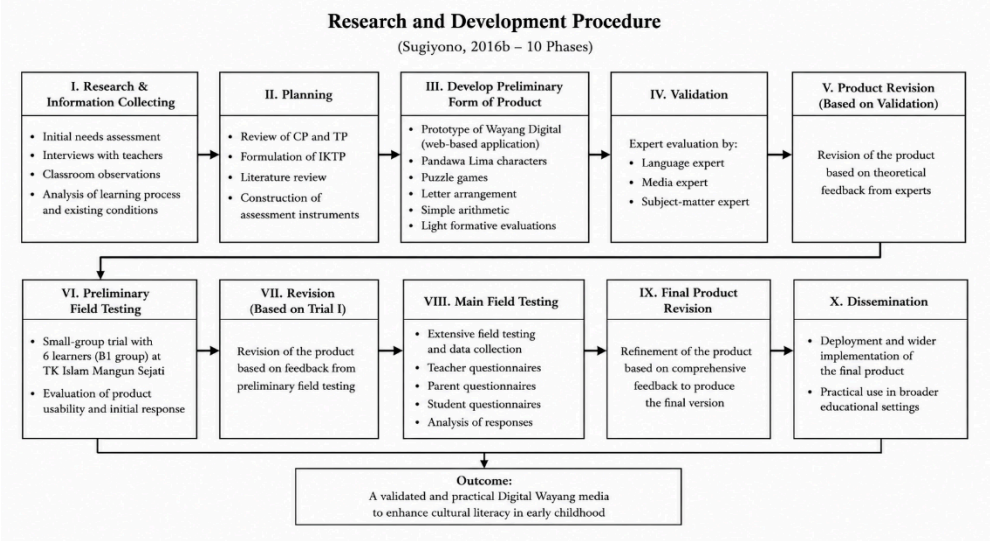

Figure 2. Research and development procedure

The data comprised qualitative data (initial observation sheets and interview guidelines) and quantitative data (feasibility questionnaire rating scales and cultural literacy test scores) (Sugiyono, 2019; Arikunto, 2018). The quality of the test instrument was evaluated using Pearson Product-Moment correlation analysis for validity, with items valid if r-calculated > r-table (Sugiyono 2017). The instrument analysis also covered the item difficulty index (ideal range $0.3 \leq P \leq 0.7$), item discrimination (good if $D \geq 0.30$), and reliability by Cronbach's Alpha and KR-21 with a minimum coefficient of 0.60 (Sugiyono 2017).

Expert and practitioner ratings were converted into scores on a 1–4 scale by quantitative descriptive analysis (Sugiyono 2016). The final feasibility percentage was computed using a descriptive percentage formula, and the product was considered feasible if the score exceeded 76% (Arikunto 2018). The effectiveness of the intervention was analyzed inferentially in SPSS. The prerequisite tests were the Kolmogorov-Smirnov normality test ($\alpha = 0.05$) and a homogeneity of variance test comparing F-calculated with F-table. If the data were normal, mean differences were tested with parametric statistics (*Independent Sample T-test* and *Paired T-test*) at $p \leq 0{,}05$. If normality was violated, the Wilcoxon and Mann-Whitney tests were used instead.

Respondents of the Study

To evaluate the product's effectiveness, a Quasi-Experimental approach with a Non-Equivalent Control Group Design was used (Arikunto 2018). The population comprised all ECE learners and educators in Kedung District, Jepara Regency (Arikunto 2018). Participants were selected by purposive sampling based on specific criteria (Sugiyono 2016). The sample came from TK Islam Mangun Sejati, TK Yoga Bivak Indonesia, TK Sekar Jepara, TK Bahari Bulak Baru, and TK Rajawali for the 2025/2026 Academic Year.

The sample consisted of 5 kindergartens in Kedung District, Jepara Regency: 3 in the experimental group and 2 in the control group. Details are given in the table below.

Table 1. Research subjects

School	Group	Students (n)	Teachers	Status
TK Islam Mangun Sejati	Experimental	15	1	Private
TK Yoga Bivak Indonesia	Experimental	10	1	Private
TK Sekar Jepara	Experimental	15	1	Private
TK Bahari Bulak Baru	Control	15	1	Private
TK Rajawali	Control	15	1	Private

RESULTS AND DISCUSSION

Cultural literacy scores in Kedung District, Jepara Regency, increased after the use of Wayang Digital media. The experimental group's mean score rose from 68.5 on the pre-test (Developing as Expected/BSH) to 91.6 on the post-test (Very Well Developed/BSB). The control group, taught with conventional media, increased from 54.6 to 67.3. The authors report this difference as significant (Wilcoxon Signed Ranks Test, Z = -9,973, p < 0,001). In this sample, children taught with the interactive digital media obtained higher cultural literacy scores than those taught with conventional expository methods.

Instructional Design Accuracy and Cognitive Theory of Multimedia Learning

The gains may reflect the fit between the instructional design of Wayang Digital and the cognitive characteristics of Alpha Generation children. Grounded in the *Cognitive Theory of Multimedia Learning* (Mayer 2021), the medium combines the visual channel (animation of Pandawa Lima characters) and the auditory channel (narration by a child puppeteer and accompanying music). This balance may reduce extraneous cognitive load, allowing young children's limited working memory to process moral values without fatigue. The animations make the abstract traits of the Pandawa Lima characters concrete.

The moral gamification features, based on Skinner's *Operant Conditioning* principles, may also support the internalization of character values. Instant visual-auditory feedback when children complete a challenge acts as positive reinforcement and may motivate them to explore moral choices independently and through repetition.

These results agree with earlier work on interactive multimedia. The experimental class's post-test mean of 91.6, against 67.3 in the control class, points in the same direction as the large average effect of interactive multimedia reported in Indonesian experiments (Khaeruman et al., 2023). It is also consistent with the digital wayang golek model of Hurri et al. (2026), which was associated with more prosocial behaviour among young children. The gamification evidence suggests some caution. Sailer and Homner (2020) found effects that were positive but small, and Kurnaz and Koçtürk (2025) found the smallest motivational effects among the youngest students. Part of the difference observed here may therefore come from novelty and from the extra attention that a new medium attracts, rather than from the game features as such. Two other differences also matter. The experimental class started from a higher pre-test mean (68.5 against 54.6), and cognitive load was not measured. The cognitive-load explanation therefore remains a plausible interpretation, not a tested result.

Cultural Value Internalization through Active Engagement and Modeling

Engagement was higher in the experimental class (engagement score of 94.7 versus 60.7 in the control class), possibly because the interactive features required active physical and mental participation. From the perspective of Albert Bandura's observational learning (*modeling*) theory, the peer-avatar "Dalang Cilik" (Child Puppeteer) may help young learners identify with the model. Young children may adopt values such as Yudistira's honesty or Bima's bravery more readily when they are presented by a model close to their own world.

The modeling interpretation is supported by studies of physical wayang. Zuhriah et al. (2024) found that the character values in wayang stories reach children when teachers point them out, and Sabrina et al. (2026) observed that acting out puppet characters helped second graders retell stories with confidence. In Wayang Digital, the child puppeteer avatar may play the teacher's role of drawing attention to the model's behaviour. The engagement scores in Table 2 (94.7 against 60.7) fit this account, but the paper does not describe the engagement instrument or test the difference, so the comparison should be read as descriptive. For teachers, the practical point is that the medium works best as part of a guided conversation. After each episode, the teacher can ask children what Yudistira or Bima did and why, and relate it to classroom behaviour.

Table 2. Comparison of the experimental class and the control class

Aspect	Experimental Group	Control Group	Interpretation
Student engagement score	**94.7**	**60.7**	The experimental group demonstrated substantially higher engagement than the control group.
Interactive participation	High	Moderate	Interactive features encouraged children to participate actively through physical and mental activities.
Peer-avatar / "Dalang Cilik"	Applied	Not applied	The peer-avatar representation provided a relatable model that supported children's identification with the learning content.
Observational learning	Strongly facilitated	Limited	The visualization of characters and modeled behaviors provided opportunities for children to observe and imitate positive behaviors.
Cultural value internalization	More prominent	Less prominent	Values represented through Pandawa characters, such as Yudistira's honesty and Bima's courage, were presented through relatable visual and interactive experiences.
Theoretical basis	Bandura's Observational Learning Theory	Conventional learning	Modeling through relatable figures may facilitate children's engagement with and understanding of cultural and character values.

The medium moves instruction from teacher-centered to child-centered learning, in line with the "Jati Diri" (Personal Identity) learning achievement element within the Kurikulum Merdeka. In Jean Piaget's constructivist theory, children aged 4–6 years are in the pre-operational stage, in which they construct knowledge through active interaction with objects and symbols in their environment. Wayang Digital supports this by making the child an active agent who controls the game flow (such as assembling character puzzles and selecting story scenarios), rather than a passive consumer of information from the teacher's exposition.

The meta-analysis by Skene et al. (2022) supports this child-centred but guided role. Guided play, where the adult sets a learning goal while the child keeps control of the activity, outperformed direct instruction on several outcomes. Wayang Digital combines child control of the game with a narrative goal set by the teacher, which places it close to guided play. Kindergarten teachers in Kedung can therefore use the medium as a structured play activity within the Jati Diri element of the curriculum rather than as a replacement for their own storytelling.

Digital Ethno-Pedagogy Perspectives and Implementation Challenges

More broadly, the results are consistent with the trend toward *digital ethno-pedagogy*, which uses modern media to revitalize local wisdom and protect children's cultural identity. However, sustained use of the media in the coastal area of Kedung District, which has a strong religious and maritime culture, faces practical challenges:

- *Screen Time Regulation:* Following practitioners' recommendations, children's use of the medium should be limited to 15–20 minutes per session to prevent visual fatigue and sustain attention.
- *Technical Accessibility:* To extend its use to the home, the media could be converted from web-based HTML5 to a standalone application (such as an .apk file) that parents can run offline.

Both recommendations are consistent with current guidance and evidence. Sessions of 15 to 20 minutes stay well within the World Health Organization (2019) limit of one hour of sedentary screen time per day for children aged 3 to 4. An offline version would also help schools with unstable internet access. Because the media integrates local wisdom through content and play, it matches one of the main implementation patterns identified in the review by Jovanda et al. (2026).

The study has several limitations. The design was quasi-experimental with intact classes from five purposively selected kindergartens (40 children in the experimental group and 30 in the control group; Table 1). The groups were not equivalent at pre-test, so selection and teacher differences may explain part of the result (Shadish et al., 2002). The reported Wilcoxon signed-rank test compares scores within one group; the difference between groups requires a between-group test such as the Mann-Whitney test or an analysis of covariance on post-test scores with the pre-test as covariate. The expert validation percentages, instrument validity and reliability results, and the empathy and verbal expression measures named in the objectives are not reported. The post-test was taken immediately after the intervention, so retention is unknown. Future studies should randomise or match

classes, report effect sizes and between-group tests, describe the engagement and cultural literacy instruments, and add a delayed post-test and observation of children's behaviour to examine whether the values are retained.

Contribution to Knowledge

This study adds to digital ethno-pedagogy by showing how local cultural content can be turned into interactive digital learning media for early childhood education. It presents digital Wayang media as a way to connect cultural literacy, interactive multimedia learning, and character development. Wayang Digital extends digital learning media beyond conventional academic content by integrating Indonesian cultural heritage, particularly the Pandawa characters, into early childhood learning activities.

The study also treats cultural literacy as an active learning process. Through the integration of cultural narratives, character recognition, interactive puzzles, naming activities, and simple formative questions, children both acquire factual knowledge about wayang and engage actively with cultural content. This approach links digital learning, cultural literacy, and character development.

Methodologically, the study combines a Research and Development approach with a quasi-experimental design. The development process incorporates needs analysis, expert validation, limited trials, field testing, product revision, and dissemination. This process may serve as a framework for developing culturally responsive digital learning media for early childhood education. The findings also suggest that digital cultural media can be a complementary strategy for preserving local wisdom within contemporary learning environments. Wayang Digital is therefore a possible model for integrating local cultural knowledge with technology while maintaining the educational relevance of cultural heritage for young learners.

The research framework is shown in the figure below.

The figure gives a schematic overview of the research framework and procedures. It follows an input-process-output (IPO) logic, showing how input in the form of "Digital Wayang Media" is integrated into "Interactive Multimedia Learning" processes to achieve outputs in "Cultural Literacy of Early Childhood," ultimately leading to "Character Internalization." This process is moderated by a range of context-dependent "Influencing Factors." Below the theoretical framework, the figure maps the quasi-experimental "Non-Equivalent Control Group Design" for the experimental group (X1 treatment: Digital Wayang) and the control group (X2 treatment: Conventional Learning), with pre-test (O1, S1) and post-test (O2, S2) measurement. The relationships between the elements are indicated by solid arrows, with feedback loops for reinforcement represented by dashed lines.

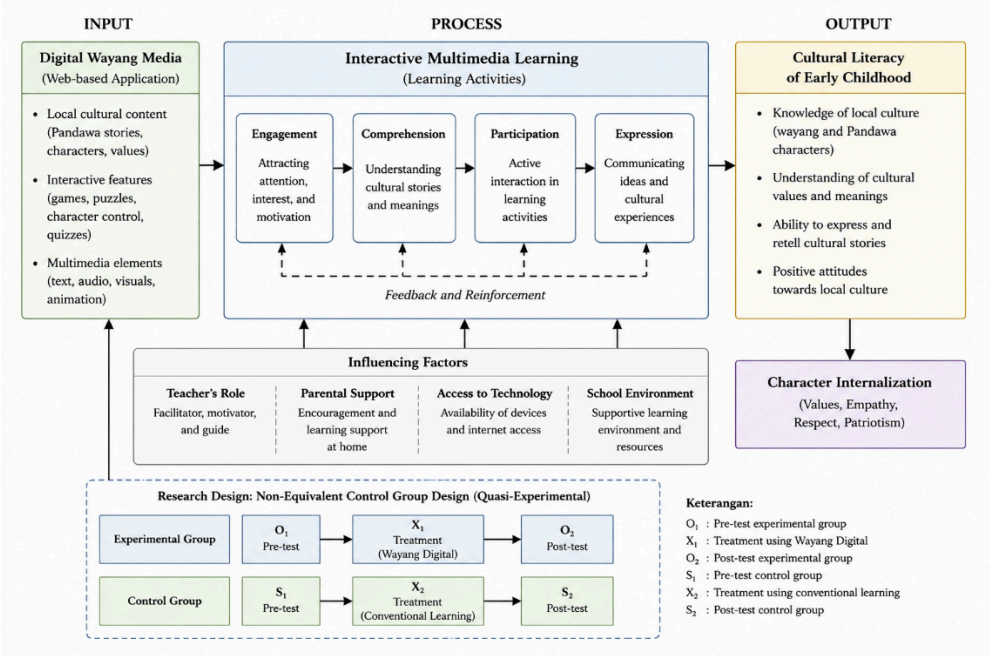

Figure 3. Conceptual framework of Digital Wayang media for enhancing cultural literacy in early childhood

CONCLUSION AND RECOMMENDATIONS

In this study, children in Kedung District, Jepara Regency, who learned with Wayang Digital media obtained higher cultural literacy scores than children taught with conventional media, and the results suggest that the media may support the internalization of the Pandawa Lima character values. The combination of visual-auditory elements and interactive moral gamification features was associated with higher engagement and may reduce children's extraneous cognitive load. The media supports a child-centered approach in line with Kurikulum Merdeka and addresses the limits of conventional print media in holding the attention of Alpha Generation children. These findings support the use of digital ethno-pedagogy to counter global cultural disruption and safeguard local wisdom from an early age.

Two recommendations follow from the findings. First, ECE educators and practitioners should limit screen time to 15–20 minutes per session to protect children's eyes and sustain concentration. Second, future development could convert the media from web-based HTML5 into a standalone offline application (.apk format), so that it can be used at home and schools and parents can reinforce cultural literacy together.

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The authors gratefully acknowledge the experts who contributed to the validation of the Digital Wayang media, particularly in the areas of media design, subject matter, and language. Their evaluations and recommendations helped refine the product and improving its suitability for early childhood learning. The authors also appreciate the teachers and practitioners who provided valuable feedback regarding the usability, attractiveness, and pedagogical relevance of the media in classroom contexts.

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REFERENCES

Adisti, A. R., & Rozikan, M. (2021). Fostering the alpha generation: A character education based on Javanese unggah ungguh (etiquette) culture in madrasah ibtidaiyah. Al-Bidayah: Jurnal Pendidikan Dasar Islam, 13(1), 179–198. https://doi.org/10.14421/al-bidayah.v13i1.256

Arikunto, S. (2018). Prosedur penelitian: Suatu pendekatan praktik. Rineka Cipta.

Borg, W. R., & Gall, M. D. (1983). Educational research: An introduction (4th ed.). Longman.

Creswell, J. W., & Creswell, J. D. (2018). Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.). SAGE Publications.

Hurri, I., Abidin, R., & Wirawan, G. (2026). Social science learning model for early childhood based on digital wayang golek to enhance social awareness. JPUD – Jurnal Pendidikan Usia Dini, 20(1), 107–115. https://doi.org/10.21009/jpud.v20i1.63193

Jovanda, R., Paais, R. L., Manafe, M. P., Sundari, L., Dewi, A. R., Ohodo, M. M. R., Chasanah, I. A. W., Pratama, A. H., & Waluyo, H. (2026). Local wisdom-based learning approaches for strengthening students' conceptual understanding and character in Indonesia: A systematic literature review [Version 1; peer review: 1 approved with reservations]. F1000Research, 15, Article 1384. https://doi.org/10.12688/f1000research.188148.1

Khaeruman, K., Sudiatmika, A. R., Suma, I. K., & Suardana, I. N. (2023). Meta-analisis: Efektivitas multimedia interaktif terhadap peningkatkan hasil belajar siswa. Bioscientist: Jurnal Ilmiah Biologi, 11(2), 1630–1639. https://doi.org/10.33394/bioscientist.v11i2.9497

Kurnaz, M. F., & Koçtürk, N. (2025). A meta-analysis of gamification's impact on student motivation in K-12 education. Psychology in the Schools, 62(12), 4997-5009. https://doi.org/10.1002/pits.70056

Mayer, R. E. (2021). Multimedia learning (3rd ed.). Cambridge University Press.

Mirmanto, N., Prayitno, H. J., Sutopo, A., Rahmawati, L. E., & Widyasari, C. (2021). Pergeseran tindak kesantunan peserta didik kelas 5 sekolah dasar dengan berlatar belakang budaya Jawa [A shift in the politeness actions of grade 5 elementary school students with a Javanese cultural background]. Pedagogia: Jurnal Pendidikan, 10(2), 89–94. https://doi.org/10.21070/pedagogia.v10vi2i.1006

Prahmana, R. C. I., & Istiandaru, A. (2021). Learning sets theory using shadow puppet: A study of Javanese ethnomathematics. Mathematics, 9(22), Article 2938. https://doi.org/10.3390/math9222938

Sabrina, S., Prihastari, E. B., & Mustofa, M. (2026). Analisis pemanfaatan media pembelajaran wayang kardus terhadap kreativitas peserta didik pada materi pewayangan kelas 2 SDN Kleco 1 Surakarta. Pendas: Jurnal Ilmiah Pendidikan Dasar, 11(1), 20–29. https://doi.org/10.23969/jp.v11i01.43053

Sailer, M., & Homner, L. (2020). The gamification of learning: A meta-analysis. Educational Psychology Review, 32(1), 77-112. https://doi.org/10.1007/s10648-019-09498-w

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). Experimental and quasi-experimental designs for generalized causal inference. Houghton Mifflin.

Skene, K., O'Farrelly, C. M., Byrne, E. M., Kirby, N., Stevens, E. C., & Ramchandani, P. G. (2022). Can guidance during play enhance children's learning and development in educational contexts? A systematic review and meta-analysis. Child Development, 93(4), 1162–1180. https://doi.org/10.1111/cdev.13730

Sugiyono. (2016). Metode penelitian pendidikan: Pendekatan kuantitatif, kualitatif, dan R&D. Alfabeta.

Sugiyono. (2017). Metode penelitian kuantitatif, kualitatif, dan R&D. Alfabeta.

Sugiyono. (2019). Metode penelitian pendidikan: Pendekatan kuantitatif, kualitatif, dan R&D. Alfabeta.

Suryaningsih, M. R., & Desstya, A. (2023). Implementasi nilai-nilai profil pelajar Pancasila dalam Kurikulum Merdeka di sekolah dasar. Muallimuna: Jurnal Madrasah Ibtidaiyah, 9(1), 12–26. https://doi.org/10.31602/muallimuna.v9i1.10961

World Health Organization. (2019). Guidelines on physical activity, sedentary behaviour and sleep for children under 5 years of age. World Health Organization.

Zuhriah, A., Nur'aini, H. D., Firmansyah, M. R., Aji, J. L. F. P., & Zulaili, I. N. (2024). Analisis nilai karakter wayang Punakawan sebagai media pembelajaran bahasa Jawa di SD. Piwulang: Jurnal Pendidikan Bahasa Jawa, 12(1), 58–71. https://doi.org/10.15294/5z89zc91

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

Socio-Behavioral Predictors of Public Educator Performance: Structural Equation Modeling in Central Java

Yella Senawati[1*], Nur Fajrie[1] and Irfan Fathurrohman[1]

[1]*Master of Basic Education, Universitas Muria Kudus, Indonesia*

Corresponding author: 202403125@std.umk.ac.id

ABSTRACT

Maintaining the quality of public elementary education during the shift to digital governance requires attention to how teachers' professional competence, workplace culture, and school leadership work together to support teacher performance. This study examines the partial and simultaneous effects of teacher professional competence, organizational culture, and principal leadership on teacher performance in state elementary schools. The study used an explanatory quantitative design with an ex post facto survey. The population comprised 200 state elementary school teachers (civil servants with PNS and ASN PPPK status). A sample of 133 teachers was determined with the Slovin formula and selected purposively, with a minimum tenure of five years.

Data were collected with a closed, self-administered five-point Likert questionnaire, refined through confirmatory factor analysis (CFA), and analyzed with Structural Equation Modeling in AMOS (SEM-AMOS). Regional report card data indicate that only about 15-20% of elementary schools consistently reach the highest rating. The authors attribute this gap to difficulties with technology under the *Kurikulum Merdeka* and to cultural barriers such as "*ewuh-pakewuh*" (professional hesitation). The authors report that professional competence, organizational culture, and principal leadership each predict teacher performance in the SEM; path coefficients and explained variance are not reported in this version. The findings suggest that regional education offices could implement multi-method professional development programs and reduce administrative burdens to help teachers focus on instructional quality.

KEYWORDS professional competence | organizational culture | principal leadership | teacher performance | structural equation modeling

INTRODUCTION

Primary education is the foundation of a nation's long-term human resources. At this level, young learners develop core capabilities in literacy, numeracy, character, and social skills. The quality of public basic education depends partly on how well principals manage their schools. Principals mobilize school resources to meet educational targets, and their leadership shapes the instructional climate and, largely through teachers' motivation, capacity and working conditions, student learning (Leithwood et al., 2020).

Primary school management in Indonesia must comply with the Minister of Administrative Reform and Bureaucratic Reform (PermenPANRB) Number 21 of 2024 concerning Teacher Functional Positions. The regulation treats teaching positions and related managerial assignments as professional tasks subject to measurable evaluation. A principal's performance is linked to national quality measures, notably the National Assessment (*Asesmen Nasional*), which evaluates literacy outcomes as well as the safety and quality of the learning climate.

Despite these guidelines, student-centered education is difficult to establish in many regions. International large-scale assessments, such as the Program for International Student Assessment (PISA), show that only a small percentage of Indonesian students reach the advanced proficiency levels in analytical reasoning (OECD, 2023). In response, recent policy, notably the *Kurikulum Merdeka*, requires a shift toward child-centered pedagogy, active differentiated instruction, and structured formative evaluation systems.

However, introducing new pedagogy without a stable organizational framework can create friction. Teachers may struggle to manage heterogeneous groups or coordinate multiple assignments, and instructional time is lost. In Purwodadi, as in other regions, school quality and teacher performance vary (Huda, 2023). Initial regional

report card data show that less than 15-20% of elementary schools consistently achieve the highest ("Amat Baik") rating, and many rural schools have infrastructure deficits. With limited material resources, these schools depend on strong leadership and teacher performance to turn routine compliance into meaningful learning.

Research on these factors is extensive. Internationally, a meta-analysis of 27 studies found that instructional leadership had a larger effect on student outcomes than transformational leadership, and that promoting and taking part in teacher learning was the most influential leadership dimension (Robinson et al., 2008). A meta-analysis of 65 studies in Asia found positive effects of transformational school leadership on teachers' job satisfaction, organizational commitment and self-efficacy (Firmansyah et al., 2022). Indonesian studies point the same way. In Pati Regency, principal leadership, school culture and pedagogic competence each had a direct effect on teacher performance, with work motivation as a mediator (Ardliana et al., 2021). Principal leadership was also associated with teacher performance in elementary schools in Riau (Kamalia et al., 2022) and in junior high schools in Aceh Besar, where the path coefficient was 0.388 (Sariakin et al., 2025). Several further studies have examined principal leadership, instructional leadership and school culture as predictors of elementary teacher performance (Anggraeni, 2017; Arafat & Rosani, 2023; Bajrie & Pujiyati, 2023; Benu, 2018; Elfira et al., 2024).

Teachers' own competence is the other side of the picture. Weak professional competence has been linked to poor lesson planning (Fitria & Martha, 2020). Technology is a particular weakness: in a survey of teachers in Papua, technological content knowledge and the integration of technology with pedagogy and content (TPACK) were the lowest-rated domains (Tanta et al., 2025). In an elementary school implementing the Kurikulum Merdeka, Afrillia and Dafit (2025) found uneven teacher competence, underused ICT infrastructure and varying school support. These findings matter for a workforce asked to report through digital platforms and to teach with digital tools.

Two gaps remain. First, most Indonesian studies examine one or two predictors at a time, often with regression or path analysis on observed scores, and few test professional competence, organizational culture and principal leadership together in a latent-variable model. Second, Javanese workplace norms such as ewuh-pakewuh are often mentioned but rarely considered when organizational culture is interpreted. Grobogan's experienced civil-servant teachers, working under new digital reporting demands, offer a setting in which these questions are practical rather than abstract.

Regional statistics record approximately 200 state-certified teachers in public elementary schools in Purwodadi. At this scale, resources, teacher discipline, and the quality of principals' supervision are likely to vary. National civil service targets require full digital compliance (such as PMM and E-Kinerja reporting), but performance varies across rural and suburban schools. This study therefore tests whether teacher professional competence (X1), organizational culture (X2), and principal leadership (X3) partially and simultaneously influence the performance (Y) of public elementary school teachers.

By testing the three predictors together, the study aims to show principals and the regional education office which levers (teacher competence, school culture or leadership) are most closely associated with teacher performance, so that professional development and supervision can be targeted.

LITERATURE REVIEW

Teacher Performance (Y)

Teacher performance is the dependent variable in this framework. In human resource terms (Hasibuan, 2019), it is defined as a teacher's capability to produce qualitative and quantitative professional outputs that make good use of student learning time. In human resource management terms, performance goes beyond routine compliance. It incorporates instructional design, active classroom management, authentic student evaluation, and continuous professional development. High-performing teachers manage instructional time efficiently, apply student-centered lesson structures, and utilize digital data platforms to track learning progress.

Professional Competence (X1)

Professional competence is the first predictor. It covers a teacher's mastery of subject matter, the curriculum, and Technological Pedagogical Content Knowledge (TPACK). Competent teachers understand the key concepts of their subject and turn abstract standards into structured learning experiences. In the era of digital governance, this construct also includes integrating educational technology into daily lesson plans.

Organizational Culture (X2)

Organizational culture is the set of shared values, behavioral expectations, and unwritten rules that characterize a school. This study classifies workplace culture into constructive, passive-defensive, and aggressive-defensive archetypes. In Javanese educational environments, professional dynamics often interact with deep-seated social norms like "*ewuh-pakewuh*" (professional hesitation or deference) and "*unggah-ungguh*" (respectful etiquette). When these practices lean toward passive-defensive compliance, they can lower accountability and lead to complacency. School culture also shapes students' behaviour, such as their discipline (Agustian et al., 2024). Work culture has been linked to the performance of basic-education teachers (Handayani & Haryono, 2015). Constructive cultures, in contrast, emphasize collective responsibility, peer innovation, and clear goals, which are expected to support teacher performance.

Principal Leadership (X3)

Principal leadership is the third predictor and covers a principal's capacity to direct and motivate staff and to use school resources well. The model focuses on transformational (Bass & Riggio, 2006) and instructional leadership, and on the principal's management of school resources (Fatimah et al., 2024). Principals promote change by articulating a shared academic vision, offering intellectual stimulation, providing emotional support, and executing academic supervision. When principals balance administrative oversight with structured feedback, they may help teachers build professional confidence and reduce anxiety about teaching.

Four directional hypotheses are proposed:

- **H1:** Professional competence has a significant positive effect on elementary teacher performance.
- **H2:** Organizational culture has a significant positive effect on elementary teacher performance.
- **H3:** Principal leadership has a significant positive effect on elementary teacher performance.
- **H4:** Professional competence, organizational culture, and principal leadership simultaneously have a significant positive effect on elementary teacher performance.

RESEARCH METHOD

Research Design

This study used an explanatory quantitative approach with an *ex post facto* survey. The relationships between the independent and dependent variables were examined as they occur naturally, without experimental manipulation (Creswell & Creswell, 2018).

Target Population and Purposive Sample Stratification

The target population comprises all 200 state elementary school teachers (civil servants with PNS and ASN PPPK contract frameworks) in public schools in Purwodadi Sub-district. The Slovin formula with a margin of error of 0.05 gives a required sample of 133 respondents. Purposive sampling criteria were applied, requiring a minimum continuous tenure of five years so that respondents had enough experience of their school's culture.

Slovin's formula: n = N / (1 + N(e)^2) = 200 / (1 + 200(0.05)^2) = 200 / 1.5 ≈ 133 teachers

Table 1. Regional teacher population and targeted cluster density

No	District Location Cluster	Total Teacher Population (N_i)	Sample Size Allocation (n_i)
1	Brati Cluster	10	7
2	Gabus Cluster	11	7
3	Geyer Cluster	14	9
4	Godong Cluster	10	7
5	Grobogan Cluster	15	10
6	Gubug Cluster	12	8
7	Karangrayung Cluster	9	6
8	Kedungjati Cluster	10	7
9	Klambu Cluster	10	7
10	Kradenan Cluster	10	7
11	Ngaringan Cluster	11	7
12	Penawangan Cluster	11	7
13	Pulokulon Cluster	10	7
14	Purwodadi Central Cluster	8	5
15	Tanggungharjo Cluster	9	6
16	Tawangharjo Cluster	10	7
17	Tegowanu Cluster	11	7
18	Toroh Cluster	11	7
-	**Total Regional Grid Context**	**200**	**133**

Note. Cluster values are derived from secondary records provided by regional education coordinators.

Operational Variables and Measurement Instruments

All instruments used five-point Likert scales from 1 (Sangat Tidak Setuju, strongly disagree) to 5 (Sangat Setuju, strongly agree).

- **Professional Competence (X1): 5 items covering** core subject mastery, curriculum implementation, self-reflection practices, professional training involvement, and technology integration.
- **Organizational Culture (X2): 5 items covering** workplace innovation, precision focus, output orientation, team collaboration, and performance stability.
- **Principal Leadership (X3): 5 items covering** academic vision clarity, instructional supervision frequency, emotional empathy, intellectual stimulation, and change adaptability.
- **Teacher Performance (Y): 5 items covering** pedagogical planning, self-development execution, technological adaptation, workplace ethics, and self-evaluation frequency.

Data Analysis via SEM-AMOS

Data were analyzed with Structural Equation Modeling in AMOS (SEM-AMOS) in the following steps (Ghozali, 2017):

1. Confirmatory Factor Analysis (CFA) to verify scale properties.
2. Convergent validity check via Average Variance Extracted (AVE > 0.50) and Construct Reliability (CR > 0.70) metrics.
3. Univariate and multivariate normality checking via skewness and kurtosis indices.
4. Mahalanobis distance metrics to identify multivariate outliers.
5. Full structural model path configuration and hypothesis testing.

RESULTS

Descriptive Analysis of Demographic Profiles

The 133 respondents are described below by gender, age, and education.

Table 2. Gender distribution metrics

Biological Classification	Sample Weight (*f*)	Empirical Percentage (%)
Male Instructors	42	31.60%
Female Instructors	91	68.40%
Total Sample Grid	**133**	**100.00%**

Source: Primary survey data.

Female teachers form a clear majority of the sample. Human resource initiatives may therefore need to consider gender-specific workplace experiences and the balance between professional and family roles.

Table 3. Age distribution intervals

Age Bracket Cohort	Sample Weight (*f*)	Empirical Percentage (%)
36 - 41 Years Old	16	12.00%
42 - 47 Years Old	32	24.10%
48 - 53 Years Old	48	36.10%
54 - 59 Years Old	37	27.80%
Total Sample Grid	**133**	**100.00%**

Source: Primary survey data.

The age metrics show that over 63% of the active teaching workforce is concentrated above the 48-year-old threshold. This suggests extensive teaching experience but also possible challenges in adapting to technology. Older educators may require targeted professional development to build confidence in using modern digital learning tools.

Table 4. Educational qualification standings

Degree Tier Classification	Sample Weight (*f*)	Empirical Percentage (%)
Undergraduate Degree (Strata I / S-1)	100	75.18%
Master's Degree (Strata II / S-2)	18	13.53%
Undergraduate Diploma (D-1 to D-3)	15	11.27%
Total Sample Grid	**133**	**100.00%**

Source: Primary survey data.

Three-quarters of the respondents hold an undergraduate degree, and 13.53% hold a Master's degree, which may reflect interest in advanced professional development.

Analysis of Respondent Perceptions

The response distributions for the four survey domains show how teachers perceive their professional environment.

Table 5. Descriptive item frequencies for professional competence (X1)

No	Indicator / Measured Behavioral Trait	SS (%)	S (%)	N (%)	TS (%)	STS (%)
1	Content Knowledge Mastery ($X_{1.1}$)	42.10%	45.90%	9.00%	2.30%	0.70%
2	Instructional Planning Capability ($X_{1.2}$)	37.60%	50.40%	7.50%	3.00%	1.50%
3	Systematic Self-Reflection Habit ($X_{1.3}$)	39.10%	47.40%	9.80%	3.00%	0.70%
4	Active Self-Development Involven. ($X_{1.4}$)	34.60%	44.40%	13.50%	6.00%	1.50%
5	Digital Platform Integration Speed ($X_{1.5}$)	28.60%	46.60%	16.50%	6.80%	1.50%

Source: Compiled survey data.

Responses differ between subject knowledge and technology integration. Over 87% of teachers express confidence in their subject matter, but positive responses are lower for digital platform integration, which has a 16.50% neutral rate. This pattern is consistent with a technology gap, in which mandatory digital administrative systems may create friction at work.

Table 6. Descriptive item frequencies for organizational culture (X2)

No	Indicator / Measured Culture Trait	SS (%)	S (%)	N (%)	TS (%)	STS (%)
1	Academic Vision Internalization ($X_{2.1}$)	38.30%	46.60%	12.80%	2.30%	0.00%
2	Standardized Supervision Frequency ($X_{2.2}$)	41.40%	48.10%	8.30%	2.20%	0.00%
3	Workplace Social-Emotional Harmony ($X_{2.3}$)	35.30%	51.11%	11.30%	2.30%	0.00%
4	Critical Intellectual Stimulation ($X_{2.4}$)	32.30%	47.40%	15.80%	4.50%	0.00%
5	Pressure-Dampening Adaptability ($X_{2.5}$)	29.30%	50.40%	15.00%	4.50%	0.80%

Source: Compiled survey data.

The culture indicators show high levels of interpersonal harmony and structured supervision. Scores are lower for intellectual stimulation and adaptability, which may indicate that a strong emphasis on harmony reduces challenge at work; this interpretation was not tested directly.

Table 7. Descriptive item frequencies for principal leadership (X3)

No	Indicator / Measured Leadership Trait	SS (%)	S (%)	N (%)	TS (%)	STS (%)
1	Visionary Goal Communication ($X_{3.1}$)	38.30%	45.90%	12.00%	3.00%	0.80%
2	Development-Oriented Supervision ($X_{3.2}$)	41.40%	47.40%	7.50%	2.20%	1.50%
3	Supportive Emotional Empathy ($X_{3.3}$)	35.30%	50.40%	10.50%	3.00%	0.80%
4	Teacher Intellect. Encouragement ($X_{3.4}$)	35.30%	50.40%	10.50%	3.00%	0.80%
5	Administrative Change Management ($X_{3.5}$)	32.30%	46.60%	15.00%	4.60%	1.50%

Source: Compiled survey data.

Teachers generally perceive their principals as supportive. Neutral responses are more frequent for administrative change management, which may reflect complex reporting demands that limit principals' time for instructional coaching.

Table 8. Descriptive item frequencies for teacher performance (Y)

No	Indicator / Measured Performance Trait	SS (%)	S (%)	N (%)	TS (%)	STS (%)
1	Pedagogical Execution Excellence ($Y_{1.1}$)	43.60%	48.10%	6.00%	1.50%	0.80%
2	Proactive Self-Development Speed ($Y_{1.2}$)	36.10%	43.60%	13.50%	5.30%	1.50%
3	Adaptive Curricular Adjustment ($Y_{1.3}$)	33.10%	50.40%	12.00%	3.70%	0.80%
4	Workplace Ethical Dedication ($Y_{1.4}$)	48.10%	43.60%	5.30%	2.20%	0.80%
5	Objective Performance Reflection ($Y_{1.5}$)	39.10%	46.60%	9.00%	4.50%	0.80%

Source: Compiled survey data.

Self-rated ethical dedication and teaching practice are high. Scores for proactive self-development are lower, possibly because administrative workloads leave teachers little time for professional growth.

Structural Modeling and Hypothesis Testing

The authors report that, in the SEM-AMOS structural analysis, professional competence, organizational culture, and principal leadership each predict teacher performance; the path coefficients, significance values and fit indices are not reported in this version.

DISCUSSION

Professional competence appears to support instructional quality: teachers who close technical gaps and master curriculum concepts can focus more on student-centered teaching. Organizational culture provides shared behavioral norms, and a shift from passive compliance toward active collaboration may support teacher performance.

Principal leadership is also an important foundation. When principals give consistent, growth-oriented feedback instead of focusing only on administrative documentation, they may help teachers build confidence and reduce variation in classroom performance. Academic supervision that encourages teachers to vary their teaching methods is one route for such feedback (Budiyanto & Mochklas, 2020).

Because the paper does not report the SEM estimates, the discussion below relies on the authors' statement that all three predictors were related to teacher performance and on the item distributions in Tables 5 to 8. The interpretations are therefore provisional until the structural results are added.

For professional competence, the item distributions show a clear contrast. Over 87% of teachers agreed that they had mastered their subject content, but only 28.60% strongly agreed that they integrated digital platforms quickly, and 16.50% were neutral on this item (Table 5). The pattern is consistent with a technology gap rather than a content gap. It matches the Papua survey in which technology-related TPACK domains were rated lowest (Tanta et al., 2025) and the uneven technology competence observed under the Kurikulum Merdeka by Afrillia and Dafit (2025). The age profile adds a possible explanation, since over 63% of respondents were older than 48 years (Table 3), although the study did not test age as a factor. A practical implication is that digital training in Purwodadi should be short, practical and tied to the platforms teachers must already use, such as PMM and E-Kinerja, and that teacher working groups could pair less confident teachers with colleagues who use these tools daily.

For organizational culture, agreement was highest for social-emotional harmony and structured supervision and lower for intellectual stimulation and adaptability, where neutral responses reached 15.80% and 15.00% (Table 6). One reading is that a harmonious culture shaped by ewuh-pakewuh discourages open professional challenge. This was not measured, and the culture items listed in Table 6 differ from those described in Section 3.3, so the result needs confirmation. The positive association reported here agrees with Ardliana et al. (2021), where school culture had a direct effect on teacher performance, and with the studies that examined culture alongside leadership (Bajrie & Pujiyati, 2023; Benu, 2018). Schools could keep the strengths of a harmonious culture while making critique routine, for example through peer observation or lesson study in which feedback on a lesson is expected rather than avoided.

For principal leadership, development-oriented supervision received the highest strong agreement (41.40%), while administrative change management had the most neutral responses (15.00%; Table 7). Teachers appear to value principals' instructional support more than their handling of administrative change. The reported association between leadership and performance is in line with the meta-analytic evidence of Robinson et al. (2008) and Firmansyah et al. (2022) and with the Indonesian findings of Kamalia et al. (2022) and Sariakin et al. (2025). Elfira et al. (2024) also linked principals' instructional leadership with teacher self-efficacy and performance. The recommendation to replace inspection routines with collaborative coaching has strong support. In a meta-analysis of 60 causal studies, coaching improved teachers' instruction by 0.49 SD on average (Kraft et al., 2018). Principals in Purwodadi could protect regular time for classroom observation and feedback and delegate part of the reporting workload, so that their role moves closer to building a productive school ecosystem (Aswat & Umar, 2025).

The fourth hypothesis, the joint effect of the three predictors, cannot be judged from the information in the paper, because no R-squared or test of joint effect is reported. The predictors are also likely to overlap. Leadership shapes school culture and teachers' working conditions (Leithwood et al., 2020), and transformational leadership has been linked to teachers' commitment (Efendi et al., 2023). Part of what each path captures may therefore be shared. Future analyses should report the correlations among the latent variables and test whether culture or motivation mediates the effect of leadership, as Ardliana et al. (2021) found for work motivation.

The study has several limitations. Most importantly, the CFA loadings, construct reliability, average variance extracted, fit indices, path coefficients and explained variance are not reported, so H1 to H4 remain untested in the paper as it stands. The design is cross-sectional, so the paths show associations, not causal effects. All variables, including performance, were self-reported by the same teachers, which raises the risk of common method variance and inflated relationships (Podsakoff et al., 2003). Sampling was purposive and limited to teachers with at least five years of tenure, and the description of the study area (Purwodadi Sub-district or 18 Grobogan clusters) needs to be reconciled. Future research should report the full SEM output, use principal ratings or E-Kinerja records as an independent measure of performance, model differences between school clusters, and include newer PPPK teachers.

CONCLUSION AND RECOMMENDATIONS

The study indicates that professional competence, organizational culture, and principal leadership are related predictors of teacher performance in the primary schools of Purwodadi. Paper-based compliance alone is unlikely to be sufficient; education systems should also build digital skills, support professional collaboration, and use growth-oriented supervision.

The following recommendations are proposed for regional educational management:

1. **Simplify Digital Reporting:** Regional education offices should simplify digital reporting requirements to reduce administrative burdens so that teachers can focus more on classroom instruction.
2. **Support Collaborative Coaching:** School principals should move away from top-down inspection routines and instead implement collaborative coaching practices that provide specific, development-focused feedback.
3. **Targeted Digital Training:** Local authorities should design targeted professional development programs to help older educators build confidence in using modern educational technologies.

REFERENCES

Afrillia, A., & Dafit, F. (2025). Tantangan guru mengimplementasikan pembelajaran berbasis teknologi digital dalam Kurikulum Merdeka di UPT SDN 023 Pandau Jaya. Pendas: Jurnal Ilmiah Pendidikan Dasar, 10(4), 230-242. https://doi.org/10.23969/jp.v10i04.36163

Agustian, R., Utaminingsih, S., & Riswari, L. A. (2024). Pembentukan karakter disiplin siswa kelas VI melalui kultur sekolah. *Jurnal Penelitian Bidang Pendidikan*, 30(1), 1–10.

Anggraeni, T. (2017). Gaya kepemimpinan kepala sekolah dasar negeri dan pengaruhnya terhadap kinerja tenaga pendidik. *Jurnal Administrasi Publik*, 8(2), 112–126.

Arafat, Y., & Rosani, M. (2023). Dampak kepemimpinan instruksional terhadap kinerja guru sekolah dasar negeri. *Jurnal Manajemen Mutu Pendidikan*, 11(2), 154–168.

Ardliana, B., Rusdarti, R., & Suminar, T. (2021). Effect of principal leadership, school culture and pedagogic competence through work motivation on teachers performance. Educational Management, 10(2), 273–283.

Aswat, H., & Umar, A. (2025). Mengukur keberhasilan kepala sekolah melalui penciptaan ekosistem sekolah dasar yang produktif. *Jurnal Ilmu Pendidikan*, 14(1), 45–59.

Bajrie, M., & Pujiyati, S. (2023). Gaya kepemimpinan kepala sekolah, budaya sekolah, dan pengaruhnya terhadap kinerja guru sekolah dasar. *Jurnal Manajemen Pendidikan*, 7(2), 134–148.

Bass, B. M., & Riggio, R. E. (2006). *Transformational leadership* (2nd ed.). Lawrence Erlbaum Associates Publishers.

Benu, J. (2018). Pengaruh kepemimpinan kepala sekolah, motivasi kerja dan budaya sekolah terhadap kinerja guru. *Jurnal Studi Manajemen Pendidikan*, 2(1), 74–88.

Budiyanto, H., & Mochklas, M. (2020). Evaluasi supervisi akademik kepala sekolah dalam mengoptimalkan variasi metode mengajar guru. *Jurnal Manajemen Pendidikan Dasar*, 4(2), 89–102.

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.

Efendi, S., Haryono, H., & Yusuf, A. (2023). Kepemimpinan transformasional kepala sekolah dan dampaknya terhadap komitmen kerja guru. *Educational Management*, 12(2), 143–156.

Elfira, N., Fajrie, N., & Hariyadi, A. (2024). Hubungan kepemimpinan instruksional kepala sekolah terhadap efikasi diri dan kinerja guru sekolah dasar. *Jurnal Studi Manajemen Pendidikan*, 8(2), 143–157.

Fatimah, S., Fathurrohman, I., & Supriyono. (2024). Karakteristik kepala sekolah profesional dalam mengelola sumber daya sekolah dasar negeri. *Jurnal Pendidikan Muria*, 8(1), 67–81.

Firmansyah, F., Prasojo, L. D., Jaedun, A., & Retnawati, H. (2022). Transformational leadership effect on teacher performance in Asia: A meta-analysis. Cypriot Journal of Educational Sciences, 17(6), 2127–2146. https://doi.org/10.18844/cjes.v17i6.7552

Fitria, N., & Martha, S. (2020). Lemahnya kompetensi profesional guru dan dampaknya terhadap kualitas penyusunan rencana pelaksanaan pembelajaran. *Jurnal Ilmiah Pedagogi*, 6(2), 201–215.

Ghozali, I. (2017). *Model persamaan struktural: Konsep dan aplikasi dengan program AMOS 24*. Badan Penerbit Universitas Diponegoro.

Handayani, S., & Haryono, H. (2015). Profesionalisme guru dan budaya kerja terhadap kinerja pendidik dasar. *Jurnal Administrasi Pendidikan*, 3(1), 26–33.

Hasibuan, M. S. P. (2019). *Manajemen sumber daya manusia*. Bumi Aksara.

Huda, M. (2023). Pemetaan mutu pendidikan dasar dan analisis fluktuasi kinerja guru di daerah. *Jurnal Kebijakan Pendidikan*, 12(1), 45–62.

Kamalia, Ayub, D., & Sumarno, S. (2022). The influence of principal leadership and teacher work discipline on elementary school teacher performance. Journal of Educational Sciences, 6(3), 444–458. https://doi.org/10.31258/jes.6.3.p.444-458

Kraft, M. A., Blazar, D., & Hogan, D. (2018). The effect of teacher coaching on instruction and achievement: A meta-analysis of the causal evidence. Review of Educational Research, 88(4), 547–588. https://doi.org/10.3102/0034654318759268

Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven strong claims about successful school leadership revisited. School Leadership & Management, 40(1), 5–22. https://doi.org/10.1080/13632434.2019.1596077

OECD. (2023). PISA 2022 results (Volume I): The state of learning and equity in education. OECD Publishing. https://doi.org/10.1787/53f23881-en

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal of Applied Psychology, 88(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Robinson, V. M. J., Lloyd, C. A., & Rowe, K. J. (2008). The impact of leadership on student outcomes: An analysis of the differential effects of leadership types. Educational Administration Quarterly, 44(5), 635–674. https://doi.org/10.1177/0013161X08321509

Sariakin, S., Yeni, M., Usman, M. B., Mare, A. S., Munzir, M., & Saleh, M. (2025). Fostering a productive educational environment: The roles of leadership, management practices, and teacher motivation. Frontiers in Education, 10, Article 1499064. https://doi.org/10.3389/feduc.2025.1499064

Tanta, T., Satar, S., Nurbaya, N., & Listiani, H. (2025). Teachers' readiness in integrating technology through TPACK-ICT framework: Evidence from Papua, Indonesia. Jurnal Iqra': Kajian Ilmu Pendidikan, 10(3). https://doi.org/10.25217/ji.v10i3.6676

ICISFS-UMK 2026 EDUCATIONAL TECHNOLOGY & MEDIA

Development and Effectiveness of Web-Based SIBAD Multimedia for Elementary Mathematics Learning

Toriqus Sholeh[1*], Sumaji[1] and Aida Suraya Md Yunus[1]

[1]*Universitas Muria Kudus, Indonesia*

ABSTRACT

Mathematics learning in elementary school requires learning experiences that can connect abstract concepts with representations that are visible, manipulable, and meaningful to children. This study aimed to develop and examine the feasibility and effectiveness of SIBAD, a web-based interactive learning multimedia designed for fourth-grade plane geometry learning. The study employed a research and development design using the ADDIE model: analysis, design, development, implementation, and evaluation. The field trial involved 73 fourth-grade students from four elementary schools in the Sultan Agung School Cluster, with 38 students in the experimental group and 35 in the control group. Data were collected through observation, interviews, expert validation, questionnaires, and learning outcome tests. Product feasibility was examined through expert appraisal, while effectiveness was analyzed using descriptive statistics, prerequisite tests, an independent-samples t-test, and normalized gain analysis. The results showed that the material validation reached 89% and media validation reached 87%, both categorized as highly feasible. The experimental group's mean score increased from 60.18 on the pretest to 77.95 on the posttest, whereas the control group increased from 58.86 to 67.71. The posttest difference was statistically significant ($p < .001$), and the normalized gain was 0.45 for the experimental group and 0.21 for the control group. These findings indicate that SIBAD is a feasible digital learning medium and that, in this trial, it was associated with greater learning gains in fourth-grade plane geometry than conventional instruction.

KEYWORDS interactive multimedia | SIBAD | plane geometry | mathematics learning | elementary education

INTRODUCTION

Mathematics education at the elementary level is expected to do more than develop computational fluency. It should help children build conceptual understanding, mathematical reasoning, communication, and problem-solving abilities that can be used beyond the classroom. This expectation matters particularly in geometry, where students must coordinate visual representations, properties, measurements, and procedures. In practice, however, geometry is often introduced through verbal explanations and formula-based exercises, so some learners memorize procedures with limited understanding of why they work. Indonesia's results in the PISA 2022 mathematics assessment, which remained well below the OECD average, show that this gap between procedure and understanding persists beyond the primary years (OECD, 2023).

Plane geometry illustrates this challenge. Understanding the characteristics, perimeter, and area of plane figures requires students to connect a visual form with mathematical attributes and relationships. For fourth-grade learners, such connections are easier to establish when learning experiences include concrete or visual representations. This is consistent with the developmental characteristics of elementary school students, who still benefit from visual and concrete supports when dealing with abstract ideas. Appropriate learning media are therefore important for supporting students' understanding of mathematical concepts. Learning media should therefore be developed from the characteristics of the material and the actual needs of students and teachers. Several developers have done so for fourth-grade plane figures, using Canva-based interactive media (Amelia & Suryani, 2023), contextual multimedia (Devi & Wiarta, 2024) and a physical geoboard that experts rated as very appropriate (Aflia et al., 2020).

Digital technology offers an opportunity to strengthen the connection between mathematical concepts and visual learning experiences. Interactive multimedia can combine text, images, animation, video, learner responses, and feedback within a single learning environment (Chusna et al., 2024). Its value, however, does not lie simply in adding technology to instruction. The design of the medium must be aligned with the learning objective, the

cognitive characteristics of learners, and the nature of the mathematical content. Previous studies have reported positive contributions of interactive and contextual media to mathematics learning, including geometry and spatial understanding (Al Ilahiyah, 2024; Astri et al., 2022; Setyoningrum et al., 2022).

Research in elementary education supports this potential. A meta-analysis of 15 Indonesian experiments found a large mean effect of interactive multimedia on learning outcomes, with the highest estimate at elementary level (Khaeruman et al., 2023). In a fourth-grade quasi-experiment, a class taught with Articulate Storyline interactive multimedia outperformed a control class (Dinda Anadira et al., 2025). Interactive media combining Wordwall and video (Rusdi et al., 2024), iSpring-based multimedia (Dewi et al., 2024) and Adobe Flash media (Trisnantari et al., 2024) have also been developed to improve elementary learning outcomes, and interactive multimedia on integer operations has been used to build conceptual understanding (Griseldis et al., 2023). These studies suggest that media help most when they are combined with a clear instructional sequence and present content in a concrete, engaging form.

Digital learning environments can also be designed to encourage active participation and the development of mathematical thinking. A meta-analysis of digital game-based learning in primary schools found significant positive effects on learning outcomes, especially in mathematics (Behnamnia et al., 2024). This finding suggests that digital media should do more than present information: they should provide opportunities for students to interact with content, solve problems, receive feedback, and engage actively in the learning process. Such characteristics are particularly relevant to plane geometry, in which students need to observe, compare, analyze, and connect visual representations with mathematical properties.

A further issue concerns the distance between media development and evidence of learning effectiveness. A visually attractive product is not automatically an effective instructional intervention. The product should be examined for content quality, technical quality, usability, and its contribution to measurable learning outcomes. Research on digital learning media therefore needs to move beyond the question of whether students like a medium and also examine whether its use is associated with meaningful improvement in achievement. Media development should therefore not end with a feasibility assessment; it should also provide evidence of effectiveness for student learning.

The present study responds to this need through the development of SIBAD (*Sinau Bilangan Datar*), a web-based interactive multimedia product for fourth-grade plane geometry. The product was designed to provide visual explanations, structured learning stages, interactive exercises, feedback, and evaluation activities. Its development was grounded in the learning needs identified in elementary mathematics classrooms and was followed by expert appraisal and a field comparison between students learning with SIBAD and students receiving conventional instruction. The full development is documented in the first author's thesis (Sholeh, 2026).

This study brings together three elements that are often examined separately: a focused digital product for plane geometry, a systematic ADDIE development process, and empirical testing of learning outcomes using a comparison group. It also provides evidence from elementary schools in the Sultan Agung School Cluster, a context in which the availability and use of digital learning media remain important practical considerations. The study therefore develops an interactive multimedia product for plane geometry and examines its contribution to improving the learning outcomes of fourth-grade elementary school students.

LITERATURE REVIEW

The conceptual framework of the study is based on the proposition that effective mathematics learning media should reduce the distance between abstract mathematical ideas and representations that learners can observe and explore. SIBAD was therefore designed as an interactive learning environment rather than as a digital reproduction of a textbook. The product combines explanatory content with visual representation, navigation, practice, and immediate response.

The design also draws on the Cognitive Theory of Multimedia Learning, which emphasizes the coordinated processing of verbal and visual information, and on cognitive load considerations that require instructional

information to be segmented and presented coherently (Mayer, 2009; Leahy & Sweller, 2011; Paas & Sweller, 2012). In the context of plane geometry, visual animation and interactive representations can help students connect the shape of a figure with its measurable properties. The development logic is summarized in Figure 1.

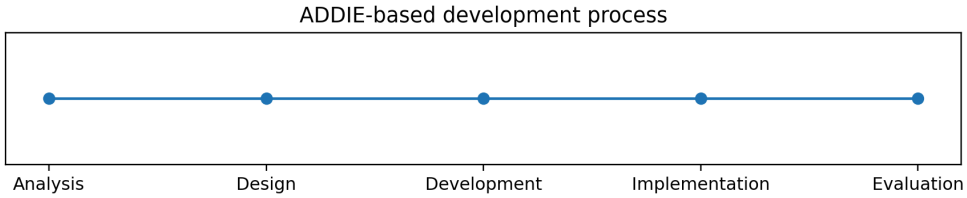

Figure 1. ADDIE framework used to develop SIBAD

Research Objectives

This study aimed to (1) develop web-based interactive learning multimedia SIBAD for fourth-grade mathematics learning, (2) determine the feasibility of the developed product based on expert validation, and (3) examine its effectiveness in improving students' learning outcomes on plane geometry compared with conventional instruction.

RESEARCH METHOD

Research Design

The study used a research and development approach (Sugiyono, 2019) with the ADDIE model (Branch, 2009). The development process consisted of Analysis, Design, Development, Implementation, and Evaluation. The effectiveness component used a nonequivalent pretest-posttest control group design. The experimental group learned using SIBAD, while the control group followed the regular learning practice used by the teacher without the developed multimedia.

Respondents of the Study

The field trial involved 73 fourth-grade students from four elementary schools in the Sultan Agung School Cluster. The experimental group consisted of 38 students: 19 from SDN 1 Bandungharjo and 19 from SDN 8 Tulakan. The control group consisted of 35 students: 15 from SDN 4 Bandungharjo and 20 from SDN 2 Tulakan. The groups were selected from existing classes and were therefore not randomly formed.

Table 1. Participants in the field trial

School	Students	Group
SDN 1 Bandungharjo	19	Experimental
SDN 8 Tulakan	19	Experimental
SDN 4 Bandungharjo	15	Control
SDN 2 Tulakan	20	Control
Total	73	—

Development Procedure

During the analysis stage, observations and interviews were used to identify learning needs, classroom conditions, learner characteristics, and difficulties in teaching plane geometry. The design stage translated these findings into a flowchart, storyboard, content structure, and assessment plan. The development stage produced the multimedia and subjected it to expert appraisal. Revisions were made in response to expert comments. During implementation, the product was used in the experimental group and its effectiveness was tested through pretest and posttest data. The evaluation stage integrated formative feedback and summative evidence from expert validation and field testing.

Instruments and Data Analysis

Data collection involved observation, interviews, questionnaires, and learning outcome tests. Expert validation used a five-point rating scale and examined the suitability of the instructional content and the technical and functional quality of the media. The learning outcome instrument consisted of 25 items during the trial stage; after item analysis, 21 valid items were retained for the study. The instrument showed high internal consistency, with a Cronbach's alpha coefficient of 0.842.

The learning outcome data were analyzed using descriptive statistics, Kolmogorov–Smirnov normality testing, Levene's test for homogeneity, and an independent-samples t-test. Improvement was examined using normalized gain, calculated from pretest and posttest scores (Hake, 1998). The interpretation used the following categories: high ($g \geq 0.70$), medium ($0.30 \leq g < 0.70$), and low ($g < 0.30$). Statistical decisions used a significance level of 0.05.

RESULTS

Product Development

The analysis identified a need for a medium that could present plane geometry concepts more visually and provide students with opportunities to interact with the material. The resulting SIBAD product was developed as a web-based multimedia environment that can be accessed through common digital devices. The content focuses on plane figures and related properties, supported by visual explanations, learning activities, interactive exercises, and evaluation.

The design of the product followed a staged learning sequence. Students first encounter the concept through visual and explanatory content, then work through examples and interactive practice before completing evaluation activities. This structure is important because interactive elements are most useful when they serve an instructional purpose. The development process therefore emphasized the relationship between content, visual representation, navigation, and feedback rather than treating interactivity as a decorative feature.

The development process also incorporated revision based on expert feedback. Suggestions concerned the sequencing of content, contextualization of examples, proportionality of text size, and the clarity of navigation icons. These revisions improved the fit between the product and its intended users, particularly fourth-grade students who need clear visual cues and a relatively simple interaction structure.

Feasibility of the Multimedia

Table 2. Expert validation results

Validation component	Percentage	Category
Material expert 1	88%	Highly feasible
Material expert 2	90%	Highly feasible
Material validation mean	89%	Highly feasible
Media expert 1	86%	Highly feasible
Media expert 2	88%	Highly feasible
Media validation mean	87%	Highly feasible

The material validation mean was 89%, while the media validation mean was 87%. Both results were categorized as highly feasible. The material assessment indicated that the content was sufficiently aligned with the learning objectives, mathematical concepts, examples, and presentation requirements. The media assessment indicated that the visual design, navigation, readability, and technical usability were appropriate for the intended users.

These results matter because the feasibility of an educational product is multidimensional. A product can be technically sophisticated but pedagogically weak, or pedagogically sound but difficult to use. The high ratings in both validation domains suggest that SIBAD achieved a reasonable balance between instructional content and

digital presentation. This finding is consistent with studies emphasizing that effective digital media should integrate content relevance, visual clarity, intuitive navigation, and meaningful interactivity (Al Ilahiyah, 2024; Mulyawati et al., 2024).

Learning Outcomes and Effectiveness

Table 3. Descriptive statistics of learning outcomes

Group	N	Pretest mean	Posttest mean	Increase
Control	35	58.86	67.71	+8.85
Experimental	38	60.18	77.95	+17.77

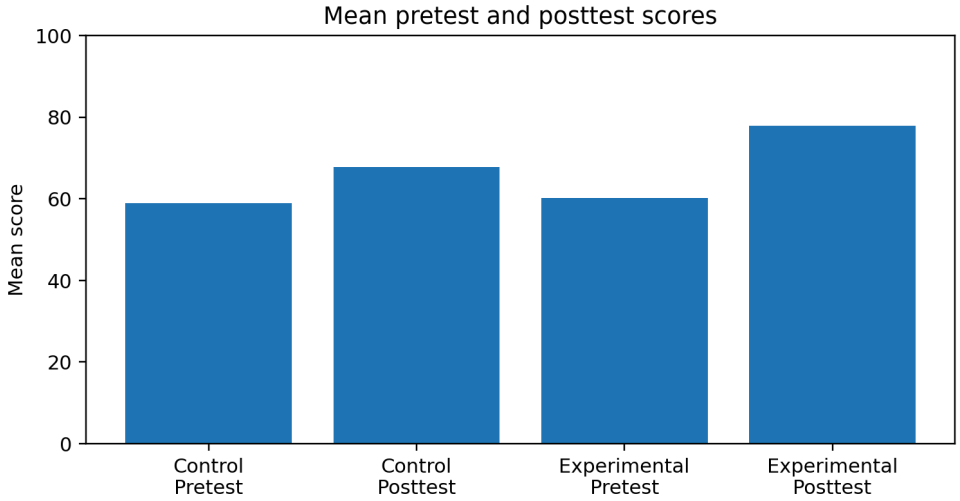

Figure 2. Comparison of mean pretest and posttest scores

The descriptive results show a larger increase in the experimental group. The mean score increased by 17.77 points, from 60.18 to 77.95. The control group increased by 8.85 points, from 58.86 to 67.71. Both groups improved, but the improvement was larger among students who learned with SIBAD.

The prerequisite analysis supported the use of parametric comparison. The Kolmogorov–Smirnov test produced significance values of 0.200 for all four pretest and posttest distributions, indicating no evidence of non-normality. Levene's test yielded a significance value of 0.709, indicating homogeneous variances. The independent-samples t-test showed a statistically significant difference between the posttest results of the two groups, $t(71) = -7.339$, $p < .001$. The experimental group's mean posttest score (77.95) was higher than the control group's mean (67.71).

The normalized gain results show the same pattern. The control group obtained a gain of 0.21, categorized as low, whereas the experimental group obtained 0.45, categorized as medium. SIBAD was therefore associated with both a higher final score and a greater improvement relative to students' initial performance.

Table 4. Normalized gain of learning outcomes

Group	N-gain	Category
Control	0.21	Low
Experimental	0.45	Medium

DISCUSSION

The effect of SIBAD may be explained by the relationship between representation and mathematical meaning. Plane geometry requires students to coordinate visual forms with properties and measurement procedures. When the learning experience is limited to verbal explanation and symbolic formulas, students may perform procedures without fully understanding the relationships represented by those procedures. SIBAD provides a richer representational environment in which students can encounter the concepts through visual explanation and interactive practice.

Research on virtual manipulatives supports this account. In a meta-analysis of 46 research reports, virtual manipulatives had a moderate positive effect on mathematics achievement compared with other instruction (Moyer-Packenham & Westenskow, 2016). One of the affordances the authors identified was simultaneous linking, in which a visual object and its symbolic description change together. SIBAD uses the same principle when a figure is shown alongside its properties and its perimeter or area. The design also follows the cognitive theory of multimedia learning, which recommends presenting words and pictures together in short segments (Mayer, 2009). Because the content was split into explanation, examples, practice and evaluation, students may have had less unnecessary information to hold in working memory at any one time (Leahy & Sweller, 2011). This mechanism was not measured directly, so it remains an interpretation.

This interpretation is consistent with the broader literature on digital mathematics learning. Interactive media can support the movement from concrete or visual representation toward more formal mathematical representation when the design is purposeful. Research involving digital applications for spatial ability and geometry has similarly emphasized the value of interactive visual environments (Bintoro et al., 2023). Studies of interactive mathematics media also report that combining digital resources with structured learning activities can support achievement and engagement (Franoto et al., 2025; Setyoningrum et al., 2022).

The size of the improvement can also be compared with earlier studies. The experimental group's normalized gain of 0.45 against 0.21 in the control group (Table 4) is close to the pattern Hake (1998) reported for interactive-engagement versus traditional physics courses, although the subjects and ages differ. The direction of the result agrees with the meta-analysis of Indonesian interactive multimedia studies by Khaeruman et al. (2023) and with the fourth-grade comparison by Dinda Anadira et al. (2025). The gain in this study was medium, not high. One likely reason is that the trial was short and focused on achievement in a single topic. Another is that SIBAD presents worked examples and practice but does not yet adapt to individual errors. The expert ratings (89% for material and 87% for media; Table 2) were similar to those reported for the geoboard medium on the same topic (Aflia et al., 2020), which suggests that digital and physical media can reach comparable expert acceptance when the content is well structured.

The present findings also complement research conducted by Universitas Muria Kudus scholars on mathematics learning media and instructional innovation. Studies involving interactive or technology-supported mathematics learning have shown that media can strengthen students' mathematical communication, conceptual understanding, and learning outcomes when integrated with an appropriate instructional design (Ningsih et al., 2023; Shahira et al., 2024; Zuliana, 2018; Zuliana et al., 2018). The current study extends this line of work by examining a web-based multimedia product specifically developed for fourth-grade plane geometry and by combining feasibility evidence with a comparison of learning outcomes.

For teachers in the Sultan Agung School Cluster, the results suggest a practical way to use SIBAD. It can be used during guided practice after the teacher has introduced a figure, so that students can check the link between shape and formula themselves, and later for independent review. The revisions requested by the experts (sequencing, contextual examples, text size and navigation icons) also give developers of similar media a checklist for designing for fourth graders. For schools, the medium only helps if students have access to devices and a stable connection, and teachers need time to prepare lessons around it. Principals and the cluster's teacher working group could therefore plan shared device schedules and short workshops on integrating SIBAD into geometry lessons, following the implementation and evaluation stages of the ADDIE cycle (Branch, 2009).

Nevertheless, the findings should be interpreted within the scope of the study. The trial involved a relatively small number of students from one school cluster, and the classes were not randomly assigned. The results therefore provide local evidence of effectiveness and should not be generalized to every school context. Differences in device availability, teacher facilitation, student digital literacy, and implementation time may influence outcomes.

Some further limitations concern the analysis. The groups started at similar pretest means (60.18 and 58.86), but no pretest comparison is reported, and the posttest t-test does not adjust for baseline differences. An analysis of covariance or a comparison of gain scores would be more suitable for a nonequivalent design. Standard deviations and an effect size are not reported, so the practical size of the difference cannot be judged. Teacher effects cannot be separated from the effect of the medium, because each group was taught by its own teachers in different schools, and part of the difference may come from the novelty of a digital medium. The posttest was given immediately after the intervention, so retention is unknown. Future studies should report effect sizes and baseline-adjusted comparisons, include a delayed posttest, and examine outcomes such as spatial reasoning and problem solving.

CONCLUSION AND RECOMMENDATIONS

This study developed SIBAD, a web-based interactive learning multimedia for fourth-grade plane geometry, through the ADDIE model. The product was judged highly feasible by experts, with a material validation mean of 89% and a media validation mean of 87%. Field testing showed that students who learned with SIBAD achieved a higher posttest mean than students in the control group, and the difference was statistically significant. The normalized gain was also higher in the experimental group (0.45, medium) than in the control group (0.21, low).

The findings indicate that SIBAD can be a viable digital learning resource for elementary mathematics, particularly when students need visual support for understanding geometric concepts. Teachers may use the medium as a classroom learning aid, for guided practice, or as a resource for independent review. Schools should support the use of digital learning media by ensuring adequate devices, connectivity, and teacher readiness.

Future studies should examine the product with larger and more diverse samples and investigate outcomes beyond achievement, including mathematical reasoning, spatial ability, problem solving, critical thinking, and learning motivation. Further development may also explore offline access and broader integration with classroom assessment systems.

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REFERENCES

Aflia, K., Yuhana, Y., & Alamsyah, T. (2020). Pengembangan media pembelajaran geoboard untuk kemampuan pemahaman matematis siswa sekolah dasar. Primary: Jurnal Pendidikan Guru Sekolah Dasar, 9(5), 680–689. https://doi.org/10.33578/jpfkip.v9i5.8028

Al Ilahiyah, I. (2024). Pengembangan multimedia interaktif Articulate Storyline 3 berbasis kontekstual untuk meningkatkan kemampuan menyelesaikan soal bangun datar. Decode: Jurnal Pendidikan Teknologi Informasi, 4(2), 581–592. https://doi.org/10.51454/decode.v4i2.376

Amelia, D., & Suryani, I. (2023). Pengembangan media pembelajaran interaktif berbasis Canva pada materi bangun datar kelas IV SD Negeri 80 Palembang. Didaktik: Jurnal Ilmiah PGSD FKIP Universitas Mandiri, 9(3).

Astri, N. K. D., Wiarta, I. W., & Wulandari, I. G. A. A. (2022). Pengembangan multimedia interaktif berbasis pendekatan kontekstual pada mata pelajaran matematika pokok bahasan bangun datar. Jurnal Pendidikan dan Konseling, 4.

Behnamnia, N., Kamsin, A., & Hayati, S. (2024). Impact of digital game-based learning on STEM education in primary schools: A meta-analysis of learning approaches. Innoeduca. International Journal of Technology and Educational Innovation, 10(2). https://doi.org/10.24310/ijtei.102.2024.19694

Bintoro, H. S., Sumaji, S., Purwaningrum, J. P., Wanabuliandari, S., Rahayu, R., & Ulya, H. (2023). Kepraktisan aplikasi berbasis Android bermuatan ethnomathematics untuk mengembangkan kemampuan spasial. Jurnal Karya Pendidikan Matematika, 10(2), 1–11. https://doi.org/10.26714/jkpm.10.2.2023.1-11

Branch, R. M. (2009). Instructional design: The ADDIE approach. Springer. https://doi.org/10.1007/978-0-387-09506-6

Chusna, N. L. U., Khasanah, U., & Najikhah, F. (2024). Interactive digital media for learning in primary schools. Asian Pendidikan, 4(2). https://doi.org/10.53797/aspen.v4i2.10

Devi, M. A. G. S., & Wiarta, I. W. (2024). Multimedia interaktif berbasis kontekstual pada pembelajaran matematika kelas IV sekolah dasar. Indonesian Journal of Instruction, 5(1), 14–24. https://doi.org/10.23887/iji.v5i1.44520

Dewi, N. L. P. Y. A., Parmiti, D. P., & Agustiana, I. G. A. T. (2024). Interactive PowerPoint multimedia based on ISpring Suite to improve social studies learning outcomes for VI grade elementary schools. International Journal of Elementary Education, 8(4), 650–660. https://doi.org/10.23887/ijee.v8i4.90921

Dinda Anadira, M., Irmaningrum, R. N., & MZ, A. S. A. (2025). The effect of interactive multimedia based on Articulate Storyline 3 on student learning outcomes in elementary schools. Jurnal Tematik, 14(1), 25–31. https://doi.org/10.24114/jt.v14i1.68192

Franoto, O. A., Sumaji, S., & Bintoro, H. S. (2025). Media games interaktif berbasis web dengan problem based learning (PBL) untuk meningkatkan hasil belajar matematika. AKSIOMA: Jurnal Program Studi Pendidikan Matematika, 14(3). https://doi.org/10.24127/ajpm.v14i3.11819

Griseldis, M. R., Khasanah, L. N., Septiani, N. L., & Prananto, I. W. (2023). Improvement of concept understanding through the development of interactive multimedia on integer operation material. DIDAKTIKA: Jurnal Pendidikan Sekolah Dasar, 6(2). https://doi.org/10.21831/didaktika.v6i2.63448

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. American Journal of Physics, 66(1), 64–74. https://doi.org/10.1119/1.18809

Khaeruman, K., Sudiatmika, A. R., Suma, I. K., & Suardana, I. N. (2023). Meta-analisis: Efektivitas multimedia interaktif terhadap peningkatkan hasil belajar siswa. Bioscientist: Jurnal Ilmiah Biologi, 11(2), 1630–1639. https://doi.org/10.33394/bioscientist.v11i2.9497

Leahy, W., & Sweller, J. (2011). Cognitive load theory, modality of presentation and the transient information effect. Applied Cognitive Psychology, 25, 943–951. https://doi.org/10.1002/acp.1787

Mayer, R. E. (2009). Multimedia learning (2nd ed.). Cambridge University Press.

Moyer-Packenham, P. S., & Westenskow, A. (2016). Revisiting the effects and affordances of virtual manipulatives for mathematics learning. In K. Terry & A. Cheney (Eds.), Utilizing virtual and personal learning environments for optimal learning (pp. 186–215). IGI Global. https://doi.org/10.4018/978-1-4666-8847-6.ch009

Mulyawati, Y., Sukmanasa, E., Rostikawati, R. T., Maharani, N. D., & Azizah, A. N. (2024). A new approach to elementary learning: An interactive digital module for critical thinking with Articulate Storyline. Pedagogia: Jurnal Ilmiah Pendidikan, 16(2), 97–102. https://doi.org/10.55215/pedagogia.v16i2.23

Ningsih, S. R., Purwaningrum, J. P., & Sumaji. (2023). Pengaruh model pembelajaran Two Stay–Two Stray berbantuan media Mathcircle terhadap kemampuan komunikasi matematis siswa. Jurnal Pendidikan Matematika, 14(2). https://doi.org/10.36709/jpm.v14i2.72

OECD. (2023). PISA 2022 results (Volume I): The state of learning and equity in education. OECD Publishing. https://doi.org/10.1787/53f23881-en

Paas, F., & Sweller, J. (2012). An evolutionary upgrade of cognitive load theory: Using the human motor system and collaboration to support the learning of complex cognitive tasks. Educational Psychology Review, 24(1), 27–45. https://doi.org/10.1007/s10648-011-9179-2

Rusdi, W. K., Parapat, H. F., Efendi, S. A., & Misman. (2024). Development of interactive Wordwall and video combined-media to improve elementary students' learning outcomes. ELSE (Elementary School Education Journal), 8(3). https://doi.org/10.30651/else.v8i3.24914

Setyoningrum, D. Y., Supriyono, & Pangestika, R. R. (2022). Pengembangan multimedia berbasis etnomatematika pada materi bangun datar kelas IV sekolah dasar. Jurnal Educatio FKIP UNMA, 8(1), 1–8. https://doi.org/10.31949/educatio.v8i1.1419

Shahira, S. P., Sumaji, S., & Ulya, H. (2024). Efektivitas model pembelajaran Creative Problem Solving berbantuan media Permath Apps terhadap kemampuan numerasi matematis. Kognitif: Jurnal Riset HOTS Pendidikan Matematika, 4(3). https://doi.org/10.51574/kognitif.v4i3.1720

Sholeh, T. (2026). Pengembangan multimedia pembelajaran interaktif "SIBAD" berbasis web untuk meningkatkan hasil belajar matematika siswa kelas IV sekolah dasar [Master's thesis, Universitas Muria Kudus].

Sugiyono. (2019). Metode penelitian kuantitatif, kualitatif, dan R&D. Alfabeta.

Trisnantari, H. E., Mutohar, P. M., & Rindrayani, S. R. (2024). The effectiveness of interactive learning media based on Adobe Flash in improving learning achievement at primary schools. International Journal of Research and Innovation in Social Science, 8(1), 1539–1549. https://doi.org/10.47772/ijriss.2024.801114

Zuliana, E. (2018). Penerapan inquiry based learning berbantuan peraga manipulatif dalam meningkatkan pemahaman konsep matematika pada materi geometri mahasiswa PGSD Universitas Muria Kudus. Lectura: Jurnal Pendidikan, 8(1). https://doi.org/10.31849/lectura.v8i1.269

Zuliana, E., et al. (2018). Peningkatan pemahaman konsep matematika melalui Realistic Mathematics Education berbantu alat peraga Bongpas. ANARGYA: Jurnal Ilmiah Pendidikan Matematika, 1(1). https://doi.org/10.24176/anargya.v1i1.2280

ICISFS-UMK 2026 EDUCATIONAL TECHNOLOGY & MEDIA

Development of ARAHAN Worksheet Based on Ethnomathematics of Jenang Kudus to Improve Mathematical Representation

Suciani Rahmah[1*], Henry Suryo Bintoro[1] and Erik Aditia Ismaya[1]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: sucianirahmah@gmail.com

ABSTRACT

This study aims to develop the ARAHAN Worksheet (Augmented Reality Mathematics Fractions Worksheet), integrated with Jenang Kudus ethnomathematics, to improve the mathematical representation ability of fifth-grade elementary school students. The research employed the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation). The study was conducted at three elementary schools within one school cluster in Mejobo District, Kudus Regency. Data were collected through needs analysis questionnaires, expert validation sheets, student and teacher response questionnaires, and posttest instruments. Three expert validators (material, media, and language) assessed the validity of the product, and all rated the ARAHAN Worksheet as "Very Feasible." Practicality was measured with response questionnaires in a small group trial involving five students and one teacher, and the worksheet met the "Very Practical" criteria. Effectiveness was evaluated with a Posttest-Only Control Group Design by comparing posttest results between the experimental class (31 students using ARAHAN Worksheet) and the control class (32 students using conventional learning). The Independent Sample T-Test showed a significance value of less than 0.001, indicating a significant difference between the two groups. The experimental class obtained a higher mean posttest score (80.00) than the control class (70.67), which suggests that the ARAHAN Worksheet supported students' mathematical representation ability. Integrating Augmented Reality technology with Jenang Kudus ethnomathematics supported learning that was meaningful, mindful, and joyful, in line with the deep learning principles of the Merdeka Curriculum.

KEYWORDS ADDIE model | augmented reality | ethnomathematics | fraction | mathematical representation | worksheet

INTRODUCTION

Mathematics is a core subject for students' cognitive development, particularly in elementary school. Among the concepts taught at this level, fractions are considered one of the most difficult for students to master. Fractions require students to understand abstract relationships between parts and wholes, which can be difficult for young learners who are still in the concrete operational stage of cognitive development (Piaget, as cited in Hidayatullah et al., 2024). In many Indonesian elementary schools, students still struggle with basic fraction concepts even though the material was introduced in earlier grades.

A needs analysis conducted at three elementary schools in Gugus Ahmad Yani, Mejobo District, Kudus Regency showed that fifth-grade students still lacked a fundamental understanding of fractions. Classroom observations showed that students were not engaged, partly because the media used were uninteresting. Teacher questionnaires indicated that only a small number of students reached the minimum competency criteria (KKTP) in fraction assessments. Teachers reported relying primarily on lecture methods and conventional media such as concrete objects and *YouTube* videos, which were insufficient to develop students' conceptual understanding of fractions. This finding is consistent with Hariyani et al. (2022), who found that elementary school students experience epistemological obstacles in fraction learning, from basic fraction concepts to arithmetic operations and problem-solving. Fraction difficulties therefore appear to be widespread in elementary mathematics education.

In response to these challenges, this study proposes the development of the ARAHAN Worksheet (Augmented Reality Mathematics Fractions Worksheet), a learning medium that integrates *Augmented Reality* (AR) technology with the ethnomathematics of Jenang Kudus, a traditional food iconic to Kudus Regency. The

use of AR technology enables students to visualize abstract fraction concepts through interactive three-dimensional representations, while the ethnomathematics context provides culturally relevant and meaningful learning experiences. Bintoro et al. (2024) showed that learning media incorporating ethnomathematics improved students' conceptual understanding. Similarly, Bintoro et al. (2023) found that android-based applications with ethnomathematics content are practical and engaging for students. The ARAHAN Worksheet also follows the deep learning principles of the Merdeka Curriculum, which emphasize meaningful, mindful, and joyful learning experiences.

LITERATURE REVIEW

Mathematical representation ability refers to the capacity to express mathematical ideas through various forms, including visual (pictures/diagrams), symbolic (numbers and mathematical symbols), and verbal (written or spoken explanations) representations (NCTM, 2000). The ability to translate between forms of representation is essential for mathematical understanding, because students who move flexibly between representations show stronger conceptual knowledge (Jones in Sabirin, 2014). Imaniyah & Fiantika (2024) reported that ethnomathematics-based learning supported students' mathematical representation process in fraction material. In their study, cultural contexts helped students express fraction concepts in visual, symbolic, and verbal forms.

Augmented Reality (AR) is a technology that overlays digital information onto the real world in real-time, creating an interactive three-dimensional experience (Azuma, 1997). In education, AR has shown potential to improve student engagement, motivation, and conceptual understanding by transforming abstract concepts into concrete, interactive visualizations (Carolina, 2023). A systematic review of 29 studies on AR in elementary education reported that AR was associated with higher motivation, interest and understanding across subjects (Tarmidzi et al., 2025). The Assemblr Edu platform, developed by an Indonesian company, enables educators to create AR content without requiring advanced coding skills and is an official partner of the government's learning platform belajar.id (Fauzi & Saputro, 2025).

Ethnomathematics refers to the study and practice of mathematics within specific cultural contexts, recognizing that mathematical knowledge is embedded in cultural activities and artifacts (Prahmana & D'Ambrosio, 2020; Soebagyo et al., 2021). Jenang Kudus, a traditional sticky rice cake from Kudus Regency, provides a suitable ethnomathematics context for teaching fractions because its rectangular shape and the common practice of cutting it into equal pieces directly represent fraction concepts. Jenang Kudus also has cultural significance: it is traditionally served at weddings, religious celebrations, and community gatherings, embodying values of togetherness, unity, and generosity. Dela Peña & Villaverde (2025) found that culturally responsive mathematics instruction correlates significantly with students' positive attitude towards mathematics. This suggests that connecting mathematical concepts to students' cultural experiences can support their confidence and engagement.

Wulandari et al. (2024) reported that integrating ethnomathematics teaching materials into elementary school mathematics improved students' engagement and conceptual understanding by connecting mathematical concepts to their everyday cultural life.

Development studies of worksheets for Indonesian fifth graders point the same way. Katon and Sukmawarti (2026) developed a Javanese batik ethnomathematics worksheet with the ADDIE model; experts rated it highly feasible, and students' mathematical literacy showed a moderate gain (N-gain 0.58). On fractions specifically, Sakinah et al. (2023) reported a moderate gain in concept understanding (N-gain 0.61) among 32 fifth graders who used a contextual electronic worksheet. On the technology side, Fauzi and Saputro (2025) built Assemblr Edu AR media for fifth-grade geometry, which shows that the platform is usable at this level.

These studies leave a gap that this study addresses. The worksheets above used either a cultural context or a digital tool, but not both in one product, and they measured literacy or concept understanding rather than mathematical representation. A review of 60 articles concluded that students' representation ability often remains low and that innovative teaching which gives students chances to meet each representation indicator can raise it (Man et al., 2022). The literature reviewed for this study contained no learning material that uses Jenang Kudus as

a context for fractions. This study therefore combines 3D AR objects with the Jenang Kudus context in one worksheet, designs its activities around visual, symbolic and verbal representation, and evaluates it for feasibility, practicality and effectiveness in one school cluster in Kudus.

Research Objectives

This study aims to: (1) develop the ARAHAN Worksheet integrated with Jenang Kudus ethnomathematics for fifth-grade elementary school students on fraction material; (2) assess the feasibility of ARAHAN Worksheet based on expert validation; (3) evaluate the practicality of ARAHAN Worksheet based on student and teacher response questionnaires; and (4) determine the effectiveness of ARAHAN Worksheet in improving students' mathematical representation ability through posttest comparison between experimental and control classes.

RESEARCH METHOD

Research Design

This study employed a Research and Development (R&D) design based on the ADDIE model, which consists of five systematic stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was selected because its systematic and flexible structure allows formative evaluation at each stage, so that errors can be detected and corrected before full implementation (Mulyasari et al., 2023). The research was conducted at three elementary schools in Gugus Ahmad Yani, Mejobo District, Kudus Regency, with a total of 63 students as research subjects.

Research Subject

The research subjects were determined using purposive sampling (Sugiyono, 2022), considering student numbers and equivalent conditions among schools within the same cluster. The experimental class consisted of 31 fifth-grade students from SD 2 Golantepus (11 students) and SD 4 Mejobo (20 students), who learned with the ARAHAN Worksheet. The control class consisted of 32 students from SD 2 Mejobo (13 students) and SD 3 Mejobo (19 students), who received conventional learning through lecture methods supported by YouTube videos and textbooks. SD 1 Golantepus served as the small group trial location with 5 students and 1 teacher.

Data Collection Technique

Data collection techniques included needs analysis questionnaires administered to teachers, expert validation sheets for material, media, and language experts, student and teacher response questionnaires during small group trials, and posttest instruments for measuring mathematical representation ability. Effectiveness was evaluated with a Posttest-Only Control Group Design, with data analysis conducted through normality testing (Shapiro-Wilk), homogeneity testing (Levene's Test), and hypothesis testing (Independent Sample T-Test) using SPSS software.

RESULTS

Product Development

The ARAHAN Worksheet was developed through three sequential processes: content drafting using Google Docs, creation of three-dimensional Jenang Kudus objects using *Assemblr Edu*, and visual design using *Canva*. The three-dimensional objects were created independently because no existing assets specifically represented fraction concepts using Jenang Kudus. The final product consists of a cover page, a welcome page with learning objectives and AR usage instructions, an introduction to Jenang Kudus ethnomathematics, six core learning activities, and a closing page with reflection and achievement badges.

The six activities were designed to progressively develop all three indicators of mathematical representation: Activity 1 (Understanding Fractions through Jenang Kudus), Activity 2 (Comparing Fractions), Activity 3 (Ordering Fractions), Activity 4 (Fraction Arithmetic Operations), Activity 5 (Reflection), and Activity 6 (Final

Evaluation). Each activity includes AR barcodes that students scan with smartphones to access interactive 3D Jenang Kudus objects, allowing them to observe fraction representations from multiple angles.

Table 1. Expert validation results of the ARAHAN Worksheet

Validator	Average Score	Criteria
Material Expert	3.37	Very Feasible
Media Expert	3.35	Very Feasible
Language Expert	3.63	Very Feasible

Feasibility

The feasibility of ARAHAN Worksheet was assessed through expert validation from three validators. As shown in Table 1, all validators rated the product as Very Feasible. The material expert gave an average score of 3.37, evaluating content appropriateness and media usefulness. The language expert gave an average score of 3.63, with the highest score (4.00) on the aspect of suitability with students' developmental level, indicating that the language is accessible and communicative for fifth-grade students. The media expert gave an average score of 3.35 and also rated the product as Very Feasible after reviewing the AR integration and visual design.

Practicality

The practicality of ARAHAN Worksheet was measured through small group trials at SD 1 Golantepus. Student response questionnaires yielded an average score of 3.50 (Very Practical), while teacher response questionnaires yielded an average score of 3.43 (Very Practical). During the trials, students were highly enthusiastic, as it was their first time using smartphones for classroom learning. Dividing the AR scanning tasks among group members encouraged collaboration. Some students were so absorbed in the 3D Jenang Kudus objects that they were reluctant to pass the smartphone to their peers. Teachers told students that the ARAHAN Worksheet could also be used at home, and students welcomed this because most of them have internet access at home.

Effectiveness

The effectiveness of ARAHAN Worksheet was evaluated by comparing posttest results between the experimental and control classes. Prior to hypothesis testing, normality testing using Shapiro-Wilk showed significance values of 0.655 for the experimental class and 0.337 for the control class, both greater than 0.05, indicating that the data were normally distributed. Homogeneity testing using Levene's Test yielded a significance value of 0.051, which is greater than 0.05, indicating homogeneous variances.

Table 2. Independent samples t-test results

Class	Mean	t	df	Sig.
Experimental	80.00	3.745	61	<0.0001
Control	70.67			

As presented in Table 2, the Independent Sample T-Test yielded a t-value of 3.745 with df = 61 and a significance value of less than 0.001, which is below the 0.05 threshold. Therefore, H0 is rejected and H1 is accepted, indicating a significant difference between the posttest results of the experimental and control classes. The experimental class achieved a higher mean score (80.00) than the control class (70.67), a difference of 9.33 points between the means.

DISCUSSION

All three validators rated the ARAHAN Worksheet as Very Feasible, with average scores of 3.37 (material), 3.35 (media) and 3.63 (language) (Table 1). The high language score for suitability with students' developmental level suggests that fifth graders can follow the instructions on their own, which matters when they must switch between the printed page and a smartphone. These ratings agree with Nurvitasari and Sulisworo (2023), whose AR-based mathematics worksheet also received high feasibility ratings, and with Handayani and Permatasari (2025), whose ADDIE-based AR worksheet for fifth graders was rated very valid by the material expert. Katon and Sukmawarti (2026) likewise reported high expert feasibility for an ethnomathematics worksheet at the same grade. Expert ratings judge the design of a product, however, not what students learn from it.

Students (3.50) and the teacher (3.43) rated the worksheet as Very Practical in the small-group trial. Part of the students' enthusiasm probably came from using smartphones in class for the first time, so this response may weaken once the medium becomes familiar. The response is consistent with a systematic review of 29 studies, which reported that AR in elementary education was associated with higher motivation and interest (Tarmidzi et al., 2025), and with Bintoro et al. (2023), who found an android-based application with ethnomathematics content practical for students. Sharing one smartphone per group encouraged collaboration, but some students were reluctant to hand the device on, so teachers should agree turn-taking rules before the lesson. Home use could extend practice time: a meta-analysis of 110 studies found a moderate mean effect (0.523) of integrating mobile devices into teaching and learning (Sung et al., 2016). Because practicality was judged by five students and one teacher at one school, these ratings are preliminary.

The experimental class scored higher on the posttest than the control class (80.00 vs. 70.67; $t = 3.745$, $df = 61$, $p < 0.001$; Table 2). The direction of this result agrees with other comparisons of culture-based mathematics teaching in Indonesian elementary schools. Abidah and Ardani (2024), who also used a posttest-only design with fifth graders, found higher numeracy literacy after ethnomathematics-based realistic mathematics education (posttest means 63.45 vs. 42.48). Outside Indonesia, Siller and Ahmad (2024) reported significant gains in mathematics achievement for grade six students taught with a collaborative approach for 12 weeks, compared with a traditionally taught group. This is relevant because the ARAHAN activities were completed in groups.

The higher performance of the experimental class may be attributed to the ARAHAN Worksheet, which supports active construction of fraction understanding through visual, interactive, and culturally contextual experiences. Unlike the control class, which mainly received information through lectures and videos, experimental class students actively engaged in activities that required them to represent fractions visually through drawings, symbolically through mathematical notation, and verbally through written explanations. With AR, students could observe three-dimensional Jenang Kudus objects cut into various fractions from multiple perspectives, which may have made the abstract concept of fractions more concrete. This interpretation is consistent with Volioti et al. (2023), who reported that AR in primary mathematics education promoted active learning and improved students' conceptual understanding compared with conventional methods. Carolina (2023) similarly noted that AR can enhance understanding and information retention through interactive visualization. The Jenang Kudus context may also have contributed by making learning meaningful and relatable to students' everyday cultural experiences, in line with Amelia et al. (2025), whose literature review linked ethnomathematics learning media to higher interest in learning mathematics.

The Jenang Kudus context gives students a familiar whole that is routinely cut into equal pieces, so the part-whole meaning of a fraction is tied to an everyday act rather than to an abstract shaded figure. Hariyani et al. (2022) traced many fraction difficulties back to the basic concept, and Hidayatullah et al. (2024) described how students represent fractions by shading plane figures; a familiar 3D object offers another entry point. Imaniyah and Fiantika (2024) observed that cultural contexts helped second graders express fractions in visual, symbolic and verbal forms, and Dela Peña and Villaverde (2025) found that culturally responsive mathematics instruction was associated with more positive attitudes towards mathematics. Virtual objects may also matter: in a fraction study with 350 grade 3-4 students, achievement in the virtual-manipulative group depended less on students'

demographic background (Moyer-Packenham et al., 2014). This study did not score the three representation indicators separately, so it cannot show which form of representation benefited most.

For teachers in Gugus Ahmad Yani and similar clusters, the results suggest introducing fractions through a local object before moving to symbols, and the AR content can be built at no cost with Assemblr Edu through belajar.id accounts (Fauzi & Saputro, 2025). Other digital content that students already know can also be built into structured lessons; Wisnujati et al. (2024) examined discovery learning assisted by TikTok creative content and its effect on students' mathematical reasoning. The design fits the deep learning principles of the Merdeka Curriculum, since Rosyidah et al. (2026) argue that mindful, meaningful and joyful learning should be applied together so that students connect content to real-life experience. Schools that adopt the worksheet will need enough working devices and a stable connection, or a printed fallback for the AR objects.

Several limitations apply. The design was posttest-only with intact classes from different schools, without random assignment or a pretest, so pre-existing differences between the groups cannot be ruled out, and the result shows a difference at posttest rather than an improvement (Shadish et al., 2002). The two conditions also differed in more than the worksheet: the experimental class used smartphones and group work, so novelty and collaboration may explain part of the difference. No effect size was reported, validity and reliability evidence for the posttest is not given, and the representation indicators were not scored separately. Practicality rests on five students and one teacher, and feasibility on three validators without an agreement index. Future studies should use a pretest-posttest control group design with larger samples, report effect sizes and indicator-level scores, follow students for longer to separate novelty from learning, and test the worksheet in other clusters and with other local artifacts.

CONCLUSION AND RECOMMENDATIONS

The ARAHAN Worksheet integrating Jenang Kudus ethnomathematics was developed using the ADDIE model and was found to be feasible, practical, and effective for fifth-grade elementary school students on fraction material. Expert validation yielded Very Feasible criteria from all three validators. Small group trial response questionnaires showed Very Practical criteria from both students (3.50) and teachers (3.43). The Independent Sample T-Test showed that the experimental class significantly outperformed the control class ($p < 0.001$), with the experimental class achieving a higher mean posttest score (80.00 vs 70.67). These findings suggest that integrating AR technology with ethnomathematics in worksheet design can create engaging and meaningful learning experiences in line with Merdeka Curriculum principles.

Teachers may consider using the ARAHAN Worksheet as an alternative for teaching fractions, provided that clear rules for smartphone use are agreed before lessons. Schools are encouraged to support technology-based learning initiatives by using the free Assemblr Edu platform accessible through belajar.id accounts. Future researchers are advised to extend this development to other mathematical topics or grade levels, use pretest-posttest designs to measure effectiveness more fully, and explore ethnomathematics contexts from other regions to promote broader cultural preservation through mathematics education.

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REFERENCES

Abidah, A. N., & Ardani, A. (2024). Pengaruh model pembelajaran realistic mathematics education berbasis etnomatematika terhadap literasi numerasi siswa sekolah dasar. *Ar-Riayah: Jurnal Pendidikan Dasar, 8*(2), 315–330. https://doi.org/10.29240/jpd.v8i2.11250

Amelia, D., Rahmadani, F. J., Septiyani, M. N. R., Abdurrafi, M. A., & Maulidah, N. (2025). Peran media pembelajaran etnomatematika dalam meningkatkan minat belajar matematika siswa SD: Tinjauan literatur (The role of ethnomathematics

learning media in improving elementary school students' interest in learning mathematics: A literature review). *Jurnal Ilmiah Profesi Pendidikan, 10*(1), 875–883. https://doi.org/10.29303/jipp.v10i1.2953

Azuma, R. T. (1997). A survey of augmented reality. *Presence: Teleoperators and Virtual Environments, 6*(4), 355–385. https://doi.org/10.1162/pres.1997.6.4.355

Bintoro, H. S., Aulya, R., & Wanabuliandari, S. (2024). The problem-based learning model assisted with the Ethlaf application contains ethnomathematics to improve students' conceptual understanding capability. Journal of Education Research and Evaluation, 8(1), 163–172. https://doi.org/10.23887/jere.v8i1.69805

Bintoro, H. S., Sumaji, Wanabuliandari, S., Purwaningrum, J. P., Rahayu, R., & Ulya, H. (2023). Kepraktisan aplikasi berbasis android bermuatan ethnomathematics untuk mengembangkan kemampuan spasial (The practicality of android-based applications with ethnomathematics content to develop spatial abilities). *Jurnal Karya Pendidikan Matematika, 10*(2), 1–11. https://doi.org/10.26714/jkpm.10.2.2023.1-11

Carolina, Y. D. (2023). Augmented reality sebagai media pembelajaran interaktif 3D untuk meningkatkan motivasi belajar siswa digital native (Augmented reality as a 3D interactive learning media to increase digital native students' learning motivation). *Ideguru: Jurnal Karya Ilmiah Guru, 8*(1), 10–16. https://doi.org/10.51169/ideguru.v8i1.448

Dela Peña, R. A., & Villaverde, J. M. (2025). The influence of culturally responsive mathematics instruction and students' sense of belonging on their attitude towards mathematics. International Journal of Research and Innovation in Social Science, 9(5), 1550–1568. https://doi.org/10.47772/IJRISS.2025.9050118

Fauzi, N. A., & Saputro, H. B. (2025). Development of augmented reality (AR) based Assemblr Edu learning media for mathematics subjects, grade V elementary school spatial building materials. *Mandalika Mathematics and Educations Journal, 7*(2), 730–745. https://doi.org/10.29303/jm.v7i2.9251

Handayani, S., & Permatasari, D. (2025). Development of augmented reality-based worksheet to improve the geometric thinking ability of fifth grade elementary school. *EMTEKA: Jurnal Pendidikan Matematika*. https://doi.org/10.24127/emteka.v6i1.11600

Hariyani, M., Herman, T., Suryadi, D., & Prabawanto, S. (2022). Exploration of student learning obstacles in solving fraction problems in elementary school. *International Journal of Educational Methodology, 8*(3), 505–515. https://doi.org/10.12973/ijem.8.3.505

Hidayatullah, F. M., Sari, A. F., & Lutfianto, M. (2024). Strategi siswa SD dalam merepresentasikan pecahan dengan mengarsir bangun datar (Elementary school students' strategies in representing fractions by shading flat shapes). *Plusminus: Jurnal Pendidikan Matematika, 4*(3), 471–486.

Imaniyah, C. D., & Fiantika, F. R. (2024). Description of the high ability representation process of second grade elementary school students in fraction material based on ethnomathematics. *Formosa Journal of Applied Sciences, 3*(9), 3847–3860. https://doi.org/10.55927/fjas.v3i9.11198

Katon, A. S., & Sukmawarti. (2026). Pengembangan lembar kerja peserta didik etnomatematika batik Jawa untuk meningkatkan literasi matematika siswa SD. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 11*(2), 228–240. https://doi.org/10.23969/jp.v11i02.50402

Man, Y. L., Asikin, M., & Sugiman, S. (2022). Systematic literature review: Students' mathematical representation ability in mathematics learning. *Daya Matematis: Jurnal Inovasi Pendidikan Matematika, 10*(1), 36–44. https://doi.org/10.26858/jdm.v10i1.26821

Moyer-Packenham, P. S., Baker, J., Westenskow, A., Anderson, K. L., Shumway, J. F., & Jordan, K. E. (2014). Predictors of achievement when virtual manipulatives are used for mathematics instruction. *REDIMAT, 3*(2). https://doi.org/10.4471/redimat.2014.46

Mulyasari, R., Irvan, & Doly, M. (2023). Pengembangan bahan ajar bangun ruang sisi datar dengan model ADDIE (sekolah dasar) (Development of flat-sided geometry teaching materials using the ADDIE model (elementary school)). *GENTA MULIA: Jurnal Ilmiah Pendidikan, 14*(1), 334–342. https://doi.org/10.61290/gm.v14i1.698

National Council of Teachers of Mathematics (NCTM). (2000). Principles and standards for school mathematics. NCTM.

Nurvitasari, I., & Sulisworo, D. (2023). Pengembangan LKPD berbasis augmented reality sebagai media pembelajaran matematika (Development of augmented reality-based worksheets as mathematics learning media). *JNPM (Jurnal Nasional Pendidikan Matematika), 7*(1), 1–11. https://doi.org/10.33603/jnpm.v7i1.5347

Prahmana, R. C. I., & D'Ambrosio, U. (2020). Learning geometry and values from patterns: Ethnomathematics on the batik patterns of Yogyakarta, Indonesia. Journal on Mathematics Education, 11(3), 439–456. https://doi.org/10.22342/jme.11.3.12949.439-456

Rosyidah, F., Parmiti, D. P., Sanjaya, D. B., & Jampel, I. N. (2026). The theories of principles in deep learning approach. *Pedagogia: Jurnal Pendidikan, 15*(1), 127–136. https://doi.org/10.21070/pedagogia.v15i1.2098

Sabirin, M. (2014). Representasi dalam pembelajaran matematika. JPM IAIN Antasari, 1(2), 33–44.

Sakinah, S., Dewi, R. S., & Hakim, Z. R. (2023). Development of contextual-based E-LKPD to improve the ability to understand fraction concepts. *EduBasic Journal: Jurnal Pendidikan Dasar, 5*(1), 71–82. https://doi.org/10.17509/ebj.v5i1.51576

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Houghton Mifflin.

Siller, H.-S., & Ahmad, S. (2024). Analyzing the impact of collaborative learning approach on grade six students' mathematics achievement and attitude towards mathematics. *Eurasia Journal of Mathematics, Science and Technology Education, 20*(2), em2395. https://doi.org/10.29333/ejmste/14153

Soebagyo, J., Andriono, R., Razfy, M., & Arjun, M. (2021). Analisis peran etnomatematika dalam pembelajaran matematika (Analysis of the role of ethnomathematics in mathematics learning). *ANARGYA: Jurnal Ilmiah Pendidikan Matematika, 4*(2), 184–190. https://doi.org/10.24176/anargya.v4i2.6370

Sugiyono. (2022). Metode penelitian kuantitatif, kualitatif, dan R&D. Alfabeta.

Sung, Y.-T., Chang, K.-E., & Liu, T.-C. (2016). The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. *Computers & Education, 94*, 252–275. https://doi.org/10.1016/j.compedu.2015.11.008

Tarmidzi, T., Andari, K. D. W., Sari, A., Nuryanti, M., Arfiyanti, R., & Noto, M. S. (2025). Augmented reality and its use in elementary school education: A systematic literature review. *Jurnal Prima Edukasia, 13*(1), 128–145. https://doi.org/10.21831/jpe.v13i1.75094

Volioti, C., Orovas, C., Sapounidis, T., Trachanas, G., & Keramopoulos, E. (2023). Augmented reality in primary education: An active learning approach in mathematics. *Computers, 12*(10), 207. https://doi.org/10.3390/computers12100207

Wisnujati, N. P., Bintoro, H. S., & Purwaningrum, J. P. (2024). Pengaruh model pembelajaran discovery learning berbantu konten kreatif TikTok terhadap kemampuan penalaran matematis siswa (The effect of discovery learning model assisted by TikTok creative content on students' mathematical reasoning ability). *Kognitif: Jurnal Riset HOTS Pendidikan Matematika, 4*(1), 96–104. https://doi.org/10.51574/kognitif.v4i1.1180

Wulandari, D. U., Mariana, N., Wiryanto, W., & Amien, M. S. (2024). Integration of ethnomathematics teaching materials in mathematics learning in elementary school. *IJORER: International Journal of Recent Educational Research, 5*(1), 204–218. https://doi.org/10.46245/ijorer.v5i1.542

ICISFS-UMK 2026 LEARNING INNOVATION

Effectiveness of Discovery Learning with a Virtual Geoboard on Elementary Students' Understanding of Quadrilateral Area

Sri Lestari[1*], Henry Suryo Bintoro[1] and Khamdun[1]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: 202403145@std.umk.ac.id

ABSTRACT

Developing students' conceptual understanding is one of the primary objectives of mathematics learning. However, many elementary school students tend to memorize formulas without understanding the underlying concepts, particularly in learning the area of quadrilaterals. This study compared the conceptual understanding of students taught with the Discovery Learning model assisted by a Virtual Geoboard and of students taught conventionally, and examined the effectiveness of the model in improving conceptual understanding. A quasi-experimental pretest-posttest control group design was used. From a population of 546 fifth-grade students in Kebonagung District, Demak Regency, 132 students from six elementary schools were selected through cluster sampling. Data were collected using conceptual understanding tests and student response questionnaires and analyzed using descriptive statistics, Independent Samples *t*-Test, One Sample *t*-Test, and N-Gain analysis. The results showed a significant difference in conceptual understanding between the experimental and control groups (Sig. = 0.000 < 0.05). The experimental group achieved a higher mean posttest score (85.09) than the control group (45.31), and its mean score exceeded the school's Minimum Learning Mastery Criterion (KKTP) of 70 (Sig. = 0.000 < 0.05). The experimental group also obtained a high N-Gain score (0.7152), with an effectiveness level of 71.50%, whereas the control group obtained an N-Gain of 0.0064. Students' responses to Discovery Learning assisted by the Virtual Geoboard were highly positive, with an average response of 86.09%. These findings indicate that the Discovery Learning model assisted by Virtual Geoboard is effective in improving elementary school students' conceptual understanding of the area of quadrilaterals.

KEYWORDS conceptual understanding | discovery learning | elementary mathematics | quadrilateral area | virtual geoboard

INTRODUCTION

Mathematics is a fundamental subject for developing students' logical, critical, systematic, and creative thinking skills. At the elementary school level, mathematics learning is intended to build conceptual understanding, and not only calculation skills, as the foundation for more advanced mathematical learning (Hayati & Jannah, 2024). Geometry is one of the essential topics in elementary mathematics. According to Van Hiele's theory of geometric thinking, students' understanding of geometric concepts develops in stages, so conceptual mastery is a prerequisite for learning more complex geometric ideas (Rizqi, 2024). Geometry instruction should therefore help students construct concepts through meaningful learning experiences rather than merely memorizing formulas (Hikmayani, Tahir, & Rosyidah, 2023).

Conceptual understanding is one of the core competencies that students are expected to achieve in mathematics learning (Radiusman, 2020). It enables students to explain mathematical concepts in their own words, connect different mathematical ideas, and apply them to solve various problems. Students with strong conceptual understanding know both the procedures for solving problems and the reasoning behind them (Rohmah, Hilyana, & Ermawati, 2024). Improving conceptual understanding is therefore a key indicator of successful mathematics instruction, particularly in geometry.

However, studies have reported that elementary school students' understanding of geometric concepts remains low, especially for the area of quadrilaterals. Many students have difficulty explaining the origin of area formulas and tend to memorize them without understanding the underlying concepts (Amaliyah, Uyun, Fitri, &

Rahmawati, 2022). As a result, they struggle to solve problems requiring conceptual reasoning or the application of concepts in different contexts. This limited conceptual understanding is also linked to instruction that remains mainly teacher-centered and verbal, which gives students few opportunities to explore mathematical concepts through meaningful learning experiences (Meyvita & Azizah, 2024).

The same problems were observed in elementary schools in Kebonagung District, Demak Regency. Preliminary observations conducted at SD Negeri Mangunrejo 1, SD Negeri Mangunrejo 2, and SD Negeri Mangunrejo 3 showed that many students had difficulty explaining the concepts of the areas of squares and rectangles. Although most students could recall the formulas, they were unable to explain the mathematical reasoning underlying those formulas. Daily assessment results showed that students' achievement remained below the school's minimum learning target, with average scores of 57.1, 62.5, and 64.2, respectively. Interviews with teachers further indicated that classroom instruction was still dominated by lectures and routine exercises, while the use of interactive instructional media was very limited. These findings suggest a gap between students' computational skills and their conceptual understanding of quadrilateral area.

One strategy to improve conceptual understanding is to use instructional media that visualize geometric concepts concretely. Previous studies have shown that geoboards help students understand geometric relationships, calculate areas, and improve mathematics learning outcomes. Limalo and Ismail (2025) reported that the use of geoboards significantly improved students' achievement in learning quadrilaterals. Similarly, Muis et al. (2024) found that integrating geoboards into Joyful Learning increased students' learning activities to 95.36% and resulted in high learning achievement. These findings suggest that geoboards are useful instructional media because they link abstract mathematical concepts to visual representations that students understand more easily.

Digital technology has produced virtual geoboards, which are more flexible, interactive, and accessible than physical ones. Virtual geoboards allow students to explore geometric shapes, dimensions, and areas dynamically through digital devices. A meta-analysis of 104 effect sizes found a moderate positive effect of virtual manipulatives on mathematics achievement compared with other instruction, and identified affordances such as simultaneous linking of representations and focused constraint (Moyer-Packenham & Westenskow, 2016). Most existing studies, however, have focused on media development or descriptive investigations, and experimental evidence on whether virtual geoboards improve students' conceptual understanding is limited.

Besides instructional media, the learning model also affects students' conceptual understanding. One model that aligns well with the characteristics of mathematics instruction is Discovery Learning. This model places students at the center of learning: they observe, explore, identify patterns, and draw conclusions, and so construct knowledge independently. Destini et al. (2025) found that Discovery Learning significantly improved students' mathematical problem-solving abilities, and Trisnani et al. (2025) reported that it improved conceptual understanding of three-dimensional geometry. A meta-analysis of 164 studies found that guided or enhanced discovery, with feedback, worked examples or scaffolding, outperformed other forms of instruction, whereas unassisted discovery did not (Alfieri et al., 2011). However, studies integrating Discovery Learning with virtual geoboards in teaching the area of quadrilaterals remain scarce. Most previous research has examined the learning model or the instructional media separately, so it is unclear how far their integration improves students' conceptual understanding.

These studies leave a gap. Research on geoboards has mostly used physical boards, studies of virtual geoboards have mostly developed media rather than tested their effect on learning, and Discovery Learning studies have usually measured achievement or problem solving rather than conceptual understanding of area. The two have rarely been combined and tested together in rural elementary schools with limited digital resources. This study therefore tests Discovery Learning assisted by a Virtual Geoboard against conventional instruction, using a pretest-posttest control group design in six rural schools.

LITERATURE REVIEW

This study is grounded in Jerome Bruner's constructivist theory, which posits that knowledge becomes more meaningful when learners discover it through exploration and inquiry (Rahmania et al., 2025). This theory underpins the implementation of the Discovery Learning model, which encourages students to identify problems, collect and process information, verify findings, and draw conclusions independently. In addition, Jean Piaget's cognitive development theory explains that elementary school students are in the concrete operational stage, during which they learn more effectively through hands-on activities and visual representations. For these reasons, the Virtual Geoboard is an appropriate medium for helping students explore two-dimensional shapes, visualize relationships among geometric elements, and develop a more concrete understanding of area concepts.

This research identifies Discovery Learning assisted by Virtual Geoboard as the independent variable and students' conceptual understanding of quadrilateral area as the dependent variable. The study hypothesizes that this instructional model has a positive and significant effect on students' conceptual understanding.

Research Objectives

This study examined the effectiveness of the Discovery Learning model assisted by Virtual Geoboard media in improving elementary school students' understanding of quadrilateral area concepts in Kebonagung District, Demak Regency. Specifically, the study aimed to analyze the differences in students' conceptual understanding between those who learned through the Discovery Learning model assisted by Virtual Geoboard and those who received conventional instruction. It also sought to determine whether the average conceptual understanding achieved by students taught using the Discovery Learning model assisted by Virtual Geoboard exceeded the Minimum Learning Achievement Criteria (KKTP) of 70, to measure the improvement in students' conceptual understanding through the N-Gain score, and to examine students' responses toward the implementation of the Discovery Learning model assisted by Virtual Geoboard.

RESEARCH METHOD

Research Design

This study employed a quantitative quasi-experimental design using a pretest–posttest control group design. The experimental group was taught using the Discovery Learning model assisted by a Virtual Geoboard, while the control group received conventional instruction. Students completed a pretest before the intervention and a posttest afterward to measure changes in their conceptual understanding of quadrilateral area. Learning improvement was evaluated using N-Gain, achievement against the Minimum Learning Achievement Criteria (KKTP), and students' responses to the instructional model (Abraham & Supriyati, 2022).

Respondents of the Study

The population consisted of 546 fifth-grade students from elementary schools in Kebonagung District, Demak Regency, during the 2025/2026 academic year. Using cluster sampling, 132 students from six elementary schools in the Pattimura Cluster were selected. Three schools were assigned to the experimental group, and three schools served as the control group. Schools were selected based on comparable characteristics, willingness to participate, and feasibility of implementing the intervention. Ethical and administrative approval was obtained from the relevant authorities and participating school principals.

Table 1. Distribution of research samples

Group	School Names	Number of Students
Experimental	SD Negeri Mangunrejo 1	18
	SD Negeri Sokokidul	24
	SD Negeri Werdoyo	24
Control	SD Negeri Paseban	23
	SD Negeri Mangunrejo 2	20
	SD Negeri Mangunrejo 3	23
Total	**6 schools**	**132**

Research Instruments

The study employed both test and non-test instruments. The test instrument consisted of essay questions designed to measure students' conceptual understanding of quadrilateral area. The non-test instruments included an observation checklist to assess students' learning activities and a questionnaire to evaluate their responses to the Discovery Learning model assisted by the Virtual Geoboard. All instruments were validated by experts and tested for reliability before data collection (Agustinaningsih & Nurjanah, 2025).

Data Collection Procedure

Data collection began with a pretest administered to both the experimental and control groups. The experimental group was then taught with Discovery Learning assisted by a Virtual Geoboard, while the control group received conventional instruction. After the intervention, both groups completed a posttest. Students' learning activities were observed throughout the instructional process, and a questionnaire was administered to gather their perceptions of the learning model.

Data Analysis

Data were analyzed using descriptive and inferential statistics. Descriptive statistics included the mean, standard deviation, minimum, and maximum scores. Data normality and homogeneity were assessed using the Shapiro–Wilk and Levene's tests, respectively. Hypothesis testing was conducted using an Independent Samples t-test to compare the two groups, a One-Sample t-test to determine whether the mean score met the Minimum Learning Achievement Criteria (KKTP = 70), and N-Gain analysis (Hake, 1998) to measure learning improvement. Students' questionnaire responses were analyzed descriptively using percentage scores (Afif et al., 2024).

RESULTS

Before the study was conducted, all research instruments were validated by three experts to check their content validity, construct validity, language clarity, and suitability for the study. The validation results for the lesson module, student response questionnaire, and conceptual understanding test are presented in Table 2.

Table 2. Expert validation results

Instrument	Validator I	Validator II	Validator III	Mean (%)	Category
Lesson Module	88.0	83.7	83.8	85.2	Highly Valid
Student Response Questionnaire	76.4	83.3	72.0	77.2	Valid
Conceptual Understanding Test	80.0	85.0	78.3	81.1	Highly Valid

The validation results indicate that all research instruments met the required standards for use in the study. Both the lesson module and the conceptual understanding test were classified as highly valid, while the student response questionnaire was categorized as valid. The instruments were therefore considered appropriate for measuring the intended research variables.

Table 3. Descriptive statistics

Statistic	Experimental (Pretest)	Experimental (Posttest)	Control (Pretest)	Control (Posttest)
N	66	66	66	66
Minimum	21.88	65.63	25.00	25.00
Maximum	68.75	100.00	65.63	62.50
Mean	46.7826	85.0874	45.7885	45.3147
Std. Deviation	10.68536	8.36334	9.18054	9.20902
Variance	114.177	69.945	84.282	84.806

The descriptive analysis shows that both groups had comparable initial abilities, with pretest means of 46.78 and 45.79 (Table 3). After the intervention, the experimental group improved considerably more than the control group. The experimental group's scores also became more consistent (a smaller standard deviation), which is consistent with improved conceptual understanding after Discovery Learning assisted by the Virtual Geoboard.

Table 4. Normality test results

	Group	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Pre_Test	Experimental	.103	66	.082	.980	66	.376
	Control	.108	66	.054	.979	66	.328
Post_Test	Experimental	.103	66	.081	.971	66	.126
	Control	.098	66	.193	.972	66	.142

Note. a. Lilliefors significance correction.

The normality test results indicate that all datasets satisfied the assumption of normality. Therefore, the data from both the experimental and control groups were appropriate for further analysis using parametric statistical tests.

Table 5. Homogeneity of variance test results

	Levene Statistic	df1	df2	Sig.
Pre_Test	1.590	1	130	.210
Post_Test	1.128	1	130	.290

The results show that the variances of the two groups were homogeneous ($p > 0.05$). The homogeneity assumption for comparing group means with parametric tests was therefore met.

Table 6. Independent samples t-test results

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Post_Test	Equal variances assumed	1.128	.290	25.974	130	.000	39.77273	1.53125	36.74334	42.80212
	Equal variances not assumed			25.974	128.812	.000	39.77273	1.53125	36.74307	42.80238

The results revealed a statistically significant difference between the two groups ($t = 25.974$, $df = 130$, $p < 0.001$; Table 6). The experimental group's posttest mean was significantly higher, indicating that Discovery Learning assisted by the Virtual Geoboard was more effective than conventional instruction in improving students' conceptual understanding of quadrilateral area.

Table 7. One-sample t-test results

	N	Mean	Std. Deviation	Std. Error Mean	KKTP	Interpretation
Posttest_Eksperimen	66	85.0874	8.36334	1.02946	70	Exceeded KKTP

The results indicate that the students' mean posttest score exceeded the school's Minimum Learning Achievement Criteria (KKTP = 70). This finding indicates that students taught with Discovery Learning assisted by the Virtual Geoboard reached and exceeded the expected level of conceptual understanding.

Table 8. N-Gain results for conceptual understanding

Variable	N	Min	Max	Mean	SD	Category
Experimental N-Gain	66	0.38	1.00	0.7152	0.1458	High
Control N-Gain	66	-0.06	0.08	0.0064	0.0217	Low
Experimental N-Gain (%)	66	37.50	100.00	71.50	14.62	Effective
Control N-Gain (%)	66	-5.56	7.69	0.64	2.14	Ineffective

The findings show that the experimental group achieved a high level of learning improvement, whereas the control group showed a negligible increase. These results indicate that Discovery Learning assisted by the Virtual Geoboard was more effective than conventional instruction in improving students' conceptual understanding of quadrilateral area.

Table 9. N-Gain by test item

Rank	Item	Mean N-Gain	Category
1	S8	0.66	Moderate (Most Difficult)
2	S7	0.82	High
3	S2	1.09	Very High
4	S1	1.22	Very High
5	S3	1.23	Very High
6	S6	1.30	Very High
7	S4	1.39	Very High
8	S5	1.39	Very High

The item-level analysis indicates that students' learning gains varied across the conceptual indicators. Item S8 showed the lowest improvement, suggesting that it represented the most challenging concept. The other items showed higher gains (Table 9).

Table 10. Descriptive statistics of the student response questionnaire

Item	N	Minimum	Maximum	Mean
P1	66	2	4	3.41
P2	66	2	4	3.44
P3	66	2	4	3.44
P4	66	2	4	3.41
P5	66	3	4	3.44
P6	66	2	4	3.41
P7	66	2	4	3.41
P8	66	3	4	3.55
P9	66	2	4	3.47
P10	66	2	4	3.47
Total Score	**66**	**26**	**40**	**34.44**
Achievement Percentage	**66**	**65.00**	**100.00**	**86.09**

The questionnaire results indicate that most students responded positively to the learning process. They reported that the Virtual Geoboard helped them better understand the concept of quadrilateral area, increased their engagement during lessons, and made learning more interesting and easier to follow. These responses are consistent with the test results and suggest that students found the combination of Discovery Learning and the Virtual Geoboard meaningful and engaging.

DISCUSSION

Differences in Conceptual Understanding of Quadrilateral Area Between Discovery Learning Assisted by Virtual Geoboard and Conventional Instruction

The findings revealed a significant difference in students' conceptual understanding of quadrilateral area between those taught using Discovery Learning assisted by the Virtual Geoboard and those receiving conventional instruction. The Independent Samples t-test showed a statistically significant difference between the two groups ($t = 25.974$, $df = 130$, $p < 0.001$; Table 6), with posttest means of 85.09 and 45.31 (Table 3). The experimental group also achieved a higher mean posttest score than the control group, which indicates that Discovery Learning assisted by the Virtual Geoboard was more effective in improving students' conceptual understanding. Conventional teacher-centered instruction, in contrast, may have encouraged students to memorize formulas without understanding how the concepts were developed, which leads mainly to procedural knowledge.

The size of this difference needs careful interpretation. The control group's mean hardly changed between pretest (45.79) and posttest (45.31), so its N-Gain was close to zero (0.0064; Table 8). A unit of conventional teaching usually produces some gain, so this flat result may reflect how the control lessons were taught or how closely the test matched them, and it inflates the between-group difference. The similar pretest means (46.78 and 45.79) reduce, but do not remove, concern about initial differences between schools that were not randomly assigned (Shadish et al., 2002).

These findings are consistent with Jerome Bruner's constructivist theory, which emphasizes that knowledge is actively constructed through learning experiences (Hatip & Setiawan, 2021). Through the stages of Discovery Learning, students observed, explored, collected data, verified findings, and drew conclusions independently, allowing concepts to be acquired through the process of discovery. The Virtual Geoboard also supports Bruner's three modes of representation (enactive, iconic, and symbolic): students manipulate geometric shapes, visualize changes in area, and finally formulate mathematical rules symbolically. This progression from concrete experience to abstract reasoning is likely to support deeper conceptual understanding.

The Virtual Geoboard enabled students to construct different quadrilateral shapes, calculate unit areas, compare geometric figures, and explore the relationships among length, width, and area through hands-on investigation. These activities made abstract area concepts concrete and helped students understand the reasoning behind the formulas, not only the formulas themselves. This is in line with Sudarmanto et al. (2021), who describe exploratory, student-centred learning models, and with Astriani and Andini (2025), who found that virtual geoboard-based media improved elementary students' spatial thinking.

The present findings also support previous studies by Wulandari (2025), who reported that Discovery Learning improves mathematics achievement, and Yoyana and Supriansyah (2025), who found that the use of Geoboards positively influences geometry learning. The novelty of this study lies in integrating Discovery Learning with a digital Virtual Geoboard to improve elementary students' conceptual understanding of quadrilateral area. The study was also conducted in six rural elementary schools, whereas Wulandari (2025), for example, worked in an urban school in Surabaya. The result also fits meta-analytic evidence: guided discovery outperformed other instruction while unassisted discovery did not (Alfieri et al., 2011), and in this study the Virtual Geoboard tasks and the Discovery Learning stages supplied that guidance.

Achievement of Students' Mean Conceptual Understanding Relative to the Minimum Learning Achievement Criteria (KKTP)

The findings indicate that the mean score for students' conceptual understanding of quadrilateral area in the experimental group exceeded the school's Minimum Learning Achievement Criteria (KKTP), with a mean of 85.09 against the criterion of 70 (Table 7). The One-Sample t-test yielded a significance value below 0.05, indicating that the students' average achievement was significantly higher than the required benchmark.

This achievement suggests that students developed a conceptual understanding of quadrilateral area rather than merely memorizing formulas. The test results suggest that they could explain the relationships among length, width, and area and solve contextual problems. Through the stages of Discovery Learning, students independently discovered the concept of area by engaging in exploration, observation, verification, and conclusion drawing with the support of the Virtual Geoboard.

The results are consistent with previous studies. Shaffitri et al. (2022) and Difallah et al. (2024) reported that Discovery Learning supported by GeoGebra-based media improves students' mathematical conceptual understanding. Likewise, Azizah et al. (2024) found that the use of Geoboards increased students' mastery of geometry topics, while the systematic literature review by Zahra and Sudihartinih (2025) concluded that integrating Discovery Learning with digital learning media creates more interactive, exploratory, and meaningful learning experiences.

Improvement in Students' Conceptual Understanding Based on N-Gain Analysis

The findings indicate that Discovery Learning assisted by the Virtual Geoboard produced greater improvement in students' conceptual understanding of quadrilateral area than conventional instruction. The N-Gain analysis showed that the experimental group achieved a high improvement category (0.7152), whereas the control group remained in the low category (0.0064) and was classified as ineffective.

An N-Gain of 0.7152 lies just above the 0.7 threshold of the high category defined by Hake (1998), whose interactive-engagement courses averaged 0.48. Maemunah et al. (2025) and Shaffitri et al. (2022) likewise reported better conceptual understanding when Discovery Learning was supported by GeoGebra, and Muryaningrum et al. (2026) reviewed empirical studies from 2020 to 2025 on Discovery Learning and conceptual understanding in elementary mathematics. Interactive multimedia showed its largest effect at elementary level in a meta-analysis of 15 Indonesian experimental studies (Khaeruman et al., 2023). The lowest item gain was on item S8 (0.66; Table 9), the concept teachers may need to revisit.

Students' Responses to the Implementation of Discovery Learning Assisted by the Virtual Geoboard

Students' responses to Discovery Learning assisted by the Virtual Geoboard were highly positive (achievement percentage 86.09%; Table 10), and most students evaluated the learning process favorably. All questionnaire indicators received high scores, suggesting that students found the lessons more engaging, interactive, and helpful in understanding the concept of quadrilateral area.

The present findings are consistent with previous studies by (Maemunah et al., 2025; Nopita, Susanto, & Koto, 2022; Yoyana & Supriansyah, 2025), which reported that interactive digital media such as GeoGebra and Virtual Geoboard enhance students' engagement, motivation, and positive attitudes toward mathematics learning. Technology in mathematics instruction lets students learn through exploration and visualization, which makes abstract concepts easier to understand.

For teachers in the Pattimura cluster, the results suggest teaching area first as the number of unit squares that cover a shape on the Virtual Geoboard, and introducing the formula only after students have found the pattern themselves. Schools need enough devices for group work; where these are limited, a physical geoboard can support the same activities (Limalo & Ismail, 2025).

Several limitations apply. Schools were selected for willingness and feasibility rather than at random, and each condition was taught by different teachers, so school and teacher effects cannot be separated from the

treatment. The control group's lack of any gain is unexplained. Six item-level N-Gain values in Table 9 exceed 1.00 and need to be recomputed, the One-Sample t-test statistic is not reported in Table 7, and the observation checklist results are not reported. The questionnaire was self-reported and given only to the experimental group. Future studies should assign classes randomly where possible, report effect sizes, include a delayed posttest, and test the approach with other geometry topics.

CONCLUSION AND RECOMMENDATIONS

Discovery Learning assisted by the Virtual Geoboard was effective in improving elementary school students' conceptual understanding of quadrilateral area in Kebonagung District, Demak Regency. The instructional model produced significantly better conceptual understanding than conventional instruction, enabled students' mean achievement to exceed the Minimum Learning Achievement Criteria (KKTP), and resulted in high learning gains based on the N-Gain analysis. Students also responded very positively: they reported that the Virtual Geoboard made learning more engaging and interactive and encouraged them to discover mathematical concepts independently.

Based on these findings, teachers and schools are encouraged to adopt Discovery Learning assisted by the Virtual Geoboard as an alternative approach to mathematics instruction, particularly for geometry topics. Implementation requires adequate technological facilities and professional development for teachers in the use of digital learning media. Future research is recommended to investigate the effectiveness of this instructional approach in other mathematics topics and educational levels, as well as to examine additional outcomes such as critical thinking, creativity, learning motivation, and numeracy literacy with larger and more diverse samples to improve generalizability.

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REFERENCES

Abraham, I., & Supriyati, Y. (2022). Desain Kuasi Eksperimen Dalam Pendidikan: Literatur Review (Quasi-Experimental Design in Education: A Literature Review). *Jurnal Ilmiah Mandala Education*, *8*(3), 2476–2482. https://doi.org/10.58258/jime.v8i3.3800

Afif, Z., Azhari, D. S., Kustati, M., & Sepriyani, N. (2024). Penelitian Ilmiah (Kuantitatif) Beserta Paradigma, Pendekatan, Asumsi Dasar, Karakteristik, Metode Analisis Data Dan Outputnya (Quantitative Scientific Research: Paradigms, Approaches, Fundamental Assumptions, Characteristics, Data Analysis Methods, and Research Outputs). *INNOVATIVE: Journal Of Social Science Research*, *3*(3), 628–693.

Agustinaningsih, W., & Nurjanah, A. (2025). Pengembangan dan Uji Validitas Serta Reliabilitas Instrumen Angket Kemampuan Sosiosaintifik Pada Evaluasi Pembelajaran Fisika (Development, Validity, and Reliability Testing of a Socioscientific Ability Questionnaire for Physics Learning Evaluation). *KUANTUM: Jurnal Pembelajaran Dan Sains Fisika*, *6*(2), 308–317. https://doi.org/10.63976/kuantum.v6i2.1186

Alfieri, L., Brooks, P. J., Aldrich, N. J., & Tenenbaum, H. R. (2011). Does discovery-based instruction enhance learning? *Journal of Educational Psychology*, *103*(1), 1–18. https://doi.org/10.1037/a0021017

Amaliyah, A., Uyun, N., Fitri, R. D., & Rahmawati, S. (2022). Analisis Kesulitan Belajar Siswa Pada Materi Geometri (Analysis of Students' Learning Difficulties with Geometry Topics). *Journal of Social & Technology/Jurnal Sosial Dan Teknologi (SOSTECH)*, *2*(7).

Astriani, L., & Andini, N. M. (2025). The Impact Of Virtual Geoboard-Based Learning Media On Elementary School Students' Spatial Thinking. *Kalamatika*: *Jurnal Pendidikan Matematika*, *10*(1), 31–46. https://doi.org/*10*.22236/KALAMATIKA.vol*10*no1.2025pp31-46

Azizah, F. N., Trisnani, N., & Wardhani, R. S. (2024). Peningkatan Pemahaman Konsep Pembelajaran Matematika Materi Bangun Datar Melalui Media Geoboard (Improving Students' Conceptual Understanding of Plane Geometry through Geoboard Media). *DIKDASTIKA: Jurnal Ilmiah Pendidikan Ke-SD-An*, *10*(1).

Destini, F., Hermawan, J. S., & Khairani, F. (2025). Pengaruh Model Discovery Learning Berbantuan Media Stamp Game Terhadap Kemampuan Pemecahan Masalah Matematika (The Effect of the Discovery Learning Model Assisted by Stamp Game Media on Students' Mathematical Problem-Solving Skills). *Didaktika Dwija Indria*, *13*(3), 417–427.

Difallah, N., Sunarso, A., & Isdaryanti, B. (2024). Efektivitas Model Pembelajaran Discovery Learning Berbantuan Mebada Berbasis Geogebra Tehadap Kemampuan Pemahaman Konsep Matematis Siswa Kelas V Sekola Dasar (The Effectiveness of the GeoGebra-Based Mebada-Assisted Discovery Learning Model on Fifth-Grade Elementary School Students' Mathematical Conceptual Understanding). *Pendas: Jurnal Ilmiah Pendidikan Dasar*, *9*(04), 223–231.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, *66*(1), 64–74. https://doi.org/10.1119/1.18809

Hatip, A., & Setiawan, W. (2021). Teori kognitif bruner dalam pembelajaran matematika (Bruner's cognitive theory in mathematics learning). *PHI: Jurnal Pendidikan Matematika*, *5*(2), 87–97.

Hayati, M., & Jannah, M. (2024). Pentingnya kemampuan literasi matematika dalam pembelajaran matematika (The Importance of Mathematical Literacy Skills in Mathematics Learning). *Griya Journal of Mathematics Education and Application*, *4*(1), 40–54. https://doi.org/10.29303/griya.v4i1.416

Hikmayani, J., Tahir, M., & Rosyidah, A. N. K. (2023). Analisis Kemampuan Pemahaman Konsep Geometri Siswa Kelas IV Menurut Teori Van Hiele di SDN 06 Cakranegara (An Analysis of Fourth-Grade Students' Conceptual Understanding of Geometry Based on Van Hiele Theory at SDN 06 Cakranegara). *Jurnal Ilmiah Profesi Pendidikan*, *8*(1), 133–141. https://doi.org/10.29303/jipp.v8i1.1111

Khaeruman, K., Sudiatmika, A. R., Suma, I. K., & Suardana, I. N. (2023). Meta-analisis: Efektivitas multimedia interaktif terhadap peningkatkan hasil belajar siswa. *Bioscientist: Jurnal Ilmiah Biologi*, *11*(2), 1630–1639. https://doi.org/10.33394/bioscientist.v11i2.9497

Limalo, S. A., & Ismail, R. (2025). Pengaruh Geoboard Terhadap Hasil Belajar Matematika Siswa Pada Materi Segi Empat (The Effect of Geoboard on Students' Mathematics Learning Outcomes in Quadrilateral Geometry). *Jurnal Pendidikan Dan Kebudayaan (Jurdikbud)*, *5*(2), 451–458. https://doi.org/10.55606/jurdikbud.v5i2.7388

Maemunah, S., Fitriani, N., & Nurfauziah, P. (2025). Meningkatkan pemahaman konsep matematis melalui discovery learning berbantuan Geogebra (Improving Students' Mathematical Conceptual Understanding through Discovery Learning Assisted by GeoGebra). *JPMI (Jurnal Pembelajaran Matematika Inovatif)*, *8*(6), 761–776.

Meyvita, I., & Azizah, A. N. (2024). Analisis Kesulitan Pembelajaran Geometri Kelas 4 Sd Serta Peran Geogebra Dalam Menanggulangi Kesulitan Siswa (Analysis of Geometry Learning Difficulties Among 4th-Grade Elementary Students and the Role of GeoGebra in Addressing Student Difficulties). *Didaktik: Jurnal Ilmiah PGSD STKIP Subang*, *10*(04), 239–249.

Moyer-Packenham, P. S., & Westenskow, A. (2016). Revisiting the effects and affordances of virtual manipulatives for mathematics learning. In K. Terry & A. Cheney (Eds.), *Utilizing virtual and personal learning environments for optimal learning* (pp. 186–215). IGI Global. https://doi.org/10.4018/978-1-4666-8847-6.ch009

Muis, N. R. M., Saleh, S. F., & Hadaming, H. (2024). Efektivitas penggunaan media geoboard dalam pembelajaran joyful learning untuk materi bangun datar di kelas III SD Muhammadiyah Mimbar (The effectiveness of using geoboards in a "joyful learning" approach for the topic of 2D shapes in Grade 3 at SD Muhammadiyah Mimbar). *Jurnal Riset Evaluasi Pendidikan*, *1*(3), 172–181.

Muryaningrum, S., Wabiser, Y. D., Amsad, L. N., & Efendi, R. (2026). Discovery Learning dan pemahaman konseptual matematika di sekolah dasar (Discovery learning and conceptual understanding of mathematics in elementary school) : Systematic review bukti empiris 2020–2025. Pendas: Jurnal Ilmiah Pendidikan Dasar, 11(01), 410–419. https://doi.org/10.23969/jp.v11i01.38665

Nopita, M., Susanto, A., & Koto, I. (2022). Pengembangan Lembar Kerja Peserta Didik (LKPD) Berbasis Discovery Learning Berbantuan Geogebra Pada Geometri Kelas IV SD (Development of Discovery Learning-Based Student Worksheets Assisted by GeoGebra for Fourth-Grade Elementary School Geometry). *Jurnal Kajian Pendidikan Dasar*, *1*(2), 206–214. https://doi.org/10.33369/kapedas.v1i2.23286

Radiusman. (2020). Studi Literasi: Pemahaman Konsep Siswa pada Pembelajaran matematika (Students' Conceptual Understanding in Mathematics Learning). *FIBONACCI: Journal of Mathematics and Mathematics Education*, *6*(1), 1.

Rahmania, C. A., Shalsabilla, F. N., Aprilia, G., Syahira, K. K., Alfiyyah, R. A., & Putri, H. E. (2025). Analisis Teori Belajar Bruner Untuk Membantu Peserta Didik Dalam Pembelajaran Matematika (An Analysis of Bruner's Learning Theory to Support Students in Mathematics Learning). *De Fermat : Jurnal Pendidikan Matematika*, *8*(1), 10–21. https://doi.org/10.36277/defermat.v8i1.2254

Rizqi, U. B. N. (2024). Penerapan Teori Van Hiele dalam Meningkatkan Kemampuan Pemahaman Konsep Geometri (The Application of Van Hiele Theory to Improve Students' Conceptual Understanding of Geometry): Systematic Literatur

Review. *SANTIKA: Seminar Nasional Tadris Matematika*, *4*, 79–91.

Rohmah, M., Hilyana, F. S., & Ermawati, D. (2024). Kemampuan Pemahaman Konsep Matematis Siswa Kelas V Materi Pecahan (Fifth-Grade Students' Mathematical Conceptual Understanding of Fractions). *Al-Madrasah: Jurnal Ilmiah Pendidikan Madrasah Ibtidaiyah*, *8*(2), 708–718.

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Houghton Mifflin.

Shaffitri, N., Alfra, S., & Astuty Yensy, N. (2022). Efektivitas penggunaan lkpd discovery learning berbantuan Geogebra terhadap kemampuan pemahaman konsep bangun ruang sisi datar (The Effectiveness of Discovery Learning Worksheets Assisted by GeoGebra in Enhancing Students' Conceptual Understanding of Polyhedra). *Jurnal Penelitian Pembelajaran Matematika Sekolah*, *6*(3), 351–361.

Sudarmanto, E., Mayratih, S., Kurniawan, A., Abdillah, L. A., Martriwati, M., Siregar, T., … Nugroho, A. G. (2021). *Model Pembelajaran Era Society 5.0* (Learning Models for the Society 5.0). (Vol. 1). Penerbit Insania.

Trisnani, N., Sugiyanta, G., & Murti, A. K. (2025). Meningkatkan Pemahaman Konsep Materi Bangun Ruang Melalui Model Discovery Learning (Improving Students' Conceptual Understanding of Three-Dimensional Geometry through the Discovery Learning Model). *Journal of* Elementary *School Education*, *5*(1), 508–522.

Wulandari, S. (2025). Penerapan Model Discovery Learning Berbantuan Geoboard Untuk Meningkatkan Hasil Belajar Matematika Siswa Kelas V SDN Putat Jaya IV/380 Surabaya (The Implementation of the Discovery Learning Model Assisted by Geoboard to Improve Mathematics Learning Outcomes of Fifth-Grade Students at SDN Putat Jaya IV/380 Surabaya). *Journal of Mathematics Education Research*, *4*(1).

Yoyana, S., & Supriansyah, S. (2025). Pengaruh Penggunaan Media Geoboard terhadap Hasil Belajar Matematika Siswa pada Materi Bangun Datar (The Effect of Using Geoboard Media on Students' Mathematics Learning Outcomes in Plane Geometry). *Jurnal Pendidikan Matematika Dan Sains*, *13*(2), 360–368.

Zahra, G. T., & Sudihartinih, E. (2025). Systematic Literature Review: Students' Conceptual Understanding Through Discovery Learning Assisted by GeoGebra. *Universal Education Journal of Teaching and Learning*, *2*(2), 86–96.

ICISFS-UMK 2026 EDUCATIONAL TECHNOLOGY & MEDIA

Interactive Web-Based OPHICAM Media for Improving Elementary Math Skills

Ronal Raharjo[1*], Nur Fajrie[1] and Eka Zuliana[1]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: ronalraharjo5@gmail.com

ABSTRACT

This study aims to develop a web-based interactive learning medium called OPHICAM (Mixed Arithmetic Operations) to improve fourth-grade elementary students' learning outcomes in Grobogan Regency. The study was motivated by students' low conceptual understanding of mixed arithmetic operations, the limited availability of interactive learning media, and low learning outcomes: average daily test scores were 60 out of 100, below the minimum criteria. A research and development (R&D) approach was used, based on a simplified Borg and Gall model with eight stages: preliminary research, planning, initial product development, initial field testing, main product revision, main field testing, final product revision, and dissemination and implementation. The study involved 60 fourth-grade students from six elementary schools in Grobogan Regency. Data collection instruments included needs questionnaires, expert validation questionnaires, student and teacher response questionnaires, observation sheets, interview guidelines, and learning outcome tests (pretest and posttest). Validity and practicality were analysed with descriptive statistics, and effectiveness with paired t-tests and N-Gain scores. OPHICAM met the validity criteria, with Aiken Index values of 0.83-0.85, and showed high practicality, with student and teacher response scores of 90-97.5% (excellent category). Mean scores rose from 58.2 (pretest) to 78.5 (posttest), a statistically significant difference ($p < 0.001$), with an average N-Gain of 0.71 (high category). OPHICAM therefore appears to be a useful medium for teaching mixed arithmetic operations, although the single-group design limits causal conclusions.

KEYWORDS OPHICAM | digital learning media | mixed arithmetic operations

INTRODUCTION

Information and communication technology (ICT) offers new ways to improve teaching and learning in primary education. The integration of technology in the classroom enables more personal, adaptive, and engaging learning experiences, especially through interactive media, which can increase students' motivation and conceptual understanding (Khaeruman et al., 2023; Zahro & Anjani, 2026). Even so, mathematics education in Indonesian elementary schools, including Grobogan Regency, faces persistent challenges. Elementary students often struggle with arithmetic operations: they misread word problems, carry out operations incorrectly, and ignore the hierarchy of operations in mixed calculations (Nengsih & Pujiastuti, 2021; Ugi, 2016).

The problem matters beyond single classrooms. In PISA 2022, Indonesian 15-year-olds again performed well below the OECD average in mathematics (OECD, 2023), and the basis for that performance, including correct and fluent operations with whole numbers, is laid in the elementary grades. In the schools that took part in this study, average daily test scores on mixed arithmetic operations were 60 out of 100, below the minimum mastery criterion.

The central problem addressed in this study is the limited conceptual understanding and poor learning outcomes in mixed arithmetic operations among Grade 4 students, made worse by the scarcity of interactive digital learning media. Existing media in many schools do not visualize abstract concepts concretely. This contributes to misconceptions, such as errors in the order of operations and in understanding story problems, and to low motivation and participation (Ugi, 2016; Yuliariatiningsih, 2016). There is also a gap between the ideals of student-centered learning advocated by the Merdeka Curriculum and the realities of classroom implementation, further complicated by disparities in technological infrastructure and teacher competencies (Afrillia & Dafit, 2025). These challenges point to the need for contextually relevant, interactive web-based media designed to support the mastery of mixed arithmetic operations at the primary school level.

Evidence on interactive media in Indonesian schools is encouraging but uneven. A meta-analysis of 15 Indonesian experimental studies found a large mean effect of interactive multimedia on learning outcomes (1.146), with the highest estimate at elementary level (Khaeruman et al., 2023), and a meta-analysis of 20 quasi-experiments reported a large effect (0.98) of interactive media on mathematical problem solving (Zahro & Anjani, 2026). Anggraeni et al. (2025) found a high N-gain in a fifth-grade class that used Smart Apps Creator media, compared with a moderate gain in a control class. Gamification adds motivation, but its effect on motivation is smallest among primary students (g = 0.309) (Kurnaz & Koçtürk, 2025). Web-based media developed for elementary classes, such as a Google Sites medium for grade 5 science, have often been evaluated for feasibility and user response only (Ratno et al., 2023).

Previous studies show that digital interactive media, particularly those incorporating animation, instant feedback, and gamification, can improve mathematical understanding and motivation (Sailer & Homner, 2020; Zahro & Anjani, 2026). However, most research and commercial tools such as Photomath or Khan Academy offer general mathematics support and are not tailored to mixed arithmetic operations aligned with Indonesian curricula or the local classroom context. Few studies have systematically developed and tested web-based learning media that combine a constructivist approach, contextual content, and adaptive features aimed specifically at the persistent difficulties encountered in basic mixed operations in lower-income or rural school settings.

This study therefore develops OPHICAM, a web-based interactive medium for mixed arithmetic operations in Grade 4, and asks three questions. Is OPHICAM valid according to content and media experts? Is it practical for students and teachers in Grobogan classrooms? Do students' scores on mixed arithmetic operations improve after learning with it? The answers give teachers in Grobogan a locally adapted medium that has been tried in their own schools, and they show developers which design features students and teachers valued and which caused difficulty.

This study introduces OPHICAM, a web-based interactive learning medium designed for Indonesian Grade 4 mathematics. OPHICAM combines constructivist strategies, interactive animations, local contextual story problems, and instant feedback. In this study, its use was associated with gains in students' mathematical understanding and with positive student and teacher responses. The study also adds a localized, curriculum-aligned resource and reports how usable it was in schools with two or three computers each. The development process may serve as a model for similar media in primary mathematics education in Indonesia and comparable settings.

LITERATURE REVIEW

The conceptual framework for OPHICAM draws on the literature review, learning theories, and the preliminary study. The framework is designed to address core challenges in the mastery of mixed arithmetic operations for Grade 4 elementary students, and it emphasizes digital interactivity, contextual content, and usability for teachers and students.

The framework is grounded in constructivist learning theory, which asserts that learners actively construct knowledge through meaningful interaction and engagement with concepts, rather than through passive reception (Noordin et al., 2011). In the context of mathematics, especially mixed arithmetic operations that involve hierarchical thinking (order of operations) and contextual problem-solving, students need both procedural proficiency and conceptual understanding, a goal that conventional methods often fail to reach (Ngatman et al., 2019; Nugroho et al., 2023).

To address this gap, the framework integrates five components:

1. Digital Interactive Media: OPHICAM is designed as a web-based platform that uses animation, instant feedback, and progressive learning modules to present abstract arithmetic concepts in concrete, accessible forms (Mayer, 2014; Moyer-Packenham & Westenskow, 2016).
2. Gamification and Motivation: The framework incorporates gamified elements such as points, levels, and visual rewards to increase student engagement and motivation, in line with evidence that such features

sustain attention and support positive attitudes to learning (Kurnaz & Koçtürk, 2025; Sailer & Homner, 2020).

3. Contextual and Localized Content: Problems and scenarios used in OPHICAM are tailored to students' real-life experiences and local settings, which keeps the content relevant and supports transfer of learning from the classroom to daily life (Jovanda et al., 2026; Sakinah et al., 2023).
4. Adaptive and Feedback-rich Learning: The framework provides adaptive feedback and differentiated practice opportunities, so that students can correct misconceptions (such as order of operations errors) and learn at their own pace (Praditya et al., 2023).
5. Teacher Facilitation and Ease of Use: Because teachers' digital competence is uneven (Afrillia & Dafit, 2025), and based on teacher feedback, OPHICAM offers clear navigation, user guides, and the flexibility to operate with minimal infrastructure, which makes it practical for diverse classrooms. The framework is operationalized through an iterative development model (Borg & Gall, 1983), in which each prototype is evaluated and revised on the basis of expert validation and field testing with students and teachers. The workflow involves:

1. Needs assessment (identifying student difficulties and teacher needs)
2. Product design (defining features and structure aligned with learning goals)
3. Prototype development (realizing core innovations: animations, gamification, feedback)
4. Classroom implementation (measuring practicality and effectiveness via observation, surveys, and learning outcomes)
5. Continuous improvement (addressing usability, accessibility, and contextual alignment as raised during field trials).

The framework links the design of OPHICAM to learning theory and to the local learning environment, with the aim of improving students' mastery of mixed arithmetic operations.

Research Objectives

The main objective of this study is to develop and evaluate the OPHICAM (Mixed Arithmetic Operations) interactive web-based learning media to improve fourth-grade students' competence in mixed arithmetic operations.

The specific objectives are as follows:

Objective 1: Validity Assessment

To assess the content validity and pedagogical soundness of OPHICAM through expert validation, examining content accuracy, curriculum alignment with the Indonesian Merdeka Curriculum, mathematical concept appropriateness for Grade 4 cognitive development, and technical functionality. Validity is quantified with the Aiken Index to check that the media is mathematically accurate and suitable for elementary learners.

Objective 2: Practicality Evaluation

To evaluate the practical usability and acceptability of OPHICAM within authentic classroom environments by assessing user experience, ease of navigation, teacher implementation feasibility, and integration compatibility with existing instructional practices. This objective examines whether teachers with different levels of technological competence can use the media in resource-constrained schools.

Objective 3: Effectiveness Measurement

To determine the effectiveness of OPHICAM in improving students' conceptual understanding, procedural fluency, and problem-solving capabilities in mixed arithmetic operations using a pretest-posttest design, measuring learning gains using normalized gain scores. This objective also examines whether the media addresses common misconceptions in this foundational topic.

Objective 4: Implementation and Scalability Analysis

To provide evidence-based recommendations for large-scale deployment, adaptation strategies for diverse educational contexts, and guidelines for sustainable integration of interactive web-based mathematics learning tools in elementary education systems. These recommendations are intended for policymakers, curriculum developers, and instructional designers.

By addressing these objectives, the study adds to research on educational technology in elementary mathematics and on how interactive digital media can support constructivist learning.

RESEARCH METHOD

Research Design

This study adopts a research and development (R&D) approach, adapting the Borg & Gall (1983) model, to develop, validate, and evaluate the OPHICAM interactive web-based learning media for mixed arithmetic operations in Grade 4 elementary students. The process has eight iterative stages that align product design, usability, and effectiveness with the identified classroom needs.

Stages of Research and Development

1. Needs Assessment

Initial identification of classroom challenges, teacher and student needs, and current limitations regarding instruction on mixed arithmetic operations. Data were collected through document analysis, interviews, observations, and preliminary surveys.

2. Planning

Specification of learning objectives, media requirements, conceptual framework, and development indicators, referencing both curriculum and empirical classroom data.

3. Initial Product Development

Design and creation of the OPHICAM prototype, focusing on content validity, interactivity, and technical accessibility (including offline compatibility and simple navigation).

4. Initial Field Testing (Pilot Test)

Small-scale implementation involving a limited group of students and teachers to assess initial practicality and gather formative feedback regarding usability, content appropriateness, and engagement.

5. Main Product Revision

Iterative improvements based on pilot test results, with revisions to content, technical features, and user support materials (such as guides).

6. Main Field Testing (Large-scale Trial)

Broader deployment in multiple schools with quantitative and qualitative evaluation, including pretest-posttest assessments, Likert-scale questionnaires for students and teachers, and direct classroom observation.

7. Final Product Revision

Integration of all field feedback to enhance content robustness, resolve usability issues, and add requested features (e.g., reporting dashboard, local context story problems).

8. Dissemination and Implementation

Product roll-out, workshops for teachers, and publication of results to facilitate replication and broader adoption.

Participants and Data Collection

Sample

The sample comprised 60 Grade 4 students and 6 mathematics teachers from selected elementary schools in Grobogan Regency.

Instruments

1. Needs assessment questionnaire
2. Validation forms for content and media experts
3. Pretest and posttest instruments
4. Student and teacher practical usability questionnaires
5. Observation sheets and semi-structured interview guides

Data Types

1. Quantitative: Test scores, questionnaire responses (Likert scale)
2. Qualitative: Observation notes, open-ended survey comments, interview transcripts

Data Analysis Techniques

Table 1. Data analysis techniques

Analysis Step	Approach
Validity Testing	Descriptive statistics, Aiken's V for agreement
Practicality Assessment	Frequency tables, percentage cut-offs (Arikunto)
Effectiveness Analysis	Paired sample t-tests, N-Gain calculation
Triangulation	Mixed-methods (source, technique, time)

Validity

Content and construct validity were assessed with expert ratings and summarized as Aiken's V coefficients for each aspect.

Practicality

Usability and acceptability were measured as percentages and categorized as "sangat baik" (very good), "baik" (good), and so on.

Effectiveness

Pretest and posttest analyzed using the N-Gain score:

$$N-Gain\ (\ g\ )\ =\ \frac{(\ XPost\ -\ XPre\ )}{(\ XMak\ Skor\ -\ XPre\ )}$$

Differences were tested for significance with paired sample t-tests.

Qualitative Data

Thematic analysis of observations and interviews, with triangulation across data sources, methods, and time-points to ensure validity.

RESULTS

The evaluation of OPHICAM for teaching mixed arithmetic operations to Grade 4 students produced positive results for validity, practicality, and effectiveness. The quantitative and qualitative results are reported below.

Quantitative Learning Outcomes

Students' mathematical performance improved from pretest to posttest. Initial assessment scores averaged 58.2 out of 100, with approximately 65% of students performing below the established minimum competency criteria (KKM) of 70. These baseline data are consistent with the preliminary findings of widespread difficulties in mixed arithmetic operations, particularly in understanding order of operations without parentheses.

After the OPHICAM intervention, the posttest average rose to 78.5, with 75% of students achieving or exceeding the KKM. The statistical analysis using paired sample t-test ($\alpha = 0.05$) yielded a p-value < 0.001, indicating a statistically significant difference between pre- and post-intervention performance.

The N-Gain analysis also supports OPHICAM's effectiveness. The overall N-Gain score of 0.71 falls into the "high effectiveness" category, with 70% of students achieving individual N-Gain scores ≥ 0.7.

Validation and Expert Assessment

Expert validation supported the pedagogical soundness and technical quality of OPHICAM. Content experts rated the media highly on completeness (3.6/4.0), accuracy (3.5/4.0), and cognitive appropriateness (3.4/4.0), with Aiken's V coefficients above 0.83 indicating high content validity. However, curriculum relevance scored 3.3/4.0, reflecting expert recommendations for greater contextualization within local Grobogan contexts.

Media experts similarly validated the technical aspects, rating visual appeal (3.7/4.0), interface usability (3.5/4.0), and language appropriateness (3.6/4.0) highly. Technical accessibility received a lower rating (3.3/4.0), which reflects infrastructure challenges and led to refinements including enhanced offline functionality and file size optimization.

Student Response and Engagement

Students responded positively to OPHICAM on all dimensions. Interest in animation and gamification elements scored highest (3.8/4.0), with 85% of students expressing strong positive attitudes. Interface usability (3.6/4.0) and immediate feedback benefits (3.7/4.0) also received favorable ratings, suggesting that the user-centered design objectives were met.

Ratings for conceptual understanding rose from 3.4/4.0 in the initial field test to 3.6/4.0, suggesting that the product refinements addressed early concerns about content accessibility for diverse learners. Observations indicated high student engagement, with 85% demonstrating active participation during interactive exercises.

Teacher Practicality Assessment

Teachers' evaluations of OPHICAM's educational value and practicality were generally positive. Visual appeal received the highest rating (3.7/4.0), with 100% of participating teachers rating this aspect favorably. Learning enhancement potential (3.5/4.0) and overall practicality (3.6/4.0) also received strong endorsements from 83% of respondents.

However, classroom implementation ease scored lower (3.3/4.0), with only 67% of teachers expressing confidence in independent implementation. This finding points to the need for teacher training and ongoing technical support, particularly in resource-constrained environments where technological infrastructure may be limited.

Addressing Learning Misconceptions

OPHICAM also appeared to help correct common misconceptions in mixed arithmetic operations. Post-intervention analysis showed that 80% of students solved contextual story problems that had previously caused substantial difficulty. The step-by-step animated demonstrations of the order of operations seemed especially helpful in addressing the common error of left-to-right calculation without regard for operation hierarchy.

The interactive feedback system helped students recognize and correct their own errors in real time, in line with the constructivist principles behind the design.

Infrastructure and Implementation Considerations

The study also identified challenges of technology integration in Indonesian elementary schools. While 90% of students expressed enthusiasm for digital learning approaches, implementation barriers included limited computer availability (2-3 units per school) and unstable internet connectivity affecting 10% of users at one participating school.

The iterative refinement addressed several technical constraints through file size optimization (reduced from 30MB to 25MB), enhanced offline functionality, and simplified user interfaces with tooltips and visual guides. These modifications are likely to be important for implementation in resource-limited settings.

DISCUSSION

Expert validation supported the content and design of OPHICAM, with Aiken's V values of 0.83 to 0.85 and most aspect ratings between 3.4 and 3.7 out of 4. Aiken's V summarises how far expert ratings sit above the lowest category, so it indicates content validity rather than learning value (Aiken, 1985). The two lowest ratings, curriculum relevance (3.3) and technical accessibility (3.3), matter most in Grobogan, where content must match local experience and devices are scarce. A similar pattern appears in other web-based media for elementary classes: Ratno et al. (2023) reported a full rating from the material expert but only 67.5% from the media expert for a Google Sites medium. The revisions made after validation, such as stronger offline functionality and local story problems, respond to these two weaknesses.

Students rated the animation and gamification elements highest (3.8 out of 4), and teachers rated visual appeal highest (3.7). Teachers were less sure about classroom use: implementation ease scored 3.3, and only 67% felt confident using the medium on their own. Two points from earlier research qualify the positive student response. Gamification has small positive effects on cognitive and motivational outcomes (Sailer & Homner, 2020), and its effect on motivation is smallest at primary level (Kurnaz & Koçtürk, 2025), so part of the enthusiasm observed here may be novelty. The teachers' lower confidence matches the uneven digital competence and underused ICT facilities reported for elementary teachers implementing the Merdeka Curriculum (Afrillia & Dafit, 2025).

Mean scores rose from 58.2 to 78.5 (paired t-test, $p < 0.001$), and 75% of students reached the KKM of 70 after the intervention, against about 65% below it before. The step-by-step animation of the order of operations and the immediate feedback target the error that Ugi (2016) found most common among Grade 4 students, working from left to right without regard to the hierarchy of operations. Multimedia learning theory predicts that combining words with dynamic pictures supports this kind of understanding (Mayer, 2014), and a meta-analysis of virtual manipulatives found a moderate positive effect on mathematics achievement (Moyer-Packenham & Westenskow, 2016). The size of the gain is in line with Indonesian meta-analyses of interactive media (Khaeruman et al., 2023; Zahro & Anjani, 2026). Unlike Anggraeni et al. (2025), however, this study had no control class, so the gain cannot be separated from the effect of a unit of instruction and repeated testing (Shadish et al., 2002). The reported mean N-Gain of 0.71 would fall in the high category of Hake (1998), but it is higher than the gain implied by the class means, so it should be read with caution until the calculation is clarified.

Infrastructure limited implementation. Each school had only two or three computers, and connectivity was unstable at one school. Mutmainnah et al. (2025) reported the same constraint, limited time and uneven technology access, when elementary teachers used simulations in mathematics lessons. Offline functionality and a smaller file size are therefore design requirements for schools like those in this study.

Students also solved contextual story problems more often after the intervention: 80% solved problems that had caused substantial difficulty before. Nengsih and Pujiastuti (2021) found that translating word problems into mathematical sentences was one of the main sources of difficulty with operations, so local story problems paired with feedback address a known weakness. A review of 47 Indonesian studies of local wisdom-based learning reported gains in conceptual understanding, but noted that most of the evidence came from development and short-term descriptive studies (Jovanda et al., 2026). The same caution applies here, because the story-problem result comes from one group without a comparison.

Implications for Educational Practice

The findings have three implications for educational technology integration in elementary mathematics instruction. First, the pretest-posttest gain suggests that interactive media may support learning in schools with limited infrastructure, although a controlled comparison is needed to confirm this. Second, iterative user feedback matters in product development: students' ratings of conceptual understanding improved after the refinements.

Third, teacher preparation appears to be a key factor. While the media itself received high usability ratings, classroom implementation confidence remained lower, which indicates that technology adoption should be accompanied by professional development. Principals and the district education office can support this with short

hands-on training, pairing less confident teachers with colleagues who have used the medium, and a timetable that rotates classes through the few available computers.

Limitations and Future Research Directions

The study has limitations. The study's focus on a specific geographic region (Grobogan Regency) may limit generalizability to other contexts with different infrastructure or cultural characteristics. The absence of a control group also limits causal inferences: the N-Gain scores show improvement, but they cannot separate the effect of OPHICAM from that of instruction in general. The paper reports many percentages and ratings without a results table, the sampling of schools and students is not described in detail, and practicality rests on self-report questionnaires. Classroom observation was brief, so novelty effects cannot be ruled out.

Future research should examine OPHICAM's effectiveness across diverse Indonesian regions, investigate long-term retention of learning gains, and explore applications to other mathematical topics. A quasi-experimental study with a control class, a delayed posttest and an effect size would give stronger evidence of the media's educational value.

CONCLUSION AND RECOMMENDATIONS

The evaluation indicates that OPHICAM, a web-based interactive medium, is promising for elementary mathematics education. The combination of strong learning outcomes (N-Gain = 0.71), positive user responses, and expert validation supports the media's educational value. While implementation challenges remain, particularly regarding teacher training and infrastructure constraints, the iterative development process produced a valid and practical tool, and students' understanding of mixed arithmetic operations improved after its use. These findings add to research on educational technology in developing-country contexts and offer a development model that others can adapt for elementary mathematics.

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REFERENCES

Afrillia, A., & Dafit, F. (2025). Tantangan guru mengimplementasikan pembelajaran berbasis teknologi digital dalam Kurikulum Merdeka di UPT SDN 023 Pandau Jaya. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 10*(4), 230–242. https://doi.org/10.23969/jp.v10i04.36163

Aiken, L. R. (1985). Three coefficients for analyzing the reliability and validity of ratings. *Educational and Psychological Measurement, 45*(1), 131–142. https://doi.org/10.1177/0013164485451012

Anggraeni, A., Erita, Y., Nora, D., & Rahmi, U. (2025). Development of Smart Apps Creator-based interactive learning media to support 21st century skills in Pancasila education for elementary schools. *Jurnal Kependidikan, 11*(2), 702–712. https://doi.org/10.33394/jk.v11i2.15136

Borg, W. R., & Gall, M. D. (1983). Educational research: An introduction (4th ed.). Longman.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics, 66*(1), 64–74. https://doi.org/10.1119/1.18809

Jovanda, R., Paais, R. L., Manafe, M. P., Sundari, L., Dewi, A. R., Ohodo, M. M. R., Chasanah, I. A. W., Pratama, A. H., & Waluyo, H. (2026). Local wisdom-based learning approaches for strengthening students' conceptual understanding and character in Indonesia: A systematic literature review [Version 1; peer review: 1 approved with reservations]. *F1000Research, 15*, Article 1384. https://doi.org/10.12688/f1000research.188148.1

Khaeruman, K., Sudiatmika, A. R., Suma, I. K., & Suardana, I. N. (2023). Meta-analisis: Efektivitas multimedia interaktif terhadap peningkatkan hasil belajar siswa. *Bioscientist: Jurnal Ilmiah Biologi*, *11*(2), 1630–1639. https://doi.org/10.33394/bioscientist.v11i2.9497

Kurnaz, M. F., & Koçtürk, N. (2025). A meta-analysis of gamification's impact on student motivation in K-12 education. *Psychology in the Schools*, *62*(12), 4997–5009. https://doi.org/10.1002/pits.70056

Mayer, R. E. (2014). Introduction to multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (2nd ed., pp. 1–24). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369.002

Moyer-Packenham, P. S., & Westenskow, A. (2016). Revisiting the effects and affordances of virtual manipulatives for mathematics learning. In K. Terry & A. Cheney (Eds.), *Utilizing virtual and personal learning environments for optimal learning* (pp. 186–215). IGI Global. https://doi.org/10.4018/978-1-4666-8847-6.ch009

Mutmainnah, N., Adrias, A., & Zulkarnaini, A. P. (2025). Implementasi pendekatan deep learning terhadap pembelajaran matematika di sekolah dasar. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 10*(1), 848–871. https://doi.org/10.23969/jp.v10i01.23781

Nengsih, G. A., & Pujiastuti, H. (2021). Analisis kesulitan dalam menyelesaikan soal materi operasi bilangan cacah siswa sekolah dasar. *JKPM (Jurnal Kajian Pendidikan Matematika), 6*(2), 293–306. https://doi.org/10.30998/jkpm.v6i2.9941

Noordin, M., Hamzah, M., & Ghazali, M. (2011). The effectiveness of constructivist approaches in learning mathematics. Journal of Mathematics and Science Education in Southeast Asia, 34(1), 85–101.

Nugroho, I. A., Purbasari, I., & Bakhruddin, A. (2023). Analisis pola kesulitan belajar matematika dalam menyelesaikan soal operasi hitung pecahan pada siswa sekolah dasar. Prismatika, 6(1), 20–33.

OECD. (2023). PISA 2022 results (Volume I): The state of learning and equity in education. OECD Publishing. https://doi.org/10.1787/53f23881-en

Praditya, K. Y., Santoso, S., & Lestari, N. (2023). The effect of digital-based learning media on student outcomes in mathematics. Jurnal Matematika dan Pendidikan Matematika, 15(1), 42–56.

Ratno, S., Sijabat, M. P., Sitorus, L., Salsabilla, S., Batubara, A., Nasution, N. A., & Syazidah, H. (2023). Pengembangan media pembelajaran berbasis web Google Sites pada pembelajaran IPA sekolah dasar materi sifat-sifat cahaya kelas V. *School Education Journal PGSD FIP UNIMED, 13*(4), 370–379. https://doi.org/10.24114/sejpgsd.v13i4.54851

Sailer, M., & Homner, L. (2020). The gamification of learning: A meta-analysis. *Educational Psychology Review, 32*(1), 77–112. https://doi.org/10.1007/s10648-019-09498-w

Sakinah, S., Dewi, R. S., & Hakim, Z. R. (2023). Development of contextual-based E-LKPD to improve the ability to understand fraction concepts. *EduBasic Journal: Jurnal Pendidikan Dasar, 5*(1), 71–82. https://doi.org/10.17509/ebj.v5i1.51576

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Houghton Mifflin.

Ugi, L. E. (2016). Analisis kesalahan siswa pada operasi hitung campuran bilangan bulat dan alternatif pemecahannya. *Daya Matematis: Jurnal Inovasi Pendidikan Matematika, 4*(1), 34–50. https://doi.org/10.26858/jds.v4i1.2450

Yuliariatiningsih, P. (2016). Pengaruh penggunaan media digital interaktif terhadap hasil belajar matematika siswa sekolah dasar. Jurnal Media Pembelajaran, 11(1), 35–44.

Zahro, M. I. A., & Anjani, R. (2026). A meta-analysis study: The effect of interactive learning media on students' mathematical problem-solving ability. *OMEGA: Jurnal Keilmuan Pendidikan Matematika*, *5*(2), 289–297. https://doi.org/10.47662/jkpm.v5i2.1309

ICISFS-UMK 2026 ASSESSMENT & EVALUATION

Design and Validation of a Numeracy Assessment Instrument Based on a 3-Dimensional Framework of Number Dimensions for Fourth-Grade Elementary School Students

Atika Dewi[1*], Sumaji[1] and Moch. Widjanarko[1]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: tikafox34@gmail.com

ABSTRACT

Numeracy skills are essential competencies that students need to understand, use, and communicate mathematical information in various real-life contexts. However, assessment instruments in elementary schools still mainly measure learning outcomes and give limited information about students' numeracy skills. This study aims to develop and validate a numeracy assessment instrument based on the 3-Dimensional Framework for number concepts for fourth-grade elementary school students. The Research and Development (R&D) method adapted Sugiyono's development model and covered four stages: needs analysis, instrument design, expert validation, and design revision. The needs analysis was conducted through interviews with seven elementary school teachers, while the instrument validation involved three experts: a numeracy expert, an assessment expert, and a language expert. The needs analysis indicated that teachers need an instrument capable of comprehensively identifying students' numeracy skills. In the expert validation, the instrument received an average score of 3.73, in the "valid" category. These findings indicate that the instrument has theoretical (content) validity for measuring elementary school students' numeracy skills more comprehensively. The study provides a numeracy assessment instrument that integrates aspects of mathematical knowledge, information literacy, and the complexity of students' understanding.

KEYWORDS 3-Dimensional Framework | assessment | numeracy | SOLO taxonomy

INTRODUCTION

Numeracy is an essential competence that should be developed from an early age, because it helps students meet the challenges of 21st-century life (Francisco et al., 2025). Numeracy involves more than calculation; it also includes the ability to use mathematical concepts, procedures, facts, and tools to solve problems in various everyday contexts (Ibrahim et al., 2026). Strengthening numeracy is therefore a main focus of efforts to improve elementary education.

Numeracy is a national concern in Indonesia. In PISA 2022, Indonesian 15-year-olds again performed well below the OECD average in mathematics (OECD, 2023), and numeracy is now assessed in elementary schools through the Asesmen Kompetensi Minimum (AKM) of the national assessment (Mustofa, 2022). Classroom studies point to the same weakness at the elementary level: in a case study of a fourth-grade student, only 17.65% of AKM-type numeracy items on geometry were solved correctly (Sari et al., 2021). Teachers therefore need classroom instruments that show not only whether students reach the expected level but also where their numeracy breaks down.

Improving students' numeracy requires learning supported by assessment that gives comprehensive information about students' learning status (Ramadhani et al., 2025). Assessment measures learning outcomes and also identifies students' learning needs, difficulties, and potential, which provides a basis for planning follow-up interventions (Levy-Feldman, 2025). Formative assessment is a goal-oriented process conducted continuously through the collection and analysis of student responses, feedback, and the application of assessment results in follow-up actions (Baartman & Gulikers, 2025). Through such assessment, teachers can choose follow-up strategies that make learning more effective and student-centered.

However, assessment in elementary schools still faces several challenges. Previous research indicates that teachers are not yet ready to understand and apply learning assessments (Warsihna et al., 2023). Assessments generally focus on final learning outcomes and give little information about the sources of students' learning difficulties (Rahmadani et al., 2025). Teachers' limited understanding of how to develop assessment instruments also limits the use of these instruments in teaching (Bhoke & Wea, 2025; Karumpa & Agus, 2025). Another challenge is the complexity of numeracy skills, which extend beyond mere mastery of mathematical content. Assessment instruments are therefore needed that measure numeracy more comprehensively, across the dimensions that make up numeracy competence.

One approach to developing a comprehensive numeracy assessment instrument is the 3-Dimensional Framework developed by Burgmanis et al. (2021). This framework consists of three main dimensions: content of mathematical knowledge, information literacy skills, and complexity of understanding. Integrating the three dimensions allows students' numeracy abilities to be identified more comprehensively.

The third dimension needs a way to grade the quality of students' thinking. The SOLO taxonomy (Biggs & Collis, 1982) has been used for this with elementary students in Indonesia. Fatikhah et al. (2024) analysed the responses of 12 fifth graders to mathematical problems and found that girls tended to reach the relational level and boys the multistructural level, which shows that SOLO levels can separate students who reach the same final answer by different routes. Sudaria and Sanchez (2024) built formative assessments around SOLO levels in science. These studies used open responses and interviews, however, so it is not yet clear how far a classroom test can capture SOLO levels in a numeracy context.

Various studies have developed numeracy instruments to measure students' abilities at the elementary school level (Astarina, 2022; Widia et al., 2024; Yusnia et al., 2024), but most of these instruments focus on mastery of mathematical content and do not fully integrate the dimensions of information literacy and complexity of understanding. Research on designing and validating numeracy instruments based on the 3-Dimensional Framework at the elementary level is also limited. Instruments that reveal several dimensions of numeracy are needed to support student-centered learning.

This study therefore describes the design and validation of a numeracy assessment instrument based on the 3-Dimensional Framework, in the number domain, for fourth-grade elementary school students. The instrument is intended to provide more comprehensive information about students' numeracy abilities and to support more precise instructional decisions. The study answers two questions. What do fourth-grade teachers need from a numeracy assessment instrument? Does an instrument built on this framework, with SOLO levels for the complexity dimension, have content validity according to experts in numeracy, assessment and language?

LITERATURE REVIEW

Numeracy

Numeracy is an individual's ability to use mathematical concepts, procedures, facts, and tools to solve problems encountered in various real-life contexts (Sumaji et al., 2023; Tsaqifah et al., 2024). Numeracy goes beyond calculation to include the ability to interpret information, analyze data, make decisions, and communicate one's reasoning logically (Danuri et al., 2025). In the context of elementary education, numeracy is a foundation for students to understand various phenomena involving quantitative representations and mathematical relationships (Arbain & Sirad, 2023).

Assessment

Assessment is a systematic process for collecting, processing, and interpreting information regarding students' learning achievements to support decision-making in learning (Ardiansyah et al., 2023; Munaroh, 2024). In education, assessment both measures learning outcomes and provides information for planning, implementing, and evaluating learning. It is therefore an integral part of the educational process.

In numeracy learning, assessment should reveal the thought processes students use to solve problems as well as their final learning outcomes. Assessment instruments must therefore be designed carefully to measure the

various aspects of competence that constitute the learning objectives. A good instrument must be valid, reliable, and capable of generating relevant information to support educational decision-making (Arta, 2024).

3-Dimensional Framework in Numeracy Assessment

The development of assessment instruments in this study is based on the 3-Dimensional Framework developed by Burgmanis et al. (2021). The framework measures numeracy through three interrelated dimensions.

The first dimension is Content of Mathematical Knowledge, which measures students' mastery of mathematical concepts, facts, and procedures. In this study, mathematical content focuses on number concepts, including number representation, properties of number sequences, and arithmetic operations. Number concepts are fundamental concepts that must be mastered in order to learn more complex concepts (Purwaningrum & Bintoro, 2018).

The second dimension is Information Literacy Skills, which measures students' ability to acquire, analyze, use, and communicate information presented in various forms. This dimension treats information literacy as an integral part of numeracy competence.

The third dimension is Complexity of Understanding and Application, which measures the level of complexity in students' understanding when solving numeracy problems. This dimension assesses whether answers are correct and also the quality of the thinking processes students use to understand and solve a problem. Together, the three dimensions allow numeracy to be measured more comprehensively than conventional assessments that focus only on mastery of subject matter.

The SOLO Taxonomy as the Basis for Measuring the Complexity of Understanding

To measure the complexity of understanding, this study uses the SOLO (Structure of Observed Learning Outcomes) Taxonomy developed by Biggs and Collis (1982). The SOLO Taxonomy classifies the quality of students' understanding into five levels: prestructural, unistructural, multistructural, relational, and extended abstract. Integrating the SOLO Taxonomy into the 3-Dimensional Framework allows the instrument to identify mastery of mathematical concepts and to reveal the depth of students' understanding in solving numeracy problems.

Research Objectives

This study aims to develop and validate a numeracy assessment instrument based on the 3-Dimensional Framework for fourth-grade elementary school students. Specifically, the study seeks to design a numeracy assessment instrument integrating the 3 dimensions, examine the content validity of the developed instrument through expert judgement, and produce a valid numeracy assessment instrument that can be used to assess elementary students' numeracy competencies comprehensively.

RESEARCH METHOD

Research Design

This study employed a research and development (R&D) methodology aimed at producing a numeracy assessment instrument based on the 3-Dimensional Framework on number concepts for fourth-grade elementary school students. The research and development approach was chosen because it allows the study to design, validate, and produce an educational product that meets user needs.

The development model adapted the research and development steps proposed by Sugiyono (2022), simplified into four main stages: 1) needs analysis, 2) instrument design, 3) instrument validation, and 4) instrument revision. Data collection was conducted through interviews, expert validation, and documentation. The validation data were analyzed using quantitative descriptive methods by calculating the average assessment scores from the validators. The results were used to determine the validity and feasibility of the instrument.

Respondents of the Study

The study subjects consisted of seven elementary school teachers involved in the needs analysis and three validators with expertise in numeracy education, assessment, and language. Research data were obtained through interviews, expert validation forms, and documentation of the instrument development process.

RESULTS

Need Analysis of Numeracy Assessment Instrument

A needs analysis was conducted to gather information regarding the implementation of numeracy assessments in elementary schools and teachers' needs for an assessment instrument that can provide a comprehensive picture of students' numeracy skills. Seven fourth-grade teachers took part in structured interviews and discussions about their current classroom assessment practices.

The results of the analysis showed that all teachers had conducted assessments as part of the learning process. However, these assessments were still dominated by conventional written tests that focused on measuring learning outcomes after the learning process was complete. The instruments were generally based on learning outcomes and were not designed to identify students' initial abilities.

Teachers also did not yet have numeracy instruments that measure students' abilities comprehensively. Most of the instruments were oriented toward mastery of calculation procedures and did not address aspects of information literacy or the complexity of students' understanding in solving contextual problems. Numeracy, however, also includes the ability to understand information, analyze data, and apply mathematical reasoning in real-life situations. All participating teachers emphasized the need to develop numeracy assessment instruments that can be used to identify students' initial abilities and learning difficulties in greater detail. Teachers also hoped that the new instruments would have clear indicators, be easy to use in the classroom, and provide information that can serve as a basis for designing follow-up learning activities.

Table 1. Results of needs analysis

Aspect	Findings
Current assessment practice	Teachers predominantly use written tests and end-of-unit assessments.
Purpose of assessment	Assessment focuses on measuring learning outcomes.
Availability of numeracy assessment instruments	No specific numeracy instrument assessment are available
Information literacy assessment	Rarely assessed
Identification of learning difficulties	Difficult to identify specific student difficulties
Teachers' expectations	Need comprehensive numeracy assessment instrument

The findings in Table 1 indicate a gap between the assessment practices carried out by teachers and the information needed to support student-centered learning. Although teachers assess routinely, their instruments do not yet comprehensively reveal students' initial numeracy abilities. This can make it difficult for teachers to design follow-up activities tailored to each student's needs.

These findings suggest that numeracy instruments should cover more than mastery of mathematical procedures. They should identify students' abilities to understand information, analyze data, and use mathematical reasoning to solve contextual problems. The 3-Dimensional Framework was therefore chosen as the basis for the instrument because it covers these aspects.

The needs analysis thus indicates that a numeracy assessment instrument based on the 3-Dimensional Framework is needed to help teachers obtain more comprehensive information regarding students' numeracy abilities. The instrument is expected to measure mastery of mathematical content, information literacy skills, and the complexity of students' understanding in solving numeracy problems.

Design of Numeracy Assessment Instrument Based on 3-Dimensional Framework

The development of the numeracy assessment instrument began with the creation of a test blueprint based on the 3-Dimensional Framework proposed by Burgmanis et al. (2021). This framework was chosen because it measures numeracy more comprehensively by integrating three dimensions: *content of mathematical knowledge*, *information literacy skills*, and *complexity of understanding*. The three dimensions were the basis for the indicators, question formats, and test items.

In the dimension of content of mathematical knowledge, the instrument focuses on number-related material, including number representations, properties of number sequences, and arithmetic operations. Each indicator is designed to measure students' ability to understand mathematical concepts and apply mathematical procedures in accordance with the context of the given problems.

The information literacy skills dimension is integrated into the instrument through indicators that measure students' ability to acquire, analyze, use, and communicate information. Information is presented in various forms, such as text, tables, images, and contextual situations closely related to daily life. In this way, the instrument measures students' ability to use information for decision-making as well as their computational skills.

The "complexity of understanding" dimension was developed based on the SOLO Taxonomy, which consists of five levels: *prestructural*, *unistructural*, *multistructural*, *relational*, and *extended abstract*. Each test item is designed to represent a different level of cognitive complexity so that the instrument can provide insight into the depth of students' understanding in solving numeracy problems.

Based on these three dimensions, an instrument blueprint was developed that includes indicators, complexity levels, and question formats. The blueprint produced 30 multiple-choice items designed to measure the numeracy skills of fourth-grade elementary school students.

During the development process, each item was written using contexts from students' daily lives. In addition, several questions integrated elements of local wisdom as the context of the problems to make the instrument more meaningful and to encourage students to connect mathematical concepts with their surrounding environment (Zuliana et al., 2023). The integration of local contexts is expected to help students understand the situations presented in the questions and to strengthen the relevance of numeracy learning to daily life.

The initial instrument developed was then reviewed by experts to obtain feedback regarding the appropriateness of its content, construction, and language. The validation results were used as the basis for revisions before the instrument was pilot-tested in the next phase.

Table 2. Distribution of instrument items based on the 3-Dimensional Framework

Dimension	Subdimension	Number of Items
Content of Mathematical Knowledge	Representasi Bilangan	7
	Sifat Urutan	10
	Operasi Hitung	13
Information Literacy Skills	Memperoleh informasi	11
	Menganalisis informasi	9
	Menggunakan dan mengkomunikasikan informasi	10
Complexity of Understanding	Prestruktural	3
	Unistruktural	6
	Multistruktural	10
	Relasional	6
	Extended abstrak	5

The items are distributed across all dimensions of the 3-Dimensional Framework so that the instrument covers each aspect of numeracy.

Expert Validation Results

Expert validation was conducted to assess the suitability of the developed numeracy assessment instrument before its use in the next phase. The validation process involved validators with expertise in numeracy and assessment, supported by a language expert.

The numeracy validator evaluated the following aspects: content appropriateness, item structure, alignment with the curriculum, difficulty level, accuracy of information, item relevance, item balance, and deep understanding. The assessment validator evaluated the following aspects: alignment with assessment objectives, distribution of difficulty levels, item reliability, alignment with the SOLO Taxonomy, assessment focus, item diversity, depth of understanding, and alignment with instructional objectives. The language validator evaluated grammar, appropriateness of instructions, question format and layout, relevance and appropriateness of context, vocabulary variety, simplicity of language, inter-question relevance, and sentence diversity.

The expert validation results show that the developed instrument received an average score of 3.73, which falls into the “valid” category. Details of the validation results for each aspect are presented in Table 3.

Table 3. Mean expert validation scores for the numeracy assessment instrument

Validation Aspect	Average Score	Category
Numeracy	3,5	Valid
Assessment	3,8	Valid
Language	3,9	Valid
Average	3,73	Valid

The numeracy aspect was rated valid, indicating that the developed content aligns with the measured numeracy competencies and represents the dimensions within the 3-Dimensional Framework. The validators assessed that the questions covered mastery of number concepts, the use of information, and a variety of thinking skills.

Regarding the assessment aspect, the validators gave a positive evaluation of the distribution of question difficulty levels and the integration of the SOLO Taxonomy into the instrument. These ratings suggest that the instrument may also help identify students’ initial ability levels in greater depth, beyond measuring learning outcomes.

The language aspect received the highest score, indicating that the wording of the questions, the simplification of sentences, and the adaptation of instructions were appropriate for elementary school students. The validators suggested a more adaptive use of local wisdom in the question contexts and the use of italics for foreign vocabulary.

Based on the validators’ feedback, revisions were made to several test items, including enriching the wording to integrate local wisdom, improving illustrations, using italics, and refining answer choices. These revisions were intended to make the instrument clearer and to align the questions with the characteristics of elementary school students.

DISCUSSION

The needs analysis showed that the seven teachers relied on written, end-of-unit tests, had no specific numeracy instrument, and rarely assessed information literacy (Table 1). This picture matches earlier reports that elementary teachers are not yet ready to apply the assessment expected by the Merdeka Curriculum (Warsihna et al., 2023) and find it difficult to design assessment that reveals the sources of students' difficulties (Rahmadani et al., 2025). Training in writing numeracy items, such as the HOTS-based workshop for early-grade teachers reported by Bhoke and Wea (2025), addresses part of this need. An instrument with ready-made items and clear indicators addresses another part, because teachers asked for tools they can use in class without writing every item themselves.

The results show that an instrument based on the 3-Dimensional Framework can cover several aspects of numeracy. Unlike conventional assessments, which generally focus on mastery of mathematical procedures, this framework integrates the dimensions of mathematical knowledge, information literacy skills, and the complexity of understanding into a single instrument. This integration is intended to give teachers deeper insight into students' numeracy, so that they can target instruction more precisely. These findings are consistent with the view that numeracy involves both calculation and the ability to understand, interpret, and use information to solve problems in various real-life contexts. Therefore, numeracy assessments need to be designed to measure various dimensions of competence in an integrated manner to provide a more complete picture of students' abilities.

A key feature of the instrument is the integration of information literacy skills and the SOLO Taxonomy in the development of test items. Information literacy enables students to acquire, analyze, and use available information before making decisions or solving problems. This ability is becoming increasingly important in 21st-century learning, which requires students to manage various types of information critically and responsibly. Previous research highlights the importance of mapping foundational information literacy skills as the basis for designing follow-up interventions (Mustofa, 2022).

The use of the SOLO Taxonomy provides an opportunity to identify the level of complexity in students' understanding. This is in line with previous research in which a SOLO-based instrument was designed to represent levels of understanding beyond correct and incorrect answers, from recognizing simple information to connecting concepts and making generalizations (Sudaria & Sanchez, 2024). The assessment results can thus provide richer information than assessments that are solely focused on final scores.

The blueprint distributes the 30 items across all subdimensions, and for complexity it places most items at the multistructural level (10 items), with 3 prestructural, 6 unistructural, 6 relational and 5 extended abstract items (Table 2). This spread is reasonable for fourth graders, since Fatikhah et al. (2024) found that fifth graders mostly reached the multistructural or relational level. One design question remains open. SOLO was developed to classify open responses (Biggs & Collis, 1982), and a multiple-choice item can show whether a student chose the relational answer but not how the student reached it. The relational and extended abstract items therefore need empirical checks, for example by comparing students' choices with short written explanations or interviews. The local wisdom contexts follow Zuliana et al. (2023) and are similar to the Luwu ethnomathematics numeracy assessment developed by Hikma et al. (2026).

The "valid" rating from expert validation suggests that the developed instrument has the potential for use in assessment practices in elementary schools. This instrument can serve as an alternative for teachers to obtain more comprehensive information about students' numeracy skills, particularly regarding number concepts.

The three aspects received average scores of 3.5 (numeracy), 3.8 (assessment) and 3.9 (language), with an overall mean of 3.73 (Table 3). The lowest score was for numeracy content, the aspect that matters most for what the instrument measures, so the numeracy validator's comments deserve the closest attention in the next revision. Each aspect was judged by a single expert, so the scores show one expert's view rather than agreement among experts. Indonesian instrument studies commonly quantify content validity with Aiken's V (Aiken, 1985), which Retnawati (2016) applied to ratings from three experts on Likert and multiple-choice items. Computing Aiken's V for each item would show which of the 30 items the experts doubted.

An instrument based on the 3-Dimensional Framework can also support assessment oriented toward students' learning needs. This is consistent with previous research showing that assessment instruments with a multidimensional framework can provide a more comprehensive picture of students' abilities (Hikma et al., 2026). Information from such assessment indicates learning achievement and also helps teachers identify aspects of numeracy skills that still require reinforcement. Follow-up activities can then be tailored to students' characteristics.

For fourth-grade teachers, the instrument offers a way to see whether a student's difficulty lies in number content, in reading and using information, or in connecting ideas. A student who computes correctly but fails the information literacy items needs different follow-up than one who cannot carry out the operations. Schools and teacher working groups (KKG) could use the blueprint as a model when they write their own numeracy items.

This study has limitations. Validation rested on expert judgement only, with one validator per aspect and no agreement index. The instrument has not yet been tried out with students, so its reliability, item difficulty and discrimination are unknown, and the ability of multiple-choice items to represent the higher SOLO levels has not been tested. The needs analysis involved seven teachers, which is enough to describe their practice but not to generalise. Future work should pilot the instrument with fourth graders, report item analysis and internal consistency, compute Aiken's V for each item, and compare students' scores with their AKM numeracy results.

CONCLUSION

This study developed a numeracy assessment instrument based on the 3-Dimensional Framework for fourth-grade elementary school students on the topic of numbers. Development began with a needs analysis, which indicated that teachers required an instrument capable of providing more comprehensive information regarding students' numeracy skills. The instrument was then designed by integrating the dimensions of content of mathematical knowledge, information literacy skills, and complexity of understanding, supported by the SOLO Taxonomy, to measure the level of complexity of students' understanding.

Expert validation placed the instrument in the "valid" category, which indicates that it meets the content-validity criteria for measuring the numeracy skills of elementary school students. Because it integrates the 3-Dimensional Framework, the instrument is designed to measure mastery of mathematical concepts, the use of information, and the depth of understanding required to solve numeracy problems. These findings align with the view that numeracy assessments need to measure the ability to use, interpret, and reason with mathematical information in various real-life contexts.

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REFERENCES

Aiken, L. R. (1985). Three coefficients for analyzing the reliability and validity of ratings. *Educational and Psychological Measurement, 45*(1), 131–142. https://doi.org/10.1177/0013164485451012

Arbain, & Sirad, L. O. (2023). Menguatkan Resiliensi Matematis dan Literasi Numerasi Siswa Sekolah Dasar melalui Inovasi Pembelajaran Kontekstual dan Konstruktif. *Aksioma: Jurnal Program Studi Pendidikan Matematika*, *12*(1), 908–921. https://doi.org/10.24127/ajpm.v12i1.6548

Ardiansyah, Mawaddah, F. S., & Juanda. (2023). Assesmen dalam Kurikulum Merdeka Belajar. *Jurnal Literasi Dan Pembelajaran Indonesia*, *3*(1), 8–13.

Arta, G. Y. (2024). Asesmen dalam pendidikan: Konsep, pendekatan, prinsip, jenis, dan fungsi. *JPBB: Jurnal Pendidikan, Bahasa Dan Budaya*, *3*(3). https://doi.org/10.55606/jpbb.v3i3.3925

Astarina, M. (2022). Pengembangan Instrumen Tes untuk Mengukur Kemampuan Numerasi Siswa Kelas V Sekolah Dasar. *Jurnal Kualita Pendidikan*, *3*(3), 152–156.

Baartman, L. K. J., & Gulikers, J. T. M. (2025). VET teacher professional development in formative assessment using learning progressions. *Journal of Formative Design in Learning*, *9*(2), 136–148. https://doi.org/10.1007/s41686-025-00107-4

Bhoke, W., & Wea, M. (2025). Pelatihan penyusunan instrumen asesmen numerasi berbasis higher order thinking skills (HOTS) untuk siswa kelas awal. *Komunita*, *4*(3), 652–660. https://doi.org/10.60004/komunita.v4i3.234

Biggs, J. B., & Collis, K. F. (1982). Evaluating the quality of learning: The SOLO taxonomy. Academic Press.

Burgmanis, G., France, I., Namsone, D., & Čakāne, L. (2021). Development and validation of diagnostic assessment instrument for numeracy skills in 7th grade. *ICERI2021 Proceedings*, 7781–7791. https://doi.org/10.21125/iceri.2021.1747

Danuri, Jana, P., Susanto, B. H., & Iswanda, A. (2025). Numerical literacy and math self-concept: Children-friendly learning in inclusive elementary schools. *Jurnal Ilmiah Sekolah Dasar*, *9*(3), 614–624. https://doi.org/10.23887/jisd.v9i3.93413

Fatikhah, W., Sukoriyanto, & Rahayuningsih, S. (2024). Analysis of students' responses in solving mathematical problems based on SOLO taxonomy viewed from gender. *ELSE (Elementary School Education Journal)*, *8*(3).

https://doi.org/10.30651/else.v8i3.24365

Francisco, P. K. D., Anating, N. B., Apurillo, S. E., Pena, P. B. D. La, Espinosa, R. C., & Tumlos, P. H. T. (2025). Numeracy skills and academic performance of elementary learners. *International Journal of Research and Innovation in Social Science (IJRISS)*, 9(3), 3720–3748. https://doi.org/10.47772/IJRISS.2025.90300295

Hikma, N., Djuniadi, Isnaeni, W., & Prabowo, A. (2026). Asesmen Penilaian Kompetensi Numerasi Beriorentasi Etnomatika Budaya Luwu. *Jurnal Studi Guru Dan Pembelajaran*, *9*(1), 346–360. https://doi.org/10.30605/jsgp.9.1.2026.7720

Ibrahim, M., Retnawati, H., Muhamad, F., Umar, U., Mufidah, M., Rosyid, M., & Dwita, T. (2026). Mathematical numeracy skills for pre-service teacher: An effectiveness of the STEAM framework. *Social Sciences & Humanities Open*, *13*, 102536. https://doi.org/10.1016/j.ssaho.2026.102536

Karumpa, A., & Agus, M. (2025). Leveraging diagnostic assessment to inform student-centred learning strategies: A qualitative case study. *Al-Ishlah: Jurnal Pendidikan*, *17*(3), 5696–5704. https://doi.org/10.35445/alishlah.v17i3.7115

Levy-Feldman, I. (2025). The role of assessment in improving education and promoting educational equity. *Education Sciences*, *15*(2), Article 224. https://doi.org/10.3390/educsci15020224

Munaroh, N. L. (2024). Asesmen dalam pendidikan: Memahami konsep, fungsi dan penerapannya. *Dewantara: Jurnal Pendidikan Sosial Humaniora*, *3*(3), 281–297. https://doi.org/10.30640/dewantara.v3i3.2915

Mustofa, Z. (2022). Literasi Informasi: Kemampuan Penting Abad 21 dan Pemetaannya di Sekolah Dalam Menghadapi Asesmen Nasional. *Pendidikan, Jurnal Penelitian Kebijakan*, *15*(2), 109–118.

OECD. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education*. OECD Publishing. https://doi.org/10.1787/53f23881-en

Purwaningrum, J. P., & Bintoro, H. S. (2018). Miskonsepsi Matematika Materi Bilangan pada Mahasiswa Calon Guru Sekolah Dasar. *Prosiding Seminar Nasional MIPA, November 2018*, 173–180.

Rahmadani, R., Arianti, N., Sofa, I. M., & Adriantoni. (2025). Asesmen Pembelajaran dalam Kurikulum Merdeka: Kesulitan dan Tantangan Guru. *Didaktik: Jurnal Ilmiah PGSD STKIP Subang*, *10*(2), 220–233.

Ramadhani, M. H., Agung, A., Izzania, R. D. S. M., Sari, R., & Supriatna, I. (2025). Kemampuan Numerasi Siswa Sekolah Dasar: Tinjauan Literatur tentang Konsep, Tantangan, dan Implikasinya bagi Pembelajaran Masa Kini. *Social, Humanities, and Educational Studies*, *8*(3), 1244–1258.

Retnawati, H. (2016). Proving content validity of self-regulated learning scale (The comparison of Aiken index and expanded Gregory index). *REID (Research and Evaluation in Education)*, *2*(2), 155–164. https://doi.org/10.21831/reid.v2i2.11029

Sari, D. R., Lukman, E. N., & Muharram, M. R. W. (2021). Analisis kemampuan siswa dalam menyelesaikan soal geometri pada asesmen kompetensi minimum-numerasi sekolah dasar. *Fondatia: Jurnal Pendidikan Dasar*, *5*(2), 153–162. https://doi.org/10.36088/fondatia.v5i2.1387

Sudaria, C. M., & Sanchez, J. M. P. (2024). SOLO-based formative assessments in teaching and learning earthquakes. *Science Education International*, *35*(4), 408–420. https://doi.org/10.33828/sei.v35.i4.11

Sugiyono. (2022). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D* (26th ed.). Alfabeta.

Sumaji, Purwanti, L., Darmanto, E., & Premprayoon, K. (2023). Development of numerical literacy-based student worksheet on improving mathematical reasoning. *Numerical: Jurnal Matematika Dan Pendidikan Matematika*, *7*(1), 37–48. https://doi.org/10.25217/numerical.v7i1

Tsaqifah, S., Sujadi, I., & Pramudya, I. (2024). Numeracy: How About Students of Junior High School Ability to Solve Problems Use Uncertainty and Data Content with Personal Contex? *Formatif: Jurnal Ilmiah Pendidikan MIPA*, *14*(1), 37–50. https://doi.org/10.30998/formatif.v14i1.19251

Warsihna, J., Ramdani, Z., Amri, A., Kembara, M. D., Steviano, I., Anas, Z., & Anggraena, Y. (2023). Tantangan dan Strategi Implementasi Kurikulum Merdeka pada Jenjang SD: Sebuah Temuan Multi-Perspektif. *Jurnal Teknologi Pendidikan*, *11*(01), 296–311. https://doi.org/10.31800/jtp.kw.v11n1.p296--311

Widia, Fuadiah, N. F., & Surmilasari, N. (2024). Pengembangan Instrumen Asessmen Berbasis Literasi Numerasi Pada Materi Sudut Untuk Kelas IV SD. *Pentagon: Jurnal Matematika Dan Ilmu Pengetahuan Alam*, *2*(3), 99–107. https://doi.org/10.62383/pentagon.v2i3.232

Yusnia, Stiadi, E., & Agusdianita, N. (2024). Pengembangan Instrumen Tes Literasi Numerasi Berbasis Hots Berbantuan Aplikasi Kahoot Bagi Guru SD. *Jurnal Pembelajaran, Bimbingan , Dan Pengelolaan Pendidikan*, *4*(1), 45–50. https://doi.org/10.17977/um065v4i12024p45-50

Zuliana, E., Dwiningrum, S. I. A., Wijaya, A., & Purnomo, Y. W. (2023). The Geometrical Patterns and Philosophical Value of Javanese Traditional Mosque Architecture for Mathematics Learning in Primary School : An Ethnomathematic Study. *Journal of Education Culture and Society*, 14(2), 512–532. https://doi.org/10.15503/jecs2023.2.512.532

ICISFS-UMK 2026 LEARNING INNOVATION

Effectiveness of PBL and Discovery Learning with E-LKPD on Critical Mathematical Thinking

Diar Rusiana Suharninuk[1*], Henry Suryo Bintoro[1] and Sumaji[1]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: diarrusiana@gmail.com

ABSTRACT

Critical thinking is a core 21st-century skill, and mathematics learning in particular requires logical reasoning, analysis, and problem solving. However, many elementary school students still struggle with geometric concepts such as cubes and cuboids, partly because mathematics instruction remains dominated by conventional teacher-centered approaches. This study aimed to examine the effectiveness of Problem Based Learning (PBL) and Discovery Learning models assisted by Electronic Student Worksheets (E-LKPD) in improving the critical mathematical thinking skills of sixth-grade elementary school students. This study employed a quantitative approach with a quasi-experimental nonequivalent control group design. Participants were sixth-grade students from three public elementary schools in Bangsri District, Jepara Regency. SDN 2 Jerukwangi served as the control group, while SDN 1 Jerukwangi and SDN 2 Krasak were assigned as experimental groups implementing PBL and Discovery Learning, respectively. Data were collected with a validated and trial-tested critical thinking test and analyzed with descriptive statistics, normality and homogeneity tests, and t-tests. The results indicated that students taught with PBL and with Discovery Learning achieved significantly higher critical mathematical thinking scores than students taught with conventional learning. No statistically significant difference was found between the two experimental groups, suggesting that the two models were comparably effective. These findings suggest that integrating PBL or Discovery Learning with E-LKPD can support student-centered mathematics learning and the development of critical thinking. Teachers are therefore encouraged to use these models to meet 21st-century learning demands and to improve elementary students' critical thinking in mathematics.

KEYWORDS PBL | discovery learning | critical thinking | E-LKPD

INTRODUCTION

Mathematics achievement in Indonesia remains a concern for schools and policymakers. In PISA 2022, Indonesian students again scored below the OECD average in mathematics (OECD, 2023), and an analysis of an elementary student's answers to geometry items in the national numeracy assessment (AKM) found low performance (Sari et al., 2021). In the elementary curriculum, geometry topics such as cubes and cuboids require students to move from recognizing shapes to reasoning about their elements and properties. The quality of this learning depends largely on teaching, and teachers are the main agents of change in how lessons are organized (Darling-Hammond, 2021). Teachers therefore need to choose learning models that help students reach the intended objectives (Serdyukov, 2017).

Critical thinking is one of the key skills that education needs to develop (Anggraeni et al., 2023; Hacıoğlu & Gülhan, 2021; Rivas et al., 2022). Students need critical thinking to face 21st-century challenges, so that they do not simply accept the information around them but check whether it is valid and reliable (Hartini, 2017). In mathematics, critical thinking is especially important because the subject often involves solving problems that require deep, analytical thinking (Dolapcioglu & Doğanay, 2022; Sachdeva & Eggen, 2021; Setiana et al., 2021). Critical thinking can be taught: a meta-analysis of 341 studies found a positive effect of instruction on critical thinking, which was largest when teaching combined dialogue, authentic problems, and mentoring (Abrami et al., 2015). Teachers therefore need to select learning models that give students such opportunities and suit their characteristics.

In practice, however, many students have difficulty developing critical thinking skills, especially in mathematics. Students find it difficult to connect solid shapes with their elements and properties. When asked to name the elements of solid shapes, some children could not yet distinguish between plane shapes and solid shapes.

This suggests that school learning has not yet prepared students to apply, analyze, synthesize, evaluate, and create on the basis of the concepts and principles they have learned (Wilsa et al., 2017). Conventional teacher-centered methods often leave students passive and less motivated to think critically. Learning models that are neither innovative nor student-centered can limit the development of students' critical thinking. Learning should therefore align with the Independent Curriculum and strengthen the scientific approach through discovery-based learning. To encourage students to produce contextual work, a problem-based learning model is recommended (Utami & Giarti, 2020).

Addressing this problem requires a learning model that actively engages students and encourages them to think critically. Two models that can be used to improve critical thinking skills are Problem Based Learning (PBL) and Discovery Learning. PBL places problem solving at the core of the learning process. PBL actively involves students and trains higher-order thinking skills, namely the ability to think critically, solve real problems, construct new knowledge, and collaborate in solving problems (Handayani & Muhammadi, 2020). Discovery Learning trains students to observe, ask, try, reason, and communicate. Lessons are not presented in their final form; instead, students are expected to organize the material themselves (Utami & Giarti, 2020). Discovery works best when it is guided: a meta-analysis of 164 studies found that unassisted discovery was less effective than explicit instruction, whereas discovery supported by feedback, worked examples, or scaffolding outperformed other forms of instruction (Alfieri et al., 2011). This suggests that both models need well-designed learning materials.

To support the implementation of PBL and Discovery Learning, teachers deliver learning materials using E-LKPD (Electronic Student Worksheets). The school already uses LKPD, but only in printed form and without the support of technology. These worksheets contain only material summaries and practice questions, which limits students' understanding. Printed LKPD also cannot present sound, video, or animation that could help clarify the material. Technology can help address these problems and improve the learning system, for example through technology-based learning media such as E-LKPD (Latifah & Auliya, 2024). E-LKPD (Electronic Student Worksheet) is a learning medium consisting of electronic worksheets that present material concisely. E-LKPD are designed to increase student involvement in the teaching and learning process, shift learning from teacher-centered to student-centered, and help educators guide students to discover concepts (Rosliana, 2019). In elementary mathematics, a contextual E-LKPD on fractions was rated feasible by experts and was followed by a moderate gain in fifth graders' conceptual understanding (Sakinah et al., 2023). With E-LKPD, students can follow the learning steps more easily and focus more on critical thinking.

Evidence on PBL in Indonesian elementary schools is consistent. Two meta-analyses of Indonesian elementary studies reported a strong effect of PBL on critical thinking (Sa'diyah et al., 2024; Setyowati & Sutikno, 2024), and a meta-analysis of 42 science studies reported a large positive effect across education levels (Aripin et al., 2025). Combining PBL with worksheets also appears helpful. Ayunda et al. (2023) found that PBL supported by LKPD had a positive effect on students' critical thinking, and Istni et al. (2022) reported a similar result in geography. Juhaeriah et al. (2021) found a difference in mathematical problem-solving ability between sixth graders with high critical thinking skills taught with PBL and LKPD and those taught without LKPD. LKPD based on PBL has also been developed for junior secondary mathematics (Astuti, 2021), and E-LKPD has been described as an engaging tool when students' interest in learning declines (Syafitri & Tressyalina, 2020). For Discovery Learning, a study with sixth-grade students found higher critical thinking scores after the model was applied (Putri et al., 2026).

Most of these studies tested one model at a time, used printed worksheets, or were conducted in science and social studies rather than elementary geometry. We found few studies that compared PBL and Discovery Learning, each supported by the same E-LKPD, against conventional teaching on the same mathematics topic. It therefore remains unclear whether the two models lead to different outcomes when the digital worksheet is held constant. This study addresses that gap with sixth-grade students in Bangsri District, Jepara Regency, learning about cubes and cuboids. It examines (1) whether students taught with PBL assisted by E-LKPD achieve higher critical mathematical thinking scores than students taught conventionally, (2) whether the same holds for Discovery

Learning assisted by E-LKPD, and (3) whether the two models differ from each other. The results are intended to help elementary teachers choose between the two models when they use E-LKPD in mathematics lessons.

LITERATURE REVIEW

Critical mathematical thinking is a competence that enables students to analyze information, evaluate mathematical ideas, and draw logical conclusions. Its development requires learning environments that actively engage students in constructing knowledge, investigating problems, and justifying their reasoning. This perspective is consistent with constructivist learning, which emphasizes students' active role in developing understanding through meaningful learning experiences (Le & Nguyen, 2024; Vijayakumar Bharathi & Pande, 2025).

Problem Based Learning (PBL) and Discovery Learning provide cognitively active learning processes that support critical thinking development. PBL engages students in identifying problems, analyzing information, and evaluating solutions, whereas Discovery Learning facilitates concept construction through exploration, verification, and conclusion drawing. Although their learning processes differ, both models encourage analytical and evaluative thinking, which are core dimensions of critical thinking (Loyens et al., 2023; Plummer et al., 2022).

The integration of Electronic Student Worksheets (E-LKPD) provides structured instructional scaffolding that guides students through problem-solving and discovery activities. Interactive and systematic learning activities can strengthen students' engagement and facilitate student-centered mathematics learning (Kerimbayev et al., 2023; Swai, 2025).

Research Objectives

This study was conducted to determine the effectiveness of Problem Based Learning (PBL) and Discovery Learning assisted by Electronic Student Worksheets (E-LKPD) in enhancing elementary school students' critical mathematical thinking skills. Specifically, the study compared the effectiveness of PBL and Discovery Learning with conventional learning and examined whether the two learning models differed in effectiveness.

RESEARCH METHOD

Research Design

This study used a quantitative method with a quasi-experimental design. A nonequivalent control group design was employed to examine the effectiveness of Problem Based Learning (PBL) and Discovery Learning assisted by Electronic Student Worksheets (E-LKPD) in enhancing elementary school students' critical mathematical thinking skills. The study involved two experimental groups and one control group. The first experimental group received PBL assisted by E-LKPD, the second received Discovery Learning assisted by E-LKPD, and the control group received conventional learning. Pretests and posttests were administered to measure students' critical mathematical thinking skills before and after the treatments (Sugiyono, 2019).

Respondents of the Study

The population of the study consisted of sixth-grade elementary school students in Bangsri District, Jepara Regency, Indonesia. The research sample involved students from three public elementary schools. SDN 1 Jerukwangi was assigned as the first experimental group and received Problem Based Learning assisted by E-LKPD, while SDN 2 Krasak was assigned as the second experimental group and received Discovery Learning assisted by E-LKPD. SDN 2 Jerukwangi served as the control group and received conventional learning. The schools were selected by purposive sampling, based on school characteristics and the suitability of the participants for the research objectives. Prior to the implementation of the study, permission was obtained from the respective schools. The three groups were then given a pretest, followed by the implementation of the designated learning models, and finally a posttest.

Research Instrument

The research instrument used in this study was a critical mathematical thinking skills test. The test was designed to measure students' ability to analyze mathematical problems, evaluate relevant information, formulate appropriate problem-solving strategies, and draw logical conclusions. The test was administered before the treatment as a pretest and after the treatment as a posttest. Prior to its use in the study, the test instrument was validated by experts and trial-tested to ensure its validity and reliability. The validated instrument was then used to collect data on students' critical mathematical thinking skills in the experimental and control groups.

Data Analysis

The data were analyzed using descriptive and inferential statistical techniques. Descriptive statistics were used to describe the distribution and mean scores of students' critical mathematical thinking skills. Prior to hypothesis testing, normality and homogeneity tests were conducted to determine whether the data met the assumptions required for parametric statistical analysis. Hypothesis testing was conducted using an independent samples t-test at a significance level of 0.05. The analysis compared (a) PBL assisted by E-LKPD with conventional learning, (b) Discovery Learning assisted by E-LKPD with conventional learning, and (c) the PBL and Discovery Learning groups with each other. The criteria for hypothesis testing are presented in Table 1.

Table 1. Criteria for hypothesis testing

Significance value	Decision	Interpretation
Sig. < 0.05	Reject H_0	A significant difference exists
Sig. ≥ 0.05	Accept H_0	No significant difference exists

RESULTS

Hypotheses 1, 2, and 3 compare the mean critical thinking scores of the groups (each experimental class with the control class, and the two experimental classes with each other). Each hypothesis was tested with a two-tailed independent samples t-test.

Table 2. Results of Hypothesis 1 test

		t_{hitung}	*df*	Sig. (2-tailed)	*α*	Information
Final Data	Equal variances assumed	6,008	35	0,000	0.05	H_0 rejected

Based on the table, the *t* value is obtained as t_{hitung} = 6.008. In addition, the Sig. (2-tailed) value is also obtained at 0.000. Because the Sig. (2-tailed) value is 0.000 <0.05, H_0 is rejected. Thus, there is a significant difference in mean critical thinking ability between students taught using the Problem Based Learning (PBL) model assisted by E-LKPD and students taught with conventional learning. Based on the results of the two-tailed independent two-sample t-test, the t-value is 6.008 and the significance value is 0.000. Because the significance value is smaller than the specified significance level (α = 0.05), the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted. Students taught with the PBL model assisted by E-LKPD therefore achieved significantly higher critical thinking scores than students taught with conventional learning.

Table 3. Results of Hypothesis 2 test

		t_{hitung}	*df*	Sig. (2-tailed)	*α*	Information
Final Data	Equal variances assumed	1,935	43	0,000	0.05	H_0 rejected

Based on the table, the *t* value is obtained as t_{hitung} = 1.935. In addition, the Sig. (2-tailed) value is also obtained at 0.000. Because the Sig. (2-tailed) value is 0.000 <0.05, H_0 is rejected. The results of the Hypothesis 2 test show a significant difference in mean critical thinking skills between students taught with the Discovery Learning model assisted by E-LKPD and students taught with conventional learning. The two-tailed independent two-sample t-test produced a t_{count} value of 1.935 with a Sig. (2-tailed) of 0.000, which means that H_0 is rejected and H_1 is accepted. Thus, students taught with the Discovery Learning model assisted by E-LKPD achieved significantly higher critical thinking scores than students taught with conventional learning.

Table 4. Results of Hypothesis 3 test

		t_{hitung}	*df*	Sig. (2-tailed)	*α*	Information
Final Data	Equal variances assumed	6,008	35	0.060	0.05	H_0 accepted

Based on the table, the *t* value is obtained as t_{hitung} = 6.008. In addition, the Sig. (2-tailed) value is also obtained at 0.060. Because the Sig. (2-tailed) value is 0.060 > 0.05, H_0 is accepted. The two-tailed independent two-sample t-test gave a t_{count} value of 6.008 with a significance value (Sig. 2-tailed) of 0.060 and 35 degrees of freedom (df). Because the significance value is greater than the significance level (0.060 > 0.05), the null hypothesis (H_0) is accepted, and the alternative hypothesis (H_1) is rejected. This shows no significant difference in mean critical thinking skills between students taught with the PBL model assisted by E-LKPD and students taught with the Discovery Learning model assisted by E-LKPD. In other words, the two models produced comparable critical thinking outcomes in this sample.

DISCUSSION

The first finding is that students taught with PBL assisted by E-LKPD obtained significantly higher critical mathematical thinking scores than students taught conventionally (t = 6.008, df = 35, Sig. = 0.000; Table 2). A plausible mechanism is that PBL begins with a problem that students cannot solve by recalling a procedure. To solve it, they must identify what is known, select relevant information, and justify a strategy, which are the analytical and evaluative actions that the test was designed to measure. This result agrees with earlier studies showing that PBL gives students room to work actively on real problems (Birgili, 2015; Silviariza et al., 2021) and that its stages of orientation, problem identification, data collection, analysis, and conclusion encourage deeper thinking (Kardoyo et al., 2020; Nargundkar et al., 2014). It is also in line with meta-analyses of Indonesian elementary studies that reported strong effects of PBL on critical thinking (Sa'diyah et al., 2024; Setyowati & Sutikno, 2024).

The E-LKPD may also have contributed to this result, although the design cannot separate its effect from that of the learning model, because every experimental lesson used both. Digital worksheets can present material in a more interactive and flexible way (Ardiansah & Zulfiani, 2023; Hidayat & Aripin, 2023), can support students' independence and motivation (Kiswari et al., 2024; Rahmayani & Atmazaki, 2025), and have been linked to higher-order thinking (Prayogi et al., 2023; Septianingsih et al., 2025; Ulyatin et al., 2023). In a PBL lesson, the worksheet can supply the structure that an open problem lacks: it breaks the problem into steps, prompts students to record data, and asks them to explain their conclusions (Risamasu & Pieter, 2024; Sa'diyah & Saptono, 2023; Sugianto et al., 2022). For teachers in Bangsri District, the practical point is that a PBL lesson on cubes and cuboids needs both a genuine problem and a worksheet that guides students through it.

The second finding is that the Discovery Learning group also scored significantly higher than the control group (t = 1.935, df = 43, Sig. = 0.000; Table 3). Discovery Learning asks students to observe, question, try, associate, and communicate, so that they build a concept such as the elements of a cuboid instead of receiving it as a finished rule. Studies in mathematics and science report similar gains in critical thinking from discovery-based lessons (Chusni et al., 2021, 2022; Nusantari et al., 2021; Rahmawati et al., 2021; Sulistyorini & Andriyani, 2023), and a recent study with sixth-grade students found higher critical thinking scores after discovery learning (Putri et al., 2026). However, the test statistic for this comparison (t = 1.935) was much smaller than for the PBL comparison (t = 6.008), so this result should be interpreted with more caution. The meta-analysis by Alfieri et al. (2011) offers one explanation for a weaker advantage: discovery outperforms other instruction when it is guided by feedback, worked examples, or scaffolding, and is less effective than explicit teaching when students are left unassisted. Teachers who use Discovery Learning should therefore build such guidance into the E-LKPD, for example through prompts that direct students' attention to the properties they are meant to discover, as in discovery-based mathematics materials developed for Indonesian classrooms (Geong & Mahmudi, 2023; Puspita & Mudrikah, 2019) and in Liveworksheets activities (Hasnunidah et al., 2024).

The third finding is that the PBL and Discovery Learning groups did not differ significantly (Sig. = 0.060 > 0.05; Table 4). Both models place students at the centre of the lesson and ask them to analyze information and justify conclusions, and both were delivered with the same E-LKPD, which may have narrowed the difference between them. PBL organizes this work around a problem, group discussion, and the evaluation of solutions, whereas Discovery Learning organizes it around exploration and the verification of a concept (Loyens et al., 2023). Reviews of PBL (Anggraeni et al., 2023) and of discovery-based instruction (Alfieri et al., 2011) both report positive effects on higher-order outcomes, which is consistent with the comparable results found here. A non-significant result does not show that the two models are equivalent, however. With p = 0.060 and small groups, a modest difference may have gone undetected. For practice, the result suggests that teachers can choose either model according to the topic and their students: PBL where a realistic problem fits the content, and Discovery Learning where the goal is to build a concept from examples. School principals can support both options by giving teachers access to devices and time to prepare E-LKPD.

This study has several limitations. First, it used intact classes from three schools selected purposively, so differences between schools may have influenced the results; the nonequivalent control group design is open to selection threats unless the groups are shown to be equivalent at pretest (Shadish et al., 2002). Pretest data were collected but are not analyzed in this report, and group sizes, means, and standard deviations are not reported. Second, every experimental class used E-LKPD, so the contribution of the worksheet cannot be separated from that of the learning model. Third, the study covered a single topic, and the validity and reliability coefficients of the test are not reported. Fourth, no effect sizes were calculated, so the practical size of the differences is unknown (Lakens, 2013). Future studies should report descriptive statistics and pretest comparisons, use ANCOVA or gain scores to adjust for initial differences, include a group taught with the model but without E-LKPD, report effect sizes, and follow students over a longer period and across other mathematics topics.

CONCLUSION AND RECOMMENDATIONS

The results indicate that the Problem Based Learning (PBL) and Discovery Learning models combined with E-LKPD had a positive effect on students' critical thinking skills. The average critical thinking skills of students who received learning through PBL assisted by E-LKPD were higher than those of students taught using conventional learning. Similar results were found among students taught using Discovery Learning assisted by E-LKPD, whose critical thinking skills were also better than those of the control group. No significant difference was found between PBL and Discovery Learning, which suggests that the two models are comparably effective in encouraging students to analyze problems, think critically, and draw logical conclusions. Both models can therefore serve as learning strategies for meeting 21st-century learning demands, particularly when integrated with digital learning media such as E-LKPD. It is recommended that elementary school teachers integrate PBL or Discovery Learning with E-LKPD into mathematics instruction according to students' learning characteristics and classroom contexts. Future studies should involve larger and more diverse samples, examine long-term learning effects, and investigate other mathematical competencies to strengthen the generalizability of the findings.

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REFERENCES

Abrami, P. C., Bernard, R. M., Borokhovski, E., Waddington, D. I., Wade, C. A., & Persson, T. (2015). Strategies for teaching students to think critically: A meta-analysis. Review of Educational Research, 85(2), 275-314. https://doi.org/10.3102/0034654314551063

Alfieri, L., Brooks, P. J., Aldrich, N. J., & Tenenbaum, H. R. (2011). Does discovery-based instruction enhance learning? Journal of Educational Psychology, 103(1), 1-18. https://doi.org/10.1037/a0021017

Anggraeni, D. M., Prahani, B. K., Suprapto, N., Shofiyah, N., & Jatmiko, B. (2023). Systematic review of problem based learning research in fostering critical thinking skills. *Thinking Skills and Creativity*, *49*, 101334. https://doi.org/10.1016/j.tsc.2023.101334

Ardiansah, R., & Zulfiani, Z. (2023). Development of interactive e-LKPD based on creative thinking skills on the concept of environmental change. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *9*(2), 179–197. https://doi.org/10.22219/jpbi.v9i2.22389

Aripin, N., Festiyed, Yerimadesi, Alberida, H., Ahda, Y., & Mufit, F. (2025). The impact of problem-based learning on science learning to improve students' critical thinking and problem-solving skills: A meta-analysis. Jurnal Penelitian Pendidikan IPA, 11(6), 45-57. https://doi.org/10.29303/jppipa.v11i6.10051

Astuti, A. (2021). Pengembangan Lembar Kerja Peserta Didik (LKPD) Berbasis Problem Based Learning (PBL) untuk Kelas VII SMP/MTs Mata Pelajaran Matematika. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, *5*(2), 1011–1024. https://doi.org/10.31004/cendekia.v5i2.573

Ayunda, S. N., Lufri, L., & Alberida, H. (2023). Pengaruh Model Pembelajaran Problem Based Learning (PBL) Berbantuan LKPD terhadap Kemampuan Berpikir Kritis Peserta Didik. *Journal on Education*, *5*(2), 5000–5015. https://doi.org/10.31004/joe.v5i2.1232

Birgili, B. (2015). Creative and Critical Thinking Skills in Problem-based Learning Environments. *Journal of Gifted Education and Creativity*, 2(2), 71–80. https://doi.org/10.18200/JGEDC.2015214253

Chusni, M. M., Saputro, S., Rahardjo, S. B., & Suranto, S. (2021). Student's Critical Thinking Skills Through Discovery Learning Model Using E-Learning on Environmental Change Subject Matter. *European Journal of Educational Research*, *10*(3), 1123–1135. https://doi.org/10.12973/eu-jer.10.3.1123

Chusni, M. M., Saputro, S., Suranto, S., & Rahardjo, S. B. (2022). Enhancing Critical Thinking Skills of Junior High School Students through Discovery-Based Multiple Representations Learning Model. *International Journal of Instruction*, *15*(1), 927–944. https://doi.org/10.29333/iji.2022.15153a

Darling-Hammond, L. (2021). Defining teaching quality around the world. *European Journal of Teacher Education*, *44*(3), 295–308. https://doi.org/10.1080/02619768.2021.1919080

Dolapcioglu, S., & Doğanay, A. (2022). Development of critical thinking in mathematics classes via authentic learning: an action research. *International Journal of Mathematical Education in Science and Technology*, *53*(6), 1363–1386. https://doi.org/10.1080/0020739X.2020.1819573

Geong, E. A. P., & Mahmudi, A. (2023). Pengembangan perangkat pembelajaran peluang berbasis discovery learning berorientasi kemampuan pemahaman konsep dan self-efficacy siswa SMP. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *12*(1), 51–66. https://doi.org/10.24127/ajpm.v12i1.6370

Hacıoğlu, Y., & Gülhan, F. (2021). The Effects of STEM Education on the 7th Grade Students' Critical Thinking Skills and STEM Perceptions. *Journal of Education in Science, Environment and Health*, 7(2), 139–155. https://doi.org/10.21891/jeseh.771331

Handayani, H. R., & Muhammadi. (2020). Penerapan Model Problem Based Learning untuk Melatih Higher Order Thinking Skill Siswa Sekolah Dasar. Jurnal Pendidikan Tambusai, *4*(2), 1494–1499.

Hartini, A. (2017). Pengembangan Perangkat Pembelajaran Model Project Based Learning Untuk Meningkatkan Kemampuan Berpikir Kritis Siswa Sekolah Dasar. *ELSE (Elementary School Education Journal): Jurnal Pendidikan Dan Pembelajaran Sekolah Dasar*, *1*(2a), 6–16.

Hasnunidah, N., Amanda, D. O., Meriza, N., Lengkana, D., & Dewi, P. S. (2024). Analysis of Students' Higher Order Thinking Skills on Science Subject Using Liveworksheet Argumentative Through Discovery Learning. *Jurnal Pendidikan MIPA*, *25*(1), 351–372. https://doi.org/10.23960/jpmipa/v25i1.pp351-372

Hidayat, W., & Aripin, U. (2023). How to develop an E-LKPD with a scientific approach to achieving students' mathematical communication abilities? *Infinity Journal*, *12*(1), 85–100. https://doi.org/10.22460/infinity.v12i1.p85-100

Istni, T., Utomo, D. H., & Utaya, S. (2022). Pengaruh model Problem Based Learning (PBL) berbantuan LKPD terhadap kemampuan berpikir kritis mata pelajaran Geografi siswa kelas XI IPS MA Bilingual Batu. *Jurnal Integrasi Dan Harmoni Inovatif Ilmu-Ilmu Sosial (JIHI3S)*, *2*(2), 194–203. https://doi.org/10.17977/um063v2i2p194-203

Juhaeriah, D., Hidayat, S., & Sudrajat, A. (2021). Pengaruh model pembelajaran berbasis masalah berbantuan LKPD dan kemampuan berpikir kritis terhadap kemampuan memecahkan masalah matematika siswa kelas VI SD. Jurnal Muara Pendidikan, 6(2), 157–165. https://doi.org/10.52060/mp.v6i2.495

Kardoyo, K., Nurkhin, A., Muhsin, M., & Pramusinto, H. (2020). Problem-Based Learning Strategy: Its Impact on Students' Critical and Creative Thinking Skills. *European Journal of Educational Research*, 9(3), 1141–1150. https://doi.org/10.12973/eu-jer.9.3.1141

Kerimbayev, N., Umirzakova, Z., Shadiev, R., & Jotsov, V. (2023). A student-centered approach using modern technologies in distance learning: a systematic review of the literature. *Smart Learning Environments*, *10*(1), 61. https://doi.org/10.1186/s40561-023-00280-8

Kiswari, L., Singgih, S., & Siswanto, S. (2024). Development of stem-based E-LKPD on substance pressure material to improve critical thinking skills of junior high school students. *Edu Sains: Jurnal Pendidikan Sains & Matematika*, *11*(2), 136–144. https://doi.org/10.23971/eds.v11i2.4243

Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for t-tests and ANOVAs. Frontiers in Psychology, 4, Article 863. https://doi.org/10.3389/fpsyg.2013.00863

Latifah, A. U., & Auliya, N. N. F. (2024). Pengembangan E-LKPD Matematika Berbasis Problem Based Learning pada Materi Matematika. Jurnal Pendidikan Matematika, 1(3), 8. https://doi.org/10.47134/ppm.v1i3.439

Le, H. Van, & Nguyen, L. Q. (2024). Promoting L2 learners' critical thinking skills: the role of social constructivism in reading class. *Frontiers in Education*, *9*. https://doi.org/10.3389/feduc.2024.1241973

Loyens, S. M. M., van Meerten, J. E., Schaap, L., & Wijnia, L. (2023). Situating Higher-Order, Critical, and Critical-Analytic Thinking in Problem- and Project-Based Learning Environments: A Systematic Review. *Educational Psychology Review*, *35*(2), 39. https://doi.org/10.1007/s10648-023-09757-x

Nargundkar, S., Samaddar, S., & Mukhopadhyay, S. (2014). A Guided Problem-Based Learning (PBL) Approach: Impact on Critical Thinking. *Decision Sciences Journal of Innovative Education*, *12*(2), 91–108. https://doi.org/10.1111/dsji.12030

Nusantari, E., Abdul, A., Damopolii, I., Alghafri, A. S. R., & Bakkar, B. S. (2021). Combination of Discovery Learning and Metacognitive Knowledge Strategy to Enhance Students' Critical Thinking Skills. *European Journal of Educational Research*, *10*(4), 1781–1791. https://doi.org/10.12973/eu-jer.10.4.1781

OECD. (2023). PISA 2022 results (Volume I): The state of learning and equity in education. OECD Publishing. https://doi.org/10.1787/53f23881-en

Plummer, K. J., Kebritchi, M., Leary, H. M., & Halverson, D. M. (2022). Enhancing Critical Thinking Skills through Decision-Based Learning. *Innovative Higher Education*, *47*(4), 711–734. https://doi.org/10.1007/s10755-022-09595-9

Prayogi, E. F., Wahyuni, S., & Ridlo, Z. R. (2023). Development of Electronic Student Worksheet to Improving Higher Order Thinking Skills in Temperature and Heat Material. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 6667–6674. https://doi.org/10.29303/jppipa.v9i8.3902

Puspita, S. K., & Mudrikah, A. (2019). Pengembangan Bahan Ajar Matematika Materi Segitiga dengan Model Discovery Learning untuk Meningkatkan Kemampuan Pemahaman Konsep Matematik Peserta Didik SMP. *Ujmes*, 4(1), 28–35.

Putri, M. Y., Miftakhuddin, & Adiyan, F. (2026). Pengaruh model discovery learning terhadap kemampuan berpikir kritis di sekolah dasar. Jurnal Tunas Pendidikan, 9(1), 209-217. https://doi.org/10.52060/pgsd.v9i1.4422

Rahmawati, S., Masykuri, M., & Sarwanto, S. (2021). The effectiveness of discovery learning module classification of materials and its changes to enhance critical thinking skills. *Jurnal Inovasi Pendidikan IPA*, *7*(1). https://doi.org/10.21831/jipi.v7i1.33253

Rahmayani, R. D., & Atmazaki, A. (2025). Development of Interactive E-LKPD Based on Live-Worksheets for Reading and Viewing Skills. *AL-ISHLAH: Jurnal Pendidikan*, *17*(1), 73–89. https://doi.org/10.35445/alishlah.v17i1.6451

Risamasu, P. V. M., & Pieter, J. (2024). Enhancing students problem solving capability with electronic student worksheet based on problem based learning. *PEDAGOGIK: Jurnal Pendidikan*, *11*(1), 116–130. https://doi.org/10.33650/pjp.v11i1.8334

Rivas, S. F., Saiz, C., & Ossa, C. (2022). Metacognitive Strategies and Development of Critical Thinking in Higher Education. *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.913219

Rosliana, I. (2019). Pengembangan LKPD Matematika dengan Model Learning Cycle 7E Berbantuan Mind Mapping. *Jurnal Pengembangan Pembelajaran Matematika*, *1*(1), 10–22. https://doi.org/10.14421/jppm.2019.11.10-22

Sa'diyah, H., Umalihayati, Hidayah, R., Salimi, M., Fajari, L. E. W., Mashudi, & Aini, S. (2024). The effect of problem based learning model on critical thinking skills in elementary school: A meta analysis study. Jurnal Iqra': Kajian Ilmu Pendidikan, 9(1). https://doi.org/10.25217/ji.v9i1.4456

Sa'diyah, N., & Saptono, S. (2023). The Effectiveness of Real Problem-Based e-LKPD to Improve Problem Solving and Collaboration Abilities on Environmental Change Material in Madrasah Aliyah. *Journal of Biology Education*, *12*(3), 306–313. https://doi.org/10.15294/jbe.v12i3.71886

Sachdeva, S., & Eggen, P.-O. (2021). Learners' Critical Thinking About Learning Mathematics. *International Electronic Journal of Mathematics Education*, *16*(3), em0644. https://doi.org/10.29333/iejme/11003

Sakinah, S., Dewi, R. S., & Hakim, Z. R. (2023). Development of contextual-based E-LKPD to improve the ability to understand fraction concepts. EduBasic Journal: Jurnal Pendidikan Dasar, 5(1), 71–82. https://doi.org/10.17509/ebj.v5i1.51576

Sari, D. R., Lukman, E. N., & Muharram, M. R. W. (2021). Analisis kemampuan siswa dalam menyelesaikan soal geometri pada asesmen kompetensi minimum-numerasi sekolah dasar. Fondatia: Jurnal Pendidikan Dasar, 5(2), 153–162. https://doi.org/10.36088/fondatia.v5i2.1387

Septianingsih, S. F., Napitupulu, N. D., Napitupulu, M., Ratman, & Kundera, I. N. (2025). Development of E-LKPD Wizer: A Solution to Improve Problem Solving Skills and Ecological Attitude in Junior High School Students. *Jurnal Penelitian Pendidikan IPA*, *10*(12), 11009–11018. https://doi.org/10.29303/jppipa.v10i12.8621

Serdyukov, P. (2017). Innovation in education: what works, what doesn't, and what to do about it? *Journal of Research in Innovative Teaching & Learning*, *10*(1), 4–33. https://doi.org/10.1108/JRIT-10-2016-0007

Setiana, D. S., Purwoko, R. Y., & Sugiman, S. (2021). The Application of Mathematics Learning Model to Stimulate Mathematical Critical Thinking Skills of Senior High School Students. *European Journal of Educational Research*, *10*(1), 509–523. https://doi.org/10.12973/eu-jer.10.1.509

Setyowati, N., & Sutikno, P. Y. (2024). Meta analisis: Model pembelajaran problem based learning (PBL) terhadap keterampilan berpikir kritis siswa sekolah dasar. Jurnal Inovasi Pendidikan dan Pembelajaran Sekolah Dasar, 8(2), 587-599. https://doi.org/10.24036/jippsd.v8i2.127679

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). Experimental and quasi-experimental designs for generalized causal inference. Houghton Mifflin.

Silviariza, W. Y., Sumarmi, S., & Handoyo, B. (2021). Improving Critical Thinking Skills of Geography Students with Spatial-Problem Based Learning (SPBL). *International Journal of Instruction*, *14*(3), 133–152. https://doi.org/10.29333/iji.2021.1438a

Sugianto, R., Syaifuddin, M., & Cholily, Y. M. (2022). Development of E-LKPD oriented minimum competency assessment (MCA) on 6C's ability of high school students. *Al-Jabar : Jurnal Pendidikan Matematika*, *13*(2), 433–453. https://doi.org/10.24042/ajpm.v13i2.15559

Sugiyono. (2019). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Alfabeta.

Sulistyorini, A., & Andriyani. (2023). *A digital trigonometry module based on discovery learning and critical thinking skills*. AIP Conference Proceedings, 2886, 020051. https://doi.org/10.1063/5.0155194

Swai, C. T. (2025). A systematic review of classroom technologies supporting student centered teaching. *Discover Education*, *4*(1), 564. https://doi.org/10.1007/s44217-025-00932-6

Syafitri, R. A., & Tressyalina. (2020). *The Importance of the Student Worksheets of Electronic (E-LKPD) Contextual Teaching and Learning (CTL) in Learning to Write Description Text during Pandemic COVID-19*. In Proceedings of the 3rd International Conference on Language, Literature, and Education (ICLLE 2020) (pp. 284–287). Atlantis Press. https://doi.org/10.2991/assehr.k.201109.048

Ulyatin, N. 'Aini A., Formen, A., Prasetya, A. T., & Parwoto, P. (2023). Liveworksheet-Based E-LKPD Feasibility Test to Improve Critical Thinking Skills of Class V Students on Ecosystem Materials. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 10236–10243. https://doi.org/10.29303/jppipa.v9i11.2727

Utami, R. A., & Giarti, S. (2020). Efektivitas model pembelajaran problem based learning (PBL) dan discovery learning ditinjau dari keterampilan berpikir kritis siswa kelas 5 SD. *PeTeKa (Jurnal Penelitian Tindakan Kelas Dan Pengembangan Pembelajaran)*, *3*(1), 1–8.

Vijayakumar Bharathi, S., & Pande, M. B. (2025). Does constructivism learning approach lead to developing creative thinking skills? The mediating role of online collaborative learning environments. *Journal of Computers in Education*, *12*(2), 551–587. https://doi.org/10.1007/s40692-024-00321-2

Wilsa, A. W., Susilowati, S. M. E., & Rahayu, E. S. (2017). Problem Based Learning Berbasis Socio-Scientific Issue untuk Mengembangkan Kemampuan Berpikir Kritis dan Komunikasi Siswa. *Journal of Innovative Science Education*, *6*(1), 129–137.

ICISFS-UMK 2026 CURRICULUM, CULTURE & CHARACTER

E-LKPD Development Based on Javanese Unggah-Ungguh Wisdom to Elevate Primary Civic Learning

Muhamad Zainudin Charis[1*]

[1]*Universitas Muria Kudus, Indonesia*

Corresponding author: zainudincharis@gmail.com

ABSTRACT

Under the Kurikulum Merdeka, Pancasila Education in primary schools aims to shape students' character and social responsibility. However, diagnostic observations in a Grade 6 classroom at SD Negeri 1 Rengging, Jepara, Central Java, revealed low achievement on the topic of Rights and Obligations. Although the lessons used Problem-Based Learning (PBL), interactive videos, image analysis, group discussions, presentations, and reflections, 16 out of 28 students (57.14%) failed to achieve the Criteria for Attainment of Learning Objectives (KKTP), with only 12 students (42.86%) meeting the benchmark score of 75. To address this problem, a Research and Development (R&D) study was conducted to design, validate, and evaluate an Electronic Student Worksheet (E-LKPD) anchored in Javanese Unggah-Ungguh local wisdom. Developed with a modified eight-step Borg and Gall model, the E-LKPD integrates local etiquette, polite communication (subasita), and socio-moral simulations into civic decision-making scenarios. Expert validation using Aiken's V gave an overall content and media validity index of 0.89 (highly valid). Practicality evaluations from teachers and students reached 94.00% and 92.50%, respectively. In the main field test, the mean learning score rose from 52.14 in the pretest to 85.71 in the posttest. The normalized gain (N-Gain) was 0.701 (high category), and a paired sample t-test indicated a statistically significant improvement. The results suggest that integrating Javanese socio-cultural etiquette into interactive digital worksheets can make abstract civic concepts more meaningful and contextually grounded for primary students.

KEYWORDS E-LKPD | learning outcomes | Javanese local wisdom

INTRODUCTION

Pancasila Education in primary schools helps shape students' character and social responsibility. The Kurikulum Merdeka prioritizes character development through the Pancasila Student Profile, project-based learning, and the internalization of civic values (Hidayat & Putro, 2024; Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi, 2024a). The profile includes critical reasoning, mutual cooperation (gotong royong), and global diversity (berkebinekaan global), and elementary schools usually build these values through daily habituation and school projects (Suryaningsih & Desstya, 2023; Wilsani et al., 2023). In Grade 5 (Fase C), students enter a stage in which social interactions become more complex, and the curriculum emphasizes social communication, contextual decision-making, and active participation in learning (Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi, 2024b). Civic rights and responsibilities are therefore better taught through real-life situations in students' family, school, and community environments than through memorizing statutory definitions (Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi, 2024c).

A gap remains between the curricular intentions of Pancasila Education and the learning outcomes achieved in classroom practice, particularly when instruction remains teacher-centered and insufficiently contextualized (Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi, 2024a). Diagnostic baseline data from a Grade 5 class at SD Negeri 1 Rengging, Jepara, Central Java, showed low achievement in lessons on rights and obligations. The teacher designed a structured lesson plan in accordance with the Merdeka Curriculum guidelines and applied Problem-Based Learning (PBL) as a student-centered instructional strategy (Az-zarkasyi & Hindun, 2023; Hanifah et al., 2025). The learning activities included digital videos, image-based analysis, small-group discussions, group presentations, and structured reflection. Summative evaluations indicated that out of 28 enrolled students, only 12 students (42.86%) achieved the designated Criteria for Attainment of Learning

Objectives (KKTP ≥ 75), whereas 16 students (57.14%) failed to reach basic competency, yielding an unsatisfactory class average of 52.14.

This mismatch between active learning procedures and low mastery needs closer analysis, particularly in elementary Pancasila Education, where learning outcomes depend strongly on teacher readiness, authentic problem design, and contextual support (Afrillia & Dafit, 2025; Hanifah et al., 2025). Interactivity matters more than the digital format itself: a meta-analysis of Indonesian experimental studies found a large effect of interactive multimedia on learning outcomes, with the highest estimate at the elementary level (Khaeruman et al., 2023). Yet digital media in civic classrooms are often used for passive presentation. Instructional videos and slides tend to present rights and obligations as abstract demonstrations, and students watch rather than act. Gamified tools and videos may hold visual attention for a while, but they seldom prompt deeper reasoning or emotional engagement. When digital media are not grounded in students' own cultural environment, learners may struggle to connect formal civic duties to real-life social choices.

One way to address this limitation is to integrate local wisdom into interactive digital learning resources. In Central Java, Javanese culture includes Unggah-Ungguh, a socio-cultural system of etiquette, deferential linguistic registers *(unggah-ungguh basa)*, mutual respect *(andhap asor)*, empathy *(tepa slira)*, and social harmony. Unggah-Ungguh values such as andhap asor and tepa slira have been used as a basis for character education with fifth graders (Adisti & Rozikan, 2021). They cannot be taken for granted, however: a study of fifth graders with a Javanese background found that their polite language use was low and shifting negatively under family and environmental influences (Mirmanto et al., 2021). Integrating Unggah-Ungguh principles into an Electronic Student Worksheet *(E-LKPD)* can link formal civic standards with the socio-cultural norms of students' daily lives.

Previous development studies have produced digital worksheets and interactive media for elementary learning. Contextual and inquiry-based E-LKPD were rated valid by experts and were followed by moderate to high learning gains (Inanta et al., 2026; Sakinah et al., 2023), and Canva-based media were associated with higher learning outcomes in Grade 5 (Khudin et al., 2025). Local wisdom has also been built into Indonesian teaching materials and media. A systematic review of 47 studies reported gains in conceptual understanding and character, although most of the evidence came from development and short-term descriptive studies (Jovanda et al., 2026). Research on unggah-ungguh has focused on character education rather than on civic content (Adisti & Rozikan, 2021), and we found few studies that used Javanese etiquette as the framework for interactive civic scenarios in an E-LKPD. It therefore remains unclear how Unggah-Ungguh can be built into an interactive E-LKPD and whether such a worksheet is valid, practical, and associated with better civic learning outcomes. This study addresses this gap by developing, validating, and testing an interactive E-LKPD anchored in Javanese Unggah-Ungguh local wisdom for Grade 5 students at SD Negeri 1 Rengging, Jepara, Central Java.

LITERATURE REVIEW

The conceptual framework of this study draws on Culturally Responsive Pedagogy (CRP), the Cognitive Theory of Multimedia Learning (CTML), and Social Simulation Pedagogy. Culturally Responsive Pedagogy holds that learning improves when educational content integrates the cultural frames of reference, heritage, and lived experiences of the learners (Ladson-Billings, 1995). In Javanese society, childhood socialization is governed by Unggah-Ungguh, which establishes clear expectations for social interactions across three domains: family *(wisma)*, school *(wiyata)*, and community *(praja)*. When civic rights and obligations are taught in isolation from Unggah-Ungguh, students may perceive civic duties as external legal impositions. Embedding Unggah-Ungguh values such as speaking politely (*subasita*), respecting elders, respecting peers' views, and taking part in communal work *(gotong royong)* into civic scenarios reframes abstract civic principles as familiar moral responsibilities.

According to Mayer's Cognitive Theory of Multimedia Learning (Mayer, 2014), effective digital learning tools manage cognitive load and use both the visual and the verbal channel. Conventional digital instruction can overload working memory with fragmented text and generic videos. An interactive E-LKPD structures digital

content through guided socio-moral simulations. Instead of watching videos, students work through interactive scenarios in which they evaluate social problems, choose actions grounded in Unggah-Ungguh etiquette, see the consequences of those actions, and complete reflective exercises.

Integrating Unggah-Ungguh into interactive E-LKPDs is intended to turn passive learning into active decision-making. In this framework, civic rights are presented as entitlements that accompany the respectful fulfillment of social obligations, rather than as selfish demands. Interactive E-LKPDs built on Canva support group collaboration, peer dialogue, and immediate feedback. The combination targets cognitive mastery, higher-order thinking, character development, and behavioral application.

Research Objectives

This study had the following objectives. First, it aimed to design an interactive Electronic Student Worksheet *(E-LKPD)* grounded in Javanese Unggah-Ungguh local wisdom for the Grade 5 Kurikulum Merdeka topic of Rights and Obligations. Second, it evaluated the construct, content, and technological validity of the E-LKPD through expert validation using Aiken's V. Third, it assessed the practicality of the E-LKPD from the perspectives of teachers and Grade 5 students during classroom instruction. Fourth, it analyzed the effectiveness of the Javanese Unggah-Ungguh based E-LKPD in improving students' learning outcomes, conceptual mastery, and KKTP attainment at SD Negeri 1 Rengging, Jepara, Central Java.

RESEARCH METHOD

Research Design

This study used a Research and Development (R&D) design, adapting Borg and Gall's ten-step model (Gall et al., 2007) into eight steps suited to developing primary education media. The developmental stages comprised educational problem identification and baseline diagnostic analysis, empirical data collection and curricular mapping, initial E-LKPD product design, expert validity assessment, initial design revision, small-group preliminary field testing, media refinement, and main field implementation with effectiveness testing.

The main field implementation adopted a One-Group Pretest-Posttest Design to evaluate learning gains after the introduction of the Javanese Unggah-Ungguh based E-LKPD. Civic understanding was assessed with a pretest before the intervention. The E-LKPD was then implemented across multiple instructional cycles, and the same test was given as a posttest.

Respondents of the Study

The research was conducted at SD Negeri 1 Rengging, an elementary school in Jepara, Central Java, during the second semester of the 2025/2026 academic year. The participants were 28 Grade 5 students with diverse baseline abilities. Other participants were one senior class teacher, university validators specializing in primary civic education, and educational technology specialists who evaluated the digital interface.

Feasibility data were collected with an e-worksheet questionnaire covering content and media feasibility. For each aspect, the validators' ratings were converted into Aiken's V coefficients (Aiken, 1985), which were interpreted with the criteria in Table 1 so that the aspects could be compared.

Table 1. Interpretation criteria for validation and trial results

Criteria	Interpretation Criteria (Questionnaire for Validators)	Interpretation Criteria (Questionnaire for Students)
0,81 – 100	Highly Valid	Very Good
0,61 – 0,80	Valid	Good
0,41 – 0,60	Quite Valid	Enough
0,21 – 0,40	Less Valid	Bad
0,00 – 0,20	Invalid	Very Bad

RESULTS

In an interview on July 20, 2026, the fifth-grade teacher reported using various conventional media and had never used electronic worksheets based on Javanese Unggah-Ungguh local wisdom. Teachers had usually given students only questions, rather than worksheets containing both material and assessments. In the needs analysis questionnaire, 60% of students reported difficulties with the material on rights and obligations. In addition, 40% of students stated that teachers had not used worksheets in their e-learning, and that the main teaching materials were textbooks.

Developed E-Worksheet

The developed e-worksheet was submitted to design experts for validation. Table 2 shows the results of the content and media feasibility test.

Table 2. Test results for content and media feasibility aspects

Item Component	V Criteria	Description
Worksheet coverage	1,00	Highly Valid
Material accuracy	0,83	Highly Valid
Recency	0,83	Highly Valid
Stimulating curiosity	0,83	Highly Valid
Local wisdom based	0,83	Highly Valid
Integration	1,00	Highly Valid
Average	0,89	Highly Valid

** An item is valid if V > the tabled Aiken's V value.*

The worksheet was revised on the basis of expert feedback from the validation test. The observation table was changed, and further work steps and information in the table were added.

Academic Performance E-Worksheet

At this stage, the local-wisdom-based electronic worksheet was tested with students. They read and completed one full theme of the worksheet, after which their learning scores were recorded. The mean scores before and after using the worksheet are shown in Figure 1.

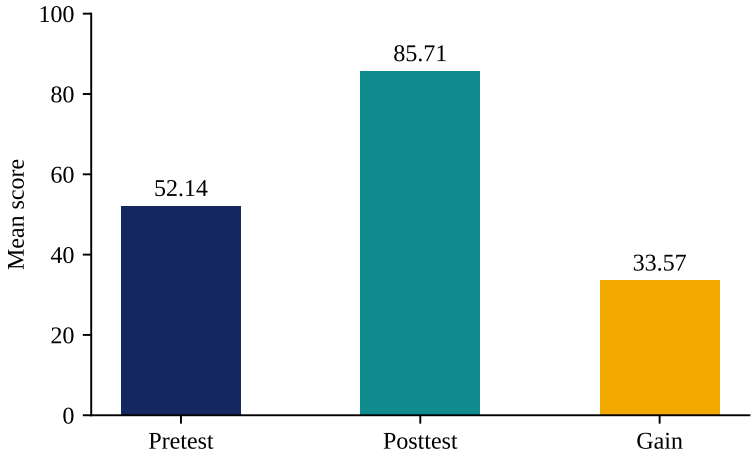

Figure 1. Learning outcome scores

Figure 1 shows that the mean learning score of the 28 students rose from 52.14 on the pretest to 85.71 on the posttest, an increase of 33.57 points.

DISCUSSION

The first finding concerns validity. The experts rated all six aspects of the E-LKPD as highly valid, with Aiken's V values from 0.83 to 1.00 and an average of 0.89 (Table 2). Worksheet coverage and integration received the highest values (V = 1.00), while material accuracy, recency, stimulating curiosity, and local wisdom content each received 0.83. Aiken's V summarizes how far experts agree that an item is relevant to what it is meant to represent (Aiken, 1985). Values of this size are similar to those reported for other expert-validated instruments and E-LKPD in Indonesia (Inanta et al., 2026; Retnawati, 2016). The revision after validation changed the observation table and added work steps and information, and the slightly lower ratings for material accuracy and local wisdom content show where future versions could be strengthened. These ratings show expert agreement on content and design; they are not evidence of learning in themselves.

The second finding concerns learning outcomes. In the main field test, the mean score rose from 52.14 on the pretest to 85.71 on the posttest, a gain of 33.57 points (Figure 1). Expressed as a normalized gain, this corresponds to about 0.70, which falls in the high category (Hake, 1998) and agrees with the N-Gain reported in the abstract. The posttest mean is also above the KKTP benchmark of 75, whereas the baseline class average was well below it. A plausible explanation is that the worksheet changed what students did during the lesson. In the earlier PBL lessons, students watched videos and analyzed images. In the E-LKPD, they had to choose an action in a familiar social situation, such as how to speak to a teacher or a neighbor, and then reflect on its consequences. This is consistent with culturally relevant pedagogy, which holds that students learn more when instruction builds on their own cultural experience (Ladson-Billings, 1995), and with the cognitive theory of multimedia learning, in which learners build understanding by actively processing words and pictures (Mayer, 2014).

The size of the gain is in line with other development studies. Elementary E-LKPD studies reported moderate to high normalized gains (Inanta et al., 2026; Sakinah et al., 2023), and Canva-based media were followed by similar score increases in Grade 5 classes (Aly et al., 2026; Khudin et al., 2025). A meta-analysis of Indonesian experimental studies also found a large effect of interactive multimedia on learning outcomes, with the highest estimate at the elementary level (Khaeruman et al., 2023). The local wisdom component is what distinguishes this worksheet from those studies. Research on unggah-ungguh in elementary schools has mostly addressed character education (Adisti & Rozikan, 2021), and the finding that fifth graders' polite language use was low and declining (Mirmanto et al., 2021) suggests that these values need active teaching. Linking civic rights and obligations to the etiquette that students meet at home and at school may serve both civic and character goals, as reviews of local wisdom-based learning suggest (Jovanda et al., 2026). This study measured only cognitive learning outcomes, however, so any effect on character or behavior remains a design intention rather than a finding.

For teachers at SD Negeri 1 Rengging and similar schools in Jepara, the results suggest that an E-LKPD built on familiar cultural situations can be a practical alternative to video-based presentation for the topic of rights and obligations. Teachers can adapt the scenarios to the etiquette of their own communities, and Canva allows such worksheets to be produced without programming. Principals can support this work by giving teachers time and devices to develop and test local materials, because uneven teacher digital competence, underused infrastructure, and varying school support remain obstacles to technology-based learning under the Kurikulum Merdeka (Afrillia & Dafit, 2025). The sequence used in this study, in which experts review a worksheet and it is revised before classroom use, also offers teachers a simple way to check their own materials before using them with a whole class.

This study has several limitations. The effectiveness test used a one-group pretest-posttest design without a control group, so the gain cannot be attributed to the E-LKPD alone; maturation, repeated testing with the same instrument, and the novelty of a digital worksheet may also have contributed (Shadish et al., 2002). The sample was a single class of 28 students in one school, and the results presented here are limited to mean scores, without standard deviations or effect sizes. The validity evidence rests on a small expert panel, and the number of validators and the critical value used for Aiken's V are not reported. The study also measured cognitive learning outcomes only. Future research should compare the E-LKPD with a control class in several schools, report the full

statistical results and the practicality data in detail, and include measures of students' civic attitudes and polite behavior over a longer period.

CONCLUSION AND RECOMMENDATIONS

The electronic worksheet based on Javanese local wisdom was developed in Canva through a define stage (needs and curriculum analysis), a design stage (worksheet design and instrument construction), a develop stage (validation and revision), and a disseminate stage (worksheet testing). Validation placed the worksheet in the "Highly Valid" category, with an overall content and media validity index of 0.89. In the main field test, the mean learning score rose from 52.14 to 85.71 (Figure 1); because the study had no control group, this gain should be confirmed in a controlled comparison. Further studies are needed to confirm and extend these findings on local-wisdom-based electronic worksheets. Research is also needed on ways to support teachers' creativity in developing multicultural competencies.

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REFERENCES

Adisti, A. R., & Rozikan, M. (2021). Fostering the alpha generation: A character education based on Javanese unggah ungguh (etiquette) culture in madrasah ibtidaiyah. Al-Bidayah: Jurnal Pendidikan Dasar Islam, 13(1), 179–198. https://doi.org/10.14421/al-bidayah.v13i1.256

Afrillia, A., & Dafit, F. (2025). Tantangan guru mengimplementasikan pembelajaran berbasis teknologi digital dalam Kurikulum Merdeka di UPT SDN 023 Pandau Jaya. Pendas: Jurnal Ilmiah Pendidikan Dasar, 10(4), 230-242. https://doi.org/10.23969/jp.v10i04.36163

Aiken, L. R. (1985). Three coefficients for analyzing the reliability and validity of ratings. Educational and Psychological Measurement, 45(1), 131–142. https://doi.org/10.1177/0013164485451012

Aly, Z. M., Wardana, Y. S., & Moh Aniq KHB. (2026). Keefektifan media pembelajaran Canva interaktif terhadap hasil belajar siswa pada materi pernapasan manusia di kelas V sekolah dasar. Pendas: Jurnal Ilmiah Pendidikan Dasar, 11(2), 249–257. https://doi.org/10.23969/jp.v11i02.49721

Az-zarkasyi, M. I. A., & Hindun, H. (2023). Penerapan metode Problem Based Learning (PBL) dalam Kurikulum Merdeka. *GURUKU: Jurnal Pendidikan dan Sosial Humaniora, 2*(1), 69–80. https://doi.org/10.59061/guruku.v2i1.562

Gall, M. D., Gall, J. P., & Borg, W. R. (2007). Educational research: An introduction (8th ed.). Pearson.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. American Journal of Physics, 66(1), 64–74. https://doi.org/10.1119/1.18809

Hanifah, N. Y., Retnasari, L., Wardani, E. K., & Ghiffari, M. A. N. (2025). Implementing problem-based learning to enhance Pancasila Education outcomes in grade IV at elementary school. *Jurnal Cakrawala Pendas*, *11*(1), 240–249. https://doi.org/10.31949/jcp.v11i1.11298

Hidayat, W., & Putro, K. Z. (2024). Implementasi kurikulum merdeka dalam pendidikan Pancasila di sekolah dasar: Profil pelajar sebagai aset bangsa. *Journal of Nusantara Education*, *3*(2), 79–90.

Inanta, I. D., Winarni, E. W., & Muktadir, A. (2026). Pengembangan e-LKPD IPA berbasis inkuiri terbimbing berbantuan Liveworksheets untuk meningkatkan hasil belajar kognitif siswa kelas V SD. Pendas: Jurnal Ilmiah Pendidikan Dasar, 11(2), 281–300. https://doi.org/10.23969/jp.v11i02.52516

Jovanda, R., Paais, R. L., Manafe, M. P., Sundari, L., Dewi, A. R., Ohodo, M. M. R., Chasanah, I. A. W., Pratama, A. H., & Waluyo, H. (2026). Local wisdom-based learning approaches for strengthening students' conceptual understanding and character in Indonesia: A systematic literature review [Version 1; peer review: 1 approved with reservations]. F1000Research, 15, Article 1384. https://doi.org/10.12688/f1000research.188148.1

Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi. (2024a). *Kurikulum Merdeka: Kajian akademik*. Badan Standar, Kurikulum, dan Asesmen Pendidikan.

Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi. (2024b). *Kurikulum Merdeka: Capaian pembelajaran pada fase C*. Kemendikbudristek.

Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi. (2024c). *Panduan mata pelajaran Pendidikan Pancasila*. Kemendikbudristek.

Khaeruman, K., Sudiatmika, A. R., Suma, I. K., & Suardana, I. N. (2023). Meta-analisis: Efektivitas multimedia interaktif terhadap peningkatkan hasil belajar siswa. Bioscientist: Jurnal Ilmiah Biologi, 11(2), 1630–1639. https://doi.org/10.33394/bioscientist.v11i2.9497

Khudin, M. I. M., Dewi, A. L. S., & Erdiana, L. (2025). Pengaruh media Canva terhadap hasil belajar siswa pada pembelajaran Bahasa Indonesia kelas V SD. Pendas: Jurnal Ilmiah Pendidikan Dasar, 10(3), 285–302. https://doi.org/10.23969/jp.v10i03.32641

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. American Educational Research Journal, 32(3), 465–491. https://doi.org/10.3102/00028312032003465

Mayer, R. E. (2014). Introduction to multimedia learning. In R. E. Mayer (Ed.), The Cambridge handbook of multimedia learning (2nd ed., pp. 1–24). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369.002

Mirmanto, N., Prayitno, H. J., Sutopo, A., Rahmawati, L. E., & Widyasari, C. (2021). Pergeseran tindak kesantunan peserta didik kelas 5 sekolah dasar dengan berlatar belakang budaya Jawa [A shift in the politeness actions of grade 5 elementary school students with a Javanese cultural background]. Pedagogia: Jurnal Pendidikan, 10(2), 89–94. https://doi.org/10.21070/pedagogia.v10vi2i.1006

Retnawati, H. (2016). Proving content validity of self-regulated learning scale (The comparison of Aiken index and expanded Gregory index). REID (Research and Evaluation in Education), 2(2), 155–164. https://doi.org/10.21831/reid.v2i2.11029

Sakinah, S., Dewi, R. S., & Hakim, Z. R. (2023). Development of contextual-based E-LKPD to improve the ability to understand fraction concepts. EduBasic Journal: Jurnal Pendidikan Dasar, 5(1), 71–82. https://doi.org/10.17509/ebj.v5i1.51576

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). Experimental and quasi-experimental designs for generalized causal inference. Houghton Mifflin.

Suryaningsih, M. R., & Desstya, A. (2023). Implementasi nilai-nilai profil pelajar Pancasila dalam Kurikulum Merdeka di sekolah dasar. Muallimuna: Jurnal Madrasah Ibtidaiyah, 9(1), 12–26. https://doi.org/10.31602/muallimuna.v9i1.10961

Wilsani, W., Chan, F., Sholeh, M., & Putriani, Z. (2023). Analysis of the implementation of the Pancasila student's profile for strengthening project in the Merdeka Curriculum in Indonesia's elementary schools. At-Taqaddum, 15(2), 126–139. https://doi.org/10.21580/at.v15i2.17884

ICISFS-UMK 2026 EARLY CHILDHOOD & INCLUSIVE EDUCATION

Interactive Flat Panel-Based Learning Model to Improve Early Childhood Expressive Language

Dewi Fatimah[1*], Nur Fajrie[1] and Irfai Fathurohman[1]

[1]*Master of Primary Education, Universitas Muria Kudus, Kudus, Indonesia*

ABSTRACT

Expressive language is a central developmental competency in early childhood because it supports communication, social interaction, and children's ability to express ideas, feelings, and experiences. This study addressed the limited use of Interactive Flat Panel (IFP) technology in systematic, child-centred learning of expressive language. The study aimed to develop an IFP-based learning model, examine its feasibility, and determine its effectiveness in improving children's expressive language skills. The research used a Research and Development (R&D) approach following a ten-step development procedure adapted from Borg and Gall. Effectiveness testing used a quasi-experimental Non-Equivalent Control Group Design. The population comprised 952 kindergarten children in Wedarijaksa District. Purposive sampling selected 25 children aged 5–6 years, with 14 children in the experimental group and 11 in the control group. Data were collected through interviews, observations, questionnaires, documentation, expert validation, and pretest–posttest assessment. Data were analysed descriptively and through normality and homogeneity tests, paired-samples t-tests, and N-gain analysis. The experimental group's mean score increased from 49.993 to 81.736, while the control group increased from 50.518 to 60.609. The paired-samples test for the experimental group yielded $t = 13.061$, $p < .001$. N-gain results showed that 57.1% of children in the experimental group reached the effective category, compared with 0% in the control group. The findings suggest that the IFP-based learning model is a promising, technology-integrated option for encouraging children's verbal participation in early childhood education.

KEYWORDS early childhood | expressive language | Interactive Flat Panel | learning model | technology integration

INTRODUCTION

Early childhood education lays the foundation for language, cognitive, social-emotional, and learning development, and development in these domains is closely connected during the early years (Talango, 2020). At this stage, children learn through direct experience, play, communication, and interaction with adults and peers. Expressive language is particularly important because children need opportunities to communicate ideas, feelings, needs, opinions, and experiences in meaningful contexts, and oral language is also a basis for emergent literacy (Septiani & Syaodih, 2021). Early childhood teachers see oral language as part of their role, but they differ in their knowledge of it and their confidence in supporting it (Weadman et al., 2023). Classroom environments that offer responsive interaction and opportunities for children to talk are therefore essential, and the quality of the support teachers give to children's engagement can be observed and improved through training (Wolf et al., 2025).

Digital technology has widened the options for designing learning environments in early childhood education. Indonesian studies describe a growing use of technology in early childhood classrooms (Prastyaningrum et al., 2023; Soniran, 2024). Digital media can combine visual, auditory, textual, and interactive stimuli, and multimedia learning theory explains how learners build understanding from words and pictures presented together (Mayer, 2014). However, technology itself does not guarantee better learning outcomes. Early childhood settings are expected to build children's digital capabilities and agency rather than only expose them to screens (Wilson et al., 2024). In a survey of Greek parents, every kindergarten child had access to at least one digital device at home, yet parents were unsure which apps were developmentally appropriate (Papadakis et al., 2022). Introducing young children to digital literacy therefore needs adult guidance (Sarifah Hairani et al., 2025). Whether technology becomes meaningful learning support rather than passive screen exposure depends on the pedagogical design, the quality of the content, teacher mediation, interaction patterns, and the suitability of the activities for young children.

The Interactive Flat Panel (IFP) is a relevant platform because it combines large-format visual display, audio-visual materials, touch interaction, animation, and collaborative activities. In early childhood settings, these features can be directed toward active communication: children can observe a stimulus, answer questions, select or manipulate objects, describe experiences, retell information, and respond to teachers and peers. In a kindergarten study, interactive learning multimedia improved children's speaking ability (Rahayu et al., 2022), and interactive multimedia has also been prepared to support early childhood teachers' practice (Rasmani et al., 2023). However, the educational value of an IFP depends on whether it is embedded in a coherent learning model or used only as a presentation device.

The preliminary study for this research indicated that teachers commonly stimulated expressive language through storytelling, conversation, questioning, singing, books, and pictures, but the available media did not consistently engage all children. Teachers and parents expressed a need for more varied, attractive, and interactive learning experiences. Children showed greater interest in images, sounds, videos, animation, and activities that allowed direct interaction. These findings suggest a gap between the availability of digital technology and its systematic pedagogical integration for expressive language development.

Previous studies in Indonesian early childhood settings point in the same direction. Storytelling supported the language development of children aged 5–6 years (Fajari & Zulkarnaen, 2023). Interactive multimedia has been used to support cognitive development (Ayu & Manuaba, 2021), interactive games have been used as learning media (Sari, 2024), and interactive multimedia has been introduced in a community early childhood centre (Wilantoro et al., 2024). An AI-based interactive medium was used to build children's digital literacy (Sari & Salehudin, 2024). A meta-analysis of Indonesian experimental studies estimated a large mean effect of interactive multimedia on learning outcomes (Khaeruman et al., 2023), and in a kindergarten quasi-experiment, children who learned with phonics videos pronounced English words better than children taught with flashcards (Patrisia et al., 2025). Fajrie et al. (2024a) showed that interactive story media can address limitations of conventional learning materials in early childhood education, and Fajrie et al. (2024b) showed how a structured learning model can be tested for effectiveness through a quasi-experimental design.

Teacher readiness is a further condition. Studies of Indonesian early childhood teachers describe uneven readiness to use information technology (Afandi, 2022) and differing perceptions of technological pedagogical and content knowledge (TPACK) in STEM learning (Andriyani Putri et al., 2025). Technology has also been discussed as a support for young children's social skills when it is used in guided and interactive ways (Suryaningsih & Aisyah, 2024). Taken together, these studies show that interactive media can support young children's learning, but most of them evaluated a single medium or activity. Few studies have designed a learning model in which a large interactive display, teacher prompting, and peer interaction are organised around expressive-language goals, and fewer have tested such a model against conventional learning in kindergarten classrooms. The preliminary findings in Wedarijaksa District point to the same gap.

The present study integrates the IFP as a component of a structured learning model rather than as a stand-alone digital medium. The model organizes teacher facilitation, child interaction, multimodal stimuli, and expressive-language activities. The model was developed for kindergarten contexts in Wedarijaksa District and was then compared with conventional learning. This study therefore asks whether an IFP-based learning model can be developed that suits kindergarten children and teachers, whether experts and practitioners judge it feasible, and whether children taught with it improve their expressive language more than children taught conventionally. It offers a development pathway that links needs analysis, product development, classroom implementation, and effectiveness testing.

LITERATURE REVIEW

The conceptual framework positions children's expressive language development as the outcome of meaningful communication experiences. The model assumes that an IFP can strengthen these experiences when visual, audio, animation, and touch-based activities are integrated with teacher prompting and peer interaction. The resulting learning environment is expected to increase children's opportunities to listen, respond, describe, retell, express opinions, and communicate spontaneously.

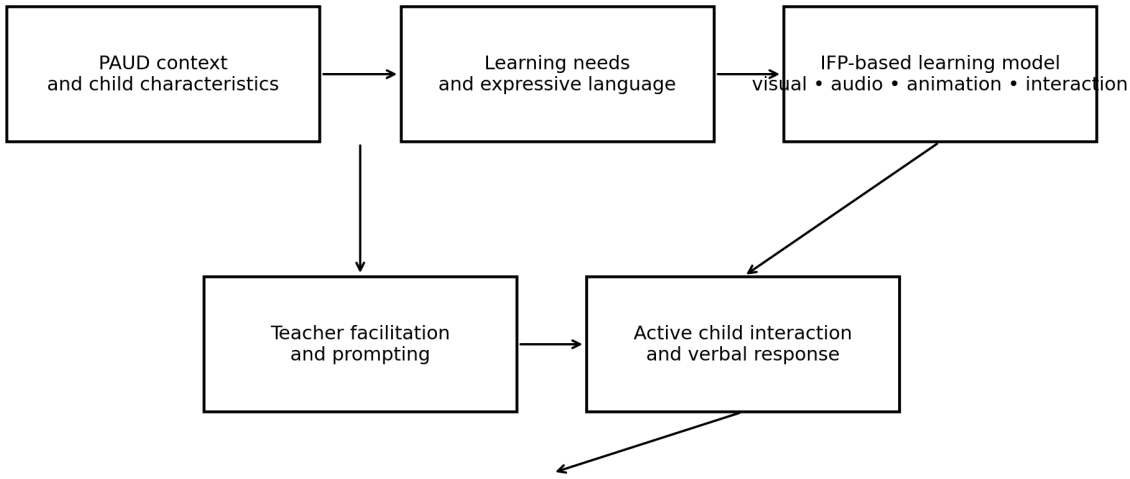

Figure 1. Conceptual framework of the IFP-based learning model.

Research Objectives

This study aimed to: (1) develop a systematic and contextual IFP-based learning model aligned with early childhood characteristics and teacher needs; (2) determine the feasibility of the developed model based on expert assessment and practitioner response; and (3) analyse the effectiveness of the model in improving children's expressive language skills.

RESEARCH METHOD

Research Design

This study used a Research and Development (R&D) design. The development followed ten steps adapted from Borg and Gall (Gall et al., 2007): research and information collecting, planning, development of a preliminary product, preliminary field testing, main product revision, main field testing, operational product revision, operational field testing, final product revision, and dissemination and implementation. Effectiveness was subsequently examined using a quasi-experimental approach with a Non-Equivalent Control Group Design (Shadish et al., 2002). R&D was the overarching method, and the quasi-experiment was used only to test the effectiveness of the product.

Population and Sample

The population consisted of 952 kindergarten children in Wedarijaksa District. Children were selected by purposive sampling based on predefined criteria. The field effectiveness test involved 25 children aged 5–6 years: 14 children in the experimental group and 11 children in the control group. The groups are reported by treatment rather than by school name.

Table 1. Sample and effectiveness-test design.

Group	n	Pretest	Treatment	Posttest
Experimental	14	49.993	IFP-based learning model	81.736
Control	11	50.518	Conventional learning	60.609

Data Collection and Instruments

Data were obtained through semi-structured interviews, structured observations, questionnaires, documentation, expert validation, and expressive-language assessment. The instruments addressed learning needs, teacher readiness, media and model feasibility, implementation, and children's expressive-language performance. Expressive-language indicators included verbal expression of ideas and feelings, vocabulary use, simple sentence construction, storytelling or retelling, answering questions, and communication with teachers and peers.

Data Analysis

Qualitative data from interviews and observations were analysed descriptively to identify needs, implementation characteristics, and responses. Quantitative data were analysed using descriptive statistics. Normality and homogeneity tests were used as prerequisites. Paired-samples t-tests examined pretest–posttest differences within groups, while N-gain (Hake, 1998) was used as a supporting indicator of improvement. For the experimental group, the paired test gave $t = 13.061$, $p < .001$, a significant pretest–posttest difference.

RESULTS

Needs Analysis and Product Development

The preliminary study identified a practical need for learning activities that could encourage children to speak more actively. Teachers reported using storytelling, conversation, questioning, singing, books, and pictures, yet some children remained reluctant to speak, gave short responses, or needed prompts to elaborate. Children were more interested in learning materials containing attractive images, sound, video, animation, and direct interaction. Parents also supported technology use when it was accompanied by teacher or adult guidance and remained aligned with children's developmental needs.

These needs were translated into a model in which IFP functions as an interactive learning environment. The developed materials combine simple text, images, audio, video, animation, and touch-based activities. Each learning sequence includes stimulus and prompting that invites children to name objects, answer questions, express opinions and feelings, tell experiences, retell information, and communicate with peers. The teacher is positioned as a facilitator rather than as the sole source of information, providing follow-up questions, scaffolding, feedback, and encouragement.

Effectiveness of the Model

The experimental group showed a larger increase than the control group. The experimental mean rose from 49.993 at pretest to 81.736 at posttest, an increase of 31.743 points. The control group rose from 50.518 to 60.609, an increase of 10.091 points. Conventional learning also produced an improvement, but the increase was larger with the IFP-based model.

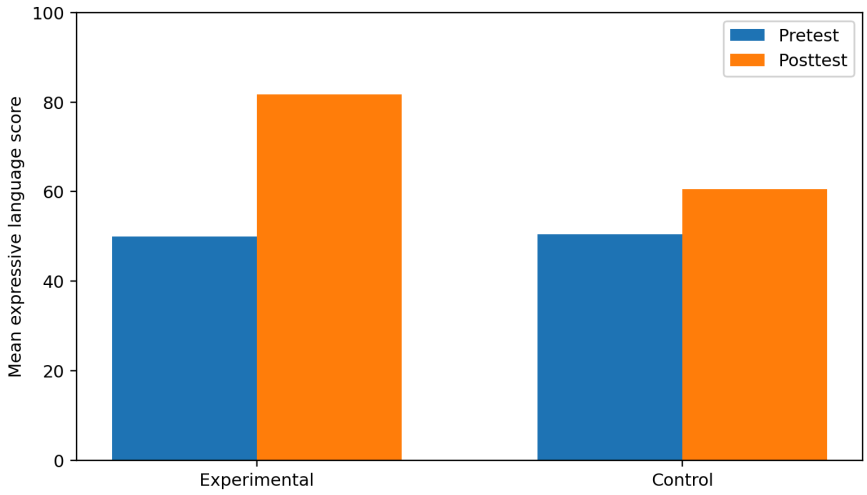

Figure 2. Mean expressive-language scores before and after treatment.

Table 2. Pretest–posttest comparison and paired-samples results.

Indicator	Experimental	Control
Pretest mean	49.993	50.518
Posttest mean	81.736	60.609
Mean increase	31.743	10.091
Paired t-test	t = 13.061; p < .001	t = 4.822; p = .001

The experimental-group paired-samples result ($t = 13.061$; $p < .001$) indicates a statistically significant difference between children's expressive-language scores before and after implementation. The control group also showed a significant within-group difference ($t = 4.822$; $p = .001$), which indicates that conventional learning activities also provided language stimulation. However, the improvement was greater in the experimental group, which suggests that the IFP-based model added value beyond conventional learning.

N-Gain Results

N-gain analysis was used as a supporting measure of improvement. In the experimental group, 8 of 14 children (57.1%) were classified as effective, 6 children (42.9%) as sufficiently effective, and none as less effective. In the control group, no children were in the effective category, 4 children (36.4%) were sufficiently effective, and 7 children (63.6%) were less effective.

Table 3. Distribution of N-gain effectiveness categories.

N-gain category	Experimental	Control
Effective	57.1%	0%
Sufficiently effective	42.9%	36.4%
Less effective	0%	63.6%

DISCUSSION

The first finding concerns the design of the model. The needs analysis showed that teachers already used storytelling, conversation, questioning, singing, books, and pictures, but that some children stayed quiet or gave short answers, and that children were drawn to images, sound, video, animation, and direct interaction. The model responded by placing the IFP inside a sequence of prompts, with the teacher as facilitator. This design is consistent with evidence that multimedia can stimulate children's speaking when interaction is active and pedagogically mediated (Rahayu et al., 2022). It also extends the interactive story media of Fajrie et al. (2024a) by placing interactive stimuli inside a broader learning model rather than treating the digital resource as a stand-alone product. A meta-analysis of guided play supports this choice: when adults guided play, children aged 1–8 years learned spatial vocabulary better than in free play (Skene et al., 2022). The IFP presents words and pictures together (Mayer, 2014), but it is the teacher's questions that turn the display into a prompt for speech.

The second finding concerns effectiveness. The experimental group's mean rose from 49.993 to 81.736, an increase of 31.743 points, while the control group's mean rose from 50.518 to 60.609, an increase of 10.091 points (Table 2). Both within-group changes were significant (experimental $t = 13.061$, $p < .001$; control $t = 4.822$, $p = .001$). The control-group gain shows that regular kindergarten activities also develop expressive language, as expected for children of this age who are taught through storytelling and conversation (Fajari & Zulkarnaen, 2023). The larger gain in the experimental group suggests that the model added language practice beyond regular activities. A plausible mechanism is the number of speaking turns: each IFP sequence asked children to name, answer, explain, and retell, so they produced more spoken language in each session. The paired tests, however, compare each group only with itself. They show that both groups improved, but they do not test whether the experimental group improved more than the control group; that question requires a between-group analysis of posttest or gain scores.

The N-gain results point the same way. In the experimental group, 57.1% of children reached the effective category and none were in the less effective category, whereas in the control group no child reached the effective category and 63.6% were less effective (Table 3). The normalized gain expresses each child's improvement as a share of the improvement that was still possible (Hake, 1998), which makes the comparison fairer when pretest scores differ. Because the two groups started at almost the same level (49.993 and 50.518), the difference between the N-gain distributions mainly reflects different progress during the treatment period rather than different starting points.

These results agree with Rahayu et al. (2022), who found that interactive multimedia stimulated speaking among children aged 5–6 years, although that study used a single group. They are also in line with the kindergarten quasi-experiment of Patrisia et al. (2025), in which phonics videos produced better pronunciation than flashcards, and with the large mean effect of interactive multimedia on learning outcomes in Indonesian studies (Khaeruman et al., 2023). The present study differs from these studies in two ways: the outcome is expressive language rather than pronunciation or general achievement, and the medium is embedded in a learning model with teacher facilitation. The development and testing sequence follows the same logic as Fajrie et al. (2024b), whose early-childhood learning model was tested with a non-equivalent control group design. Fathurohman (2023), in a study of poetry-reading assessment among primary teacher education students, stressed assessing expressive performance through observable aspects of verbal expression. The present instrument likewise scored observable behaviours such as vocabulary use, sentence construction, retelling, and answering questions.

For teachers, the main implication is that the contribution of the IFP lies in the learning opportunities it enables rather than in the device itself. A large interactive screen becomes educationally meaningful when it is connected to purposeful questions, child choice, storytelling, conversation, and teacher scaffolding. This agrees with studies cautioning that young children need guided, developmentally appropriate technology use (Papadakis et al., 2022; Wilson et al., 2024). Kindergartens that adopt the model will also need to address teachers' readiness to use information technology (Afandi, 2022) and their technological pedagogical knowledge (Andriyani Putri et

al., 2025). Parents can extend the model at home, because parents shape the home literacy environment in which young children practise language (Hermawati & Sugito, 2021).

Several limitations qualify these findings. The sample was small (14 and 11 children) and was selected purposively in one district, so the results cannot be generalised to other kindergartens. The groups were intact classes in a non-equivalent control group design, which leaves threats such as selection differences, teacher effects, and novelty effects uncontrolled (Shadish et al., 2002). This article does not report a between-group test, standard deviations, an effect size, or the results of the normality and homogeneity tests, and the feasibility results from expert validation and practitioner responses are not reported. It is also not stated whether the assessors knew which group each child belonged to. Future studies should compare posttest or gain scores between groups with an appropriate test and effect size, include more schools and a delayed posttest, and examine which components of the model (the display, the prompting sequence, or peer interaction) contribute most to children's expressive language.

CONCLUSION AND RECOMMENDATIONS

The study produced an IFP-based learning model designed around the characteristics and needs of early childhood learners and the practical conditions of kindergarten learning in Wedarijaksa District. The model integrates multimodal digital stimuli with teacher facilitation and expressive-language activities, including answering questions, expressing ideas and feelings, storytelling, retelling, and peer communication. The development process used a ten-step R&D procedure adapted from Borg and Gall, and effectiveness was tested separately through a quasi-experimental Non-Equivalent Control Group Design.

The effectiveness findings indicate that expressive language improved more with the model than with conventional learning. The experimental mean increased from 49.993 to 81.736, compared with an increase from 50.518 to 60.609 in the control group. The experimental paired-samples test was significant ($t = 13.061$, $p < .001$), and N-gain classification showed that 57.1% of experimental-group children reached the effective category compared with 0% in the control group. The model is therefore a promising option for technology-integrated expressive-language learning in early childhood.

For teachers and schools, the model should be implemented as a pedagogical sequence rather than as a presentation tool, with adult mediation and developmentally appropriate screen use. Schools adopting the model should consider teacher readiness, infrastructure, content quality, and opportunities for face-to-face communication. Future research should examine the model across more schools and larger samples, refine the learning syntax and assessment indicators, and investigate longer-term effects on children's expressive language.

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REFERENCES

Afandi, A. (2022). Menyongsong era digital: Kesiapan guru dalam teknologi informasi dalam pendidikan anak usia dini. Journal of Practice Learning and Educational Development, 2(4), 140–144. https://doi.org/10.58737/jpled.v2i4.68

Andriyani Putri, D., Hendri Mulyana, E., & Qonita. (2025). Persepsi guru PAUD tentang Technological Pedagogical and Content Knowledge (TPACK) dalam pembelajaran STEM. Jurnal Pendidikan Tambusai, 9(1), 3625–3630.

Ayu, N. K., & Manuaba, I. B. S. (2021). Media pembelajaran Zoolfabeth menggunakan multimedia interaktif untuk perkembangan kognitif anak usia dini. Jurnal Pendidikan Anak Usia Dini Undiksha, 9(2), 194–201. https://doi.org/10.23887/paud.v9i2.35498

Fajari, F. W. U., & Zulkarnaen, Z. (2023). Implementasi perkembangan bahasa anak usia 5–6 tahun melalui metode bercerita. Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini, 7(6), 7933–7939. https://doi.org/10.31004/obsesi.v7i6.5620

Fajrie, N., Nofeca, Y., Utaminingsih, S., & Aliriad, H. (2024a). Bolokuncoro: Photographic story media in interactive learning introduction to local culture literacy for early childhood students. Jurnal Pendidikan Anak Usia Dini Undiksha, 12(1), 120–

128. https://doi.org/10.23887/paud.v12i1.73874

Fajrie, N., Kartika, D. D., Utaminingsih, S., & Santoso, D. A. (2024b). Natural material-based art learning model increases aesthetic experiences in early childhood. Jurnal Pendidikan Anak Usia Dini Undiksha, 12(1), 109–119. https://doi.org/10.23887/paud.v12i1.74612

Fathurohman, I. (2023). Evaluasi penilaian ekspresi keterampilan membaca puisi pada mahasiswa Pendidikan Guru Sekolah Dasar. Jurnal Educatio, 9(2), 515–521. https://doi.org/10.31949/educatio.v9i2.2993

Gall, M. D., Gall, J. P., & Borg, W. R. (2007). Educational research: An introduction (8th ed.). Pearson.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. American Journal of Physics, 66(1), 64–74. https://doi.org/10.1119/1.18809

Hermawati, N. S., & Sugito, S. (2021). Peran orang tua dalam menyediakan home literacy environment (HLE) pada anak usia dini. Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini, 6(3), 1367–1381. https://doi.org/10.31004/obsesi.v6i3.1706

Khaeruman, K., Sudiatmika, A. R., Suma, I. K., & Suardana, I. N. (2023). Meta-analisis: Efektivitas multimedia interaktif terhadap peningkatkan hasil belajar siswa. Bioscientist: Jurnal Ilmiah Biologi, 11(2), 1630–1639. https://doi.org/10.33394/bioscientist.v11i2.9497

Mayer, R. E. (2014). Introduction to multimedia learning. In R. E. Mayer (Ed.), The Cambridge handbook of multimedia learning (2nd ed., pp. 1–24). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369.002

Papadakis, S., Alexandraki, F., & Zaranis, N. (2022). Mobile device use among preschool-aged children in Greece. Education and Information Technologies, 27(2), 2717–2750. https://doi.org/10.1007/s10639-021-10718-6

Patrisia, W., Widayat, E., & Huda, N. (2025). Application of video phonics media towards pronunciation and cognitive development of English learning children of preschool age Saint Nicholas Kindergarten Pantai Indah Kapuk Jakarta. Jurnal Teknologi Pendidikan: Jurnal Penelitian dan Pengembangan Pembelajaran, 10(1), 154–162. https://doi.org/10.33394/jtp.v10i1.14028

Prastyaningrum, I., Ardi, P., & Pratama, F. Y. D. (2023). Analisis pemanfaatan teknologi dalam pembelajaran untuk anak usia dini. EDUKASIA: Jurnal Pendidikan dan Pembelajaran, 4(1), 755–760. https://doi.org/10.62775/edukasia.v4i1.393

Rahayu, M., Rusdiyani, I., & Fadlullah, F. (2022). Efektivitas multimedia pembelajaran interaktif dalam menstimulasi kemampuan berbicara anak usia 5–6 tahun. Tunas Siliwangi, 8(2), 108–114. https://doi.org/10.22460/ts.v8i2p108-114.3175

Rasmani, U. E. E., Wahyuningsih, S., Nurjanah, N. E., Jumiatmoko, J., Widiastuti, Y. K. W., & Agustina, P. (2023). Multimedia pembelajaran interaktif untuk guru PAUD. Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini, 7(1), 10–16. https://doi.org/10.31004/obsesi.v7i1.3480

Sari, B. M. (2024). Permainan interaktif sebagai media pembelajaran pada anak usia dini. EDUKASIA: Jurnal Pendidikan dan Pembelajaran, 5(1), 2049–2058. https://doi.org/10.62775/edukasia.v5i1.1169

Sari, P. N., & Salehudin, M. (2024). Peran teknologi AI PAUDPEDIA sebagai media pembelajaran interaktif dalam meningkatkan literasi digital anak usia dini di TK ABA 3 Samarinda. EDUCASIA, 9(3), 169–179. https://doi.org/10.21462/educasia.v9i3.279

Sarifah Hairani, S., Maureen, I. Y., & Khotimah, N. (2025). Analisis pengenalan literasi digital pada anak usia dini di era abad 21. Indonesian Journal of Early Childhood, 7(1), 215–223. https://doi.org/10.35473/ijec.v7i1.2816

Septiani, N., & Syaodih, E. (2021). Emergent literacy in early childhood. In Proceedings of the 5th International Conference on Early Childhood Education (pp. 52–55). Atlantis Press. https://doi.org/10.2991/assehr.k.210322.012

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). Experimental and quasi-experimental designs for generalized causal inference. Houghton Mifflin.

Skene, K., O'Farrelly, C. M., Byrne, E. M., Kirby, N., Stevens, E. C., & Ramchandani, P. G. (2022). Can guidance during play enhance children's learning and development in educational contexts? A systematic review and meta-analysis. Child Development, 93(4), 1162–1180. https://doi.org/10.1111/cdev.13730

Soniran, S. A. (2024). Integrasi teknologi dalam pembelajaran PAUD: Dampaknya terhadap perkembangan kognitif, sosial, dan emosional anak. Pernik, 7(2), 20–24. https://doi.org/10.31851/pernik.v7i2.17124

Suryaningsih, S., & Aisyah, E. N. (2024). The role of technology in improving early childhood social skills. Education and Sociedad Journal, 1(2), 53–61. https://doi.org/10.61987/edsojou.v1i2.598

Talango, S. R. (2020). Konsep perkembangan anak usia dini. Early Childhood Islamic Education Journal, 1(1), 92–105. https://doi.org/10.54045/ecie.v1i1.35

Weadman, T., Serry, T., & Snow, P. C. (2023). The oral language and emergent literacy skills of preschoolers: Early childhood teachers' self-reported role, knowledge and confidence. International Journal of Language & Communication Disorders, 58(1), 154–168. https://doi.org/10.1111/1460-6984.12777

Wilantoro, S. C. A., Saputro, A., Anif, M., Utama, G. P., & Prasetyo, B. H. (2024). Multimedia interaktif sebagai media pembelajaran di Yayasan Al Karomah Pendidikan Anak Usia Dini (PAUD) Umi Handayani. Indonesian Journal of Education and Computer Science, 2(2), 131–142. https://doi.org/10.60076/indotech.v2i2.679

Wilson, S., Murcia, K., Cross, E., & Lowe, G. (2024). Digital technologies and the early childhood sector: Are we fostering digital capabilities and agency in young children? Australian Educational Researcher, 51(4), 1425–1443. https://doi.org/10.1007/s13384-023-00647-3

Wolf, S., Jukes, M. C. H., Yoshikawa, H., Stern, J., & Kim, S. (2025). Examining the validity of an observational tool of classroom support for children's engagement in learning. Early Childhood Education Journal, 53(4), 1325–1339. https://doi.org/10.1007/s10643-024-01731-8

ICISFS-UMK 2026 EDUCATIONAL LEADERSHIP & MANAGEMENT

Development of a Teacher Supervision Guideline Based on the MAK DARTI Model (Observation, Analysis, Collaboration, Support, Concrete Action, Reflection, Follow-up) in Elementary Schools in Jepara

Dewi Saptariani[1*]

[1]*Master of Basic Education, Universitas Muria Kudus, Indonesia*

ABSTRACT

This study aimed to (1) analyze the need for a MAK DARTI-based teacher supervision handbook, (2) describe its design, (3) assess its feasibility, and (4) examine its effectiveness in improving teachers' teaching skills.

Academic supervision is the assistance given to teachers across the instructional process: planning, implementation and assessment. When it is continuous, it can help teachers resolve instructional problems. Teaching skills are a teacher's ability to manage the classroom and conduct instruction, and they allow teachers to deliver instruction that matches students' development.

This study used a Research and Development (R&D) method following the ADDIE model. Data were obtained from teachers and school principals through questionnaires, observation and documentation. Data validity was established through expert validation and preliminary data analysis. Feasibility was analyzed descriptively from expert validation and principal response percentages.

The results describe teachers' need for guidance activities that can improve teaching skills and the design of the MAK DARTI-based teacher supervision handbook, which comprises Observation, Analysis, Collaboration, Support, Concrete Action, Reflection and Follow-up. Validation by the subject matter expert reached 80% ("suitable"), and validation by the practitioner expert reached 90%, indicating a high level of validity. Principal responses averaged 96.1% ("Highly Feasible"). The guidebook and platform were judged feasible; their effect on teachers' teaching skills still needs to be tested.

KEYWORDS academic supervision | MAK DARTI | teaching skills | Google Sites | ADDIE

INTRODUCTION

Academic supervision is the principal's main means of helping teachers improve classroom practice. It is meant to follow a cycle of planning, classroom observation and follow-up, so that teachers receive concrete feedback on how they plan, deliver and assess lessons (Glickman et al., 2018). Research on school leadership shows why this cycle matters. A meta-analysis of 27 studies found that instructional leadership had a larger average effect on student outcomes than transformational leadership, and that principals' promotion of and participation in teacher learning had the largest effect of the five leadership dimensions examined (Robinson et al., 2008). A review of four decades of research reached a similar conclusion: leadership affects learning mainly indirectly, through the conditions it creates for teachers (Hallinger, 2011). Teacher coaching, which shares supervision's focus on observation and feedback, produced a pooled effect of 0.49 SD on instruction across 60 causal studies (Kraft et al., 2018).

Indonesian studies point in the same direction. In a survey of 64 elementary school teachers in Lebak Regency, principal leadership and academic supervision were each positively related to teacher performance (Starlinsky et al., 2022). Other studies have examined academic supervision as a way to improve teacher competence in primary schools (Fahmi et al., 2019) and distance learning in junior high schools (Ellyta et al., 2022), and have linked teacher performance to training, work motivation, discipline and competence (Alimmudin, 2022; Bastian et al., 2022). Studies of how principals carry out supervision in Indonesian elementary schools

describe its planning, implementation and follow-up and its connection with teacher performance assessment (Haimah, 2019; Halmaida et al., 2022; Ramadhan et al., 2022).

The schools in Mlonggo District, Jepara Regency, show the problems this study addresses. Initial observations in May 2026 in several public elementary schools found that academic supervision by principals fell into the "poor" category (50%), and the teaching skills of 75% of teachers (15 of 20) were only at a "fair" level. In practice, supervision tended to be monotonous and generic. It was treated as a paper-based check of administrative documents (lesson plans, RPP or Modul Ajar) and gave no concrete follow-up on teachers' needs. Principals reported limited time and few supporting resources, and supervision planning was rarely structured, collaborative or humanistic. The six schools in this study (SDN 5 Jambu, SDN 3 Karanggondang, SDN 4 Sekuro, SDN 1 Srobyong, SDN 10 Karanggondang and SDN 1 Sekuro) still kept supervision records on paper, so performance evaluation was slow and the data could not be accessed in real time.

Digital tools offer one way to reduce this administrative load. Google Sites is a free, no-code platform that brings documents, forms and spreadsheets together on one web page. It has been used to support shared knowledge construction in teaching (Ambrós Pallarés & Ramos Sabaté, 2017), to build learning resources for science concepts and process skills (Hidayat et al., 2023) and, in an ADDIE study, to develop web-based science media that experts and users rated as feasible (Ratno et al., 2023). For supervision itself, a collaborative web-based academic supervision model was rated highly feasible by technology and supervision experts (83.33% and 92.9%) and reached 81.4% user satisfaction among principals, teachers and staff (Junirianto et al., 2025). Digital tools also bring demands. Elementary teachers' digital literacy varies (Suwarjo et al., 2022), and principals' digital initiatives can be held back by budget limits, teachers' low digital competence and uneven infrastructure (Ofita et al., 2024).

These studies show that supervision matters and that web platforms for schools can be built and rated as feasible. We found few reports, however, of a supervision model that sets out concrete steps for diagnosis, collaboration, support and follow-up and links each step to a digital record that principals with limited time can manage. This study therefore developed MAK DARTI, a seven-phase supervision model: Mengamati (Observing), Analisis (Analyzing), Kolaborasi (Collaborating), Dukungan (Supporting), Aksi Nyata (Real Action), Refleksi (Reflecting) and Tindak Lanjut (Following Up). The model is delivered through a guidebook and a Google Sites platform linked to Google Drive, Google Forms and Google Sheets, which stores supervision files in the cloud and presents teacher performance data in simple visualizations. Following the ADDIE model (Branch, 2009), the study aimed to analyze the need for the guideline, describe its design, assess its validity and feasibility with experts and principals, and report its trial in public elementary schools in Mlonggo District. The intended contribution is a practical, low-cost supervision guideline that schools with limited resources could adopt.

LITERATURE REVIEW

The conceptual framework links the problems of conventional academic supervision to a proposed solution, the MAK DARTI model integrated with Google Sites, which is intended to improve teachers' instructional skills and school management efficiency.

Input: Existing Baseline and Problems

- **Supervision Constraints:** Academic supervision is often reduced to an administrative routine instead of a tool for professional growth.
- **Paper-based practice:** Principals rely on paper-based tracking, so evaluations are slow and teachers receive no real-time feedback on their performance.
- **Deficit Focus:** Traditional evaluations tend toward fault-finding rather than collaborative, humanistic mentoring.

Process: Two-Pronged Intervention

Pedagogical Modification (MAK DARTI): The conventional supervision cycle is restructured into seven steps:

- *Mengamati (Observing):* direct classroom observation and in-depth interviews.
- *Analisis (Analyzing):* diagnosis of teachers' needs and problems.
- *Kolaborasi (Collaborating):* seeking input from peers and support from others in the school.
- *Dukungan (Supporting):* Providing psychological, moral, and technical backing.
- *Aksi Nyata (Real Action):* applying improved teaching strategies in the classroom.
- *Refleksi (Reflecting):* Joint evaluation to assess strengths and weaknesses.
- *Tindak Lanjut (Following Up):* targeted workshops or mentoring.
- **Technological integration (Google Sites):** Google Sites is the operational platform. This no-code platform hosts the rubrics, stores files (Google Drive), collects inputs (Google Forms) and summarizes performance data (Google Sheets) on cloud-based dashboards.
- **Development model:** The guidebook and the digital system were developed with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model.

Output: Desired Institutional Impacts

- **Teacher competence:** expected progress in core teaching dimensions, including lesson plan design, classroom management and student engagement.
- **Operational efficiency:** less paper use, faster communication between principals and teachers, and structured access to data.
- **School culture:** a collaborative school environment that supports 21st-century digital literacy among principals and teachers.

Research Objectives

The objectives of this research and development study are:

- **To design and develop a structured guidebook** for academic supervision that modifies conventional supervision steps into the 7-phase MAK DARTI model (*Mengamati, Analisis, Kolaborasi, Dukungan, Aksi Nyata, Refleksi, and Tindak Lanjut*) adapted to the operational needs of public elementary schools.
- **To build a digital platform on Google Sites** (interconnected with Google Drive, Forms, and Sheets) that moves the paper-based academic supervision workflow to an efficient, cloud-based and transparent system.
- **To measure the validity and feasibility** of the developed MAK DARTI guidebook and Google Sites platform based on evaluations and feedback from subject-matter and media/technology experts.
- **To evaluate the effectiveness and efficiency** of the digital supervision system in improving the teaching skills of elementary school teachers across the six designated public elementary schools in Mlonggo District.
- To offer a practical, replicable model for educational management that shows how accessible technology can support teachers' professional development and reduce administrative workload.

RESEARCH METHOD

Research Design

This study employs a **Research and Development (R&D)** approach. Development research aims to create a new product or improve an existing one so that the result can be justified scientifically and empirically.

In this study, the R&D framework is used to design, develop and evaluate a model for improving school management practice. Specifically, this research aims to develop a **Guidebook for Academic Supervision Based**

on the MAK DARTI Model Assisted by Google Sites. A descriptive method is used to analyze the data collected during the development process.

Development Model (ADDIE)

This study adopts the **ADDIE model** (Analysis, Design, Development, Implementation, Evaluation). ADDIE is a systematic framework for designing instruction and instructional support.

The ADDIE model was selected for three reasons:

- **Systematic approach:** The model is sequential. Moving through analysis, design, development, implementation and evaluation keeps the research organized.
- **Developmental Flexibility:** ADDIE can be adapted to the needs and local contexts of the elementary schools involved in this study.
- **Emphasis on evaluation:** The model includes evaluation throughout, with formative evaluation *during* development and summative evaluation *after* implementation, which helps to secure product quality and validity.

Operational Phases of the ADDIE Model

The implementation of the five phases of the ADDIE model in this research is detailed below:

Analysis

The first phase diagnoses the problems and identifies needs in the field.

- **Needs Assessment:** Analyzing the current state of academic supervision in Mlonggo District elementary schools, which relies on manual, paper-based, and administration-heavy processes.
- **Performance Analysis:** Examining the current gaps in teachers' instructional skills and the technical constraints faced by school principals.
- **Contextual & Technological Analysis:** Evaluating the readiness of principals and teachers to adopt digital platforms, specifically the Google Sites ecosystem.

Design

The design phase produces the blueprint for the pedagogical model and the technology platform.

- **Drafting the Guideline:** Mapping out the structure of the guidebook based on the 7-step **MAK DARTI** model (*Mengamati, Analisis, Kolaborasi, Dukungan, Aksi Nyata, Refleksi, Tindak Lanjut*).
- **Storyboard & Web Architecture:** Designing the user interface (UI), navigation layout, and user experience (UX) for the Google Sites platform, including the integration plan for Google Forms, Drive, and Sheets.
- **Instrument Design:** Constructing validation sheets for experts, observation rubrics, and evaluation questionnaires.

Development

This phase turns the designs into working products.

- **Production of the Guidebook:** Writing and compiling the physical/digital manuscript of the *MAK DARTI Academic Supervision Guidebook*.
- **Platform Building:** Developing the live Google Sites workspace, setting up cloud storage folders, and embedding data-entry forms and automated visualization sheets.
- **Expert Validation (Formative Evaluation):** Submitting the guidebook and website to content experts (academic supervision specialists) and media/technology experts to evaluate validity, clarity, and usability. Revisions are made based on their feedback.

Implementation

The validated product is tried out in schools.

- **Initial Training:** Holding orientation and technical workshops for selected elementary school principals and teachers in Mlonggo District on how to navigate the MAK DARTI phases via Google Sites.
- **Trial Run:** Carrying out academic supervision using the newly developed guidebook and digital platform during active classroom sessions.

Evaluation

The final phase measures the effectiveness, efficiency and usefulness of the system.

- **Summative Evaluation:** Analyzing data from questionnaires, observation rubrics, and pre-/post-intervention scores to measure improvements in teachers' instructional skills.
- **System Evaluation:** Assessing the efficiency, data accuracy, and user-friendliness of the Google Sites application in reducing administrative burdens.

Respondents of the Study

The research subjects were six public elementary school principals in Mlonggo District, Jepara Regency. These subjects were selected as the primary users and implementation samples for the developed academic supervision guideline. The participating schools are as follows: **SD Negeri 5 Jambu** (5th Public Elementary School of Jambu), **SD Negeri 4 Sekuro** (4th Public Elementary School of Sekuro), **SD Negeri 1 Sekuro** (1st Public Elementary School of Sekuro), **SD Negeri 3 Karanggondang** (3rd Public Elementary School of Karanggondang), **SD Negeri 10 Karanggondang** (10th Public Elementary School of Karanggondang), **SD Negeri 1 Srobyong** (1st Public Elementary School of Srobyong).

Instruments were developed to measure the validity, effectiveness and practicality of the Google Sites-based academic supervision. The data collection instruments for the development of this Google Sites-based academic supervision consist of (a) a validation questionnaire, (b) interview guidelines, and (c) a response questionnaire. Table 1 presents the research instruments, which were adapted, with several modifications, from an earlier instrument.

Table 1. Evaluation aspects, instruments, observed data, and respondents

Measured Aspect	Instrument	Observed Data	Respondents
Validity of Google Sites-based academic supervision	Expert validation questionnaire	Validity of the Mak Darti supervision guidebook, the Google Sites application, and the evaluation rubrics	• Content / Subject-matter experts • Practitioner experts
Needs assessment for the Mak Darti academic supervision guidebook assisted by Google Sites	Interview guide	Perceived ease of use and level of interest in implementing Google Sites-based academic supervision based on interview responses	Trial subjects (Teachers)
Principals' responses toward the Mak Darti academic supervision guidebook assisted by Google Sites	School principal response questionnaire	Completed evaluation forms reflecting the principals' feedback and usability assessment	Trial subjects (School Principals)

RESULTS

This section presents the findings by ADDIE phase and discusses how the MAK DARTI model and the Google Sites platform address administrative constraints and instructional quality.

Research Findings by ADDIE Phase

- **Analysis**: Four baseline issues were identified in the Mlonggo elementary schools: discontinuous supervision by principals, low teacher instructional skills, little variety in teaching, and poorly organized, paper-based data archives.
- **Design:** A three-layer blueprint was formulated: program goals and schedules, a 7-step MAK DARTI pedagogical track built into a 5-portal Google Sites workspace (Cover, Home, MAK DARTI, Aksi Nyata, Refleksi/RTL), and qualitative/quantitative evaluation metrics.
- **Development:** Digital instruments and linked web applications were created. Validation by the main content expert gave a score of 100%, and the content and practitioner experts rated the final platform at

90% after the layout was simplified.

- **Implementation:** Trials were run in six public elementary schools after orientation workshops. Principals gave positive feedback on the structure and usability, while teachers reported a need for ongoing technical training.
- **Evaluation:** The system outcomes showed better scheduling, automated data collation and high satisfaction scores from users.

The principal response questionnaires gave an average score of 96.1%, which places the guidebook and application in the **"Highly Feasible" (Sangat Layak)** category.

Qualitative Feedback: Principals and teachers reported that the system saved time, simplified file organization and made evaluation more encouraging. Principals made two recommendations: one principal requested additional targeted technical workshops to assist users who struggle with technology, and five principals suggested upgrading data security features to safeguard evaluation profiles.

Feasibility Ratings

The ratings of content quality and technical performance indicate that the platform is feasible. Content feasibility scores across various subjects and classes were consistently high, ranging from **93.3% to 98.3%**, suggesting that the material fits current curricular requirements. Technical quality metrics ranged from **83.3% to 100%**, with most classes achieving a perfect 100% score. The lower technical scores (such as 83.3%) were attributed to differing levels of digital literacy among users. The overall composite scores remained between 90% and 97.7%, all in the "Highly Feasible" category. This suggests that the strong content ratings offset the smaller user-side technical differences.

The procedure for this development research employs an R&D model based on the ADDIE framework, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation.

The stages of the ADDIE model, as applied to the development of the Google Sites-assisted, MAK DARTI-based academic supervision guidelines, are shown in the figure below.



Figure 1. Research procedure based on the ADDIE model

DISCUSSION

The first finding concerns validity. The main content expert rated the guidebook at 100%, and the content and practitioner experts rated the final platform at 90% after the layout was simplified. These ratings indicate that the experts judged the seven MAK DARTI phases and the Google Sites structure to be appropriate for elementary school supervision. They are in line with other ADDIE studies of web-based school products, in which expert ratings were also high, for example 100% from the material expert for Google Sites science media (Ratno et al., 2023) and 83.33% to 92.9% for a collaborative web-based supervision system (Junirianto et al., 2025). Expert ratings, however, measure judged quality, not impact. The abstract reports a lower subject-matter expert score (80%) than the Findings (100%), and the number of validators, the rating scale and the aspects rated are not reported, so the validity result should be read with caution. Iterative design approaches treat expert review as one cycle of evaluation that must be followed by evidence from real use (Cennamo & Kalk, 2019).

The second finding is the principals' response. The principal questionnaires averaged 96.1%, in the "Highly Feasible" category, and principals reported that the system saved time, simplified file organization and made evaluation more encouraging. A plausible mechanism is that the platform removes the most time-consuming parts of paper-based supervision: copying, filing and summarizing observation sheets. When form entries go straight into Google Sheets and the results appear on one site, principals can see each teacher's record without collating paper files. This matters in the study schools, where principals reported limited time and where supervision often ended with an administrative check and never reached follow-up. The result is consistent with the 81.4% user satisfaction reported for a web-based supervision model (Junirianto et al., 2025). It also fits the finding that principals contribute most to teaching when they take part in teachers' learning (Robinson et al., 2008), because time saved on paperwork can be spent on classroom visits and feedback. Two cautions apply. The 96.1% figure is a self-report from the six principals who used and tested the product, and no comparison with paper-based supervision was made, so it shows acceptance rather than a measured gain in efficiency.

Third, the MAK DARTI phases change the emphasis of supervision. By placing Kolaborasi (Collaborating) and Dukungan (Supporting) between analysis and action, the model moves away from fault-finding, and the principal acts more as a consultant. This fits the developmental view of supervision, in which the supervisor adjusts the level of direction to the teacher's needs and works with the teacher on improvement (Glickman et al., 2018). It also resembles coaching, which has improved instruction in causal studies (Kraft et al., 2018). The Refleksi and Tindak Lanjut phases respond to the weakness found at baseline, where supervision gave no concrete follow-up. Reviews of teacher evaluation practice (Margolis, 2019) and studies of who should evaluate teachers (Erkan, 2017) show that the choice of evaluator and procedure is itself a design decision. MAK DARTI keeps the principal as the evaluator but adds peer input in the collaboration phase, which may make feedback more acceptable to teachers. Whether these phases change teaching practice was not measured in this study.

Fourth, the technical quality ratings ranged from 83.3% to 100%, and the composite scores from 90% to 97.7%. The lower technical scores were attributed to differences in users' digital literacy, and teachers asked for ongoing technical training. This agrees with a survey of 153 elementary school teachers in Yogyakarta, which found uneven digital literacy and recommended school-provided training (Suwarjo et al., 2022), and with reports that teachers' low digital competence and uneven infrastructure limit principals' digital initiatives (Ofita et al., 2024). Five principals also asked for stronger data security. Because supervision records contain personal evaluations, access to the site should be restricted to the principal and the teacher concerned.

For principals in Jepara, the practical implication is that a free platform can carry the supervision cycle if it is introduced with short, hands-on training and clear rules for data access. For teachers, the collaboration and support phases give a channel to raise their own needs instead of only receiving a score. For the district education office, the guideline could be piloted in more schools in Mlonggo District, which face similar time and resource constraints. Indonesian studies have linked academic supervision with teacher competence and performance (Fahmi et al., 2019; Halmaida et al., 2022; Starlinsky et al., 2022), so a structured, low-cost supervision cycle is a reasonable investment, provided that its effect on teaching is confirmed.

This study has several limitations. The evidence comes from expert validation and the responses of six principals. No pretest-posttest or control-group data on teachers' teaching skills are reported, so the effectiveness of the guideline for improving teaching skills has not yet been shown. The number and qualifications of the validators, the rating instruments and the raw scores are not reported. The principals who rated the product also took part in its trial, which may have raised their ratings. The study covered six schools in one district. Future research should compare teachers supervised with MAK DARTI with teachers supervised in the usual way, using the observation rubrics before and after the intervention, report effect sizes, and examine whether any benefits last beyond one supervision cycle.

CONCLUSION AND RECOMMENDATIONS

Based on the results and discussion of the development of a *Mak Darti*-based academic supervision guidebook supported by Google Sites, the following conclusions can be drawn:

- The development of the *Mak Darti*-based academic supervision guidebook, supported by Google Sites, supports more efficient digital management, documentation and oversight of academic activities than conventional methods. This is supported by interviews with school principals, who noted that the guidebook makes the implementation of academic supervision more practical and structured.
- The *Mak Darti*-based academic supervision guidebook, supported by Google Sites, is highly feasible for evaluating the teaching skills of educators in elementary schools within the Mlonggo District. This is supported by validation results from subject matter experts and practitioners, as well as feedback from school principals, all of which rated the resource as "highly feasible."

Recommendations

Based on the research results and discussion, the following recommendations are offered:

- **For teachers:** Teachers who are not yet familiar with the *Mak Darti* framework or the use of Google Sites are encouraged to participate in additional training or guidance to improve their digital skills. This will enable them to overcome technical challenges and utilize the guidebook and application with greater confidence.
- **For school principals:** School principals should conduct periodic monitoring and evaluation of the implementation of the *Mak Darti*-based academic supervision guidebook. This will help ensure that the *Mak Darti* framework and the application are fully used to support teaching and learning, and that shortcomings are corrected as they arise.
- **For future research:** To enhance the security of data uploaded to the application, future research should apply strict access controls through the "restricted" access setting. Additionally, researchers could provide video tutorials to assist new users in understanding how to navigate the application and to improve teachers' competence in using technology.

REFERENCES

Alimmudin, A. (2022). The effect of teacher competence, work discipline and work motivation on teacher performance. International Journal of Social Science and Human Research, 5(6). https://doi.org/10.47191/ijsshr/v5-i6-67

Ambrós Pallarés, A., & Ramos Sabaté, J. M. (2017). El uso didáctico de Google Sites en la construcción compartida del conocimiento. RESED. Revista de Estudios Socioeducativos, (5), 63–74. https://doi.org/10.25267/Rev_estud_socioeducativos.2017.i5.07

Bastian, A., Nasution, J. A., & Wahyuni, S. (2022). Teacher performance under the influence of training, work motivation and teacher competence. Al-Ishlah: Jurnal Pendidikan, 14(3), 3601–3612. https://doi.org/10.35445/alishlah.v14i3.2189

Branch, R. M. (2009). Instructional design: The ADDIE approach. Springer. https://doi.org/10.1007/978-0-387-09506-6

Cennamo, K., & Kalk, D. (2019). Real world instructional design: An iterative approach to designing learning experiences (2nd ed.). Routledge.

Ellyta, E., Murniati, M., & Usman, N. (2022). The effectiveness of academic supervision of principal in improving distance learning in junior high school. Al-Ishlah: Jurnal Pendidikan, 14(4), 5363–5372. https://doi.org/10.35445/alishlah.v14i4.744

Erkan, T. (2017). Who should evaluate teachers' performance at schools? Journal of Education and Practice, 8(29), 168–177.

Fahmi, C. N., Murniati, A. R., Nurliza, E., & Usman, N. (2019). The implementation of academic supervision in improving teacher competency at primary school. Jurnal Ilmiah Peuradeun, 7(1), 181–194. https://doi.org/10.26811/peuradeun.v7i1.202

Glickman, C. D., Gordon, S. P., & Ross-Gordon, J. M. (2018). SuperVision and instructional leadership: A developmental approach (10th ed.). Pearson.

Haimah, H. (2019). Academic supervision by school principals at state elementary schools in Indonesia. In Proceedings of the International Conference on Educational Sciences and Teacher Profession (ICETeP 2018) (pp. 34–37). Atlantis Press. https://doi.org/10.2991/icetep-18.2019.9

Halmaida, H., Yusrizal, Y., & Niswanto, N. (2022). Implementation of academic supervision and teacher performance assessment. Al-Ishlah: Jurnal Pendidikan, 14(3), 4209–4216. https://doi.org/10.35445/alishlah.v14i3.2249

Hallinger, P. (2011). Leadership for learning: Lessons from 40 years of empirical research. Journal of Educational Administration, 49(2), 125–142. https://doi.org/10.1108/09578231111116699

Hidayat, H., Hidayat, O. S., & Widiasih, W. (2023). Development of Google Sites-based learning resources to improve mastery of concepts and process skills in electrical circuit materials. Jurnal Penelitian Pendidikan IPA, 9(6), 4624–4631. https://doi.org/10.29303/jppipa.v9i6.3612

Junirianto, F., Dwikurnaningsih, Y., & Sanoto, H. (2025). Development of a collaborative web-based academic supervision model to improve learning quality. Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran, dan Pembelajaran, 11(2), 713–722. https://doi.org/10.33394/jk.v11i2.14997

Kraft, M. A., Blazar, D., & Hogan, D. (2018). The effect of teacher coaching on instruction and achievement: A meta-analysis of the causal evidence. Review of Educational Research, 88(4), 547–588. https://doi.org/10.3102/0034654318759268

Margolis, A. A. (2019). Teacher performance evaluation: A review of best foreign practices. Psychological Science and Education, 24(1), 5–30. https://doi.org/10.17759/pse.2019240101

Ofita, C., Komariah, A., & Abubakar, A. (2024). Assessing digital leadership of junior high school principals. Journal of Educational Management and Instruction, 4(1), 127–139. https://doi.org/10.22515/jemin.v4i1.9502

Ramadhan, A. H., Winata, C., Bancin, N. Z., Dewi, P., Mulyani, S., Pratiwi, T., & Nasution, I. (2022). Implementing of education supervision at school of SDN 112304 Panigoran. Edumaspul: Jurnal Pendidikan, 6(2), 1512–1520.

https://doi.org/10.33487/edumaspul.v6i2.4362

Ratno, S., Sijabat, M. P., Sitorus, L., Salsabilla, S., Batubara, A., Nasution, N. A., & Syazidah, H. (2023). Pengembangan media pembelajaran berbasis web Google Sites pada pembelajaran IPA sekolah dasar materi sifat-sifat cahaya kelas V. School Education Journal PGSD FIP UNIMED, 13(4), 370–379. https://doi.org/10.24114/sejpgsd.v13i4.54851

Robinson, V. M. J., Lloyd, C. A., & Rowe, K. J. (2008). The impact of leadership on student outcomes: An analysis of the differential effects of leadership types. Educational Administration Quarterly, 44(5), 635–674. https://doi.org/10.1177/0013161X08321509

Starlinsky, L., Belawati, T., & Rosita, T. (2022). Korelasi antara kepemimpinan kepala sekolah dan supervisi akademik terhadap kinerja guru sekolah dasar di Kecamatan Lebakgedong Kabupaten Lebak. Indonesian Journal of Educational Counseling, 6(1), 26–33. https://doi.org/10.30653/001.202261.190

Suwarjo, S., Haryanto, H., Wuryandani, W., Mahfuzah, A., Hidayah, R., & Erviana, V. Y. (2022). Digital literacy analysis of elementary school teachers on distance learning instructional process in Yogyakarta. Al-Ishlah: Jurnal Pendidikan, 14(2), 1145–1156. https://doi.org/10.35445/alishlah.v14i2.1233

ICISFS-UMK 2026 EDUCATIONAL TECHNOLOGY & MEDIA

Developing Holokulo 3D Hologram Media for Mathematical Reasoning

Septiana Farikhatun[1*], Santikasari[2] and Dian Kurniawati[3]

[1]*Universitas Muria Kudus, Indonesia*
[2]*SD 1 Sadang Kudus, Indonesia*
[3]*SD 2 Sadang Kudus, Indonesia*

Corresponding author: 202403138@std.umk.ac.id

ABSTRACT

Mathematical reasoning in elementary geometry requires students to interpret and connect spatial representations, yet three-dimensional objects such as cubes and rectangular prisms are often taught with two-dimensional pictures, which may limit students' spatial understanding. This study aimed to develop Holokulo and examine its effectiveness. Holokulo is a 3D hologram-based learning medium designed to support mathematical reasoning in sixth-grade elementary school students. The study employed a Research and Development (R&D) approach using the ADDIE model, comprising analysis, design, development, implementation, and evaluation. The product consisted of a hologram pyramid and four-sided visualization videos depicting cubes and rectangular prisms. Data were collected through observation, interviews, questionnaires, expert validation, and mathematical reasoning tests. The effectiveness analysis compared pretest and posttest scores between control and experimental groups using normalized gain (N-Gain) and an independent-samples t-test. The pretest data were normally distributed and homogeneous, and the groups showed no significant difference in initial mathematical reasoning ability ($p = 0.414 > 0.05$). The mean N-Gain was 0.439 for the control group and 0.628 for the experimental group, both categorized as moderate. The difference in N-Gain between groups was statistically significant ($p = 0.017 < 0.05$), indicating greater improvement in the experimental group. These findings suggest that Holokulo 3D hologram media can support students' mathematical reasoning when they learn about cubes and rectangular prisms.

KEYWORDS 3D hologram | elementary mathematics | Holokulo | mathematical reasoning | spatial visualization

INTRODUCTION

Mathematical reasoning is a core competency in mathematics learning. It enables students to analyze problems, identify relationships, construct logical arguments, and draw conclusions. In elementary mathematics, geometry provides opportunities to develop this competency through spatial visualization and the understanding of three-dimensional objects. However, lessons on cubes and rectangular prisms often rely on two-dimensional textbook illustrations. These may hinder students' understanding of spatial relationships among faces, edges, and vertices. Visual representations support mathematical understanding, particularly when students encounter abstract concepts (Aurelia et al., 2026).

The problem matters in Indonesia, where international assessments such as PISA show relatively low mathematics performance. A review of 20 Indonesian and Scopus-indexed articles found that mathematical reasoning in elementary school has received limited research attention in recent years, and that geometry was among the most frequently studied topics in this small body of work (Hs et al., 2023). Reasoning about solid figures is therefore both a weak point for students and an open area for research.

Learning media can present abstract mathematical concepts in more concrete and engaging forms, and varied media can support learning (Yu et al., 2024). In preliminary interviews, a sixth-grade teacher at SD 1 Sadang, Kudus, reported that students had difficulty visualizing cubes and rectangular prisms because the materials were primarily presented through two-dimensional images. This points to a need for learning media that represent three-dimensional objects more clearly and support students' spatial understanding.

Hologram technology offers an alternative for presenting three-dimensional objects from different perspectives. Previous studies have explored its use in education. Safitri and Djuniadi (2021) developed 3D

hologram media for learning about coconut plants, Imran et al. (2022) developed hologram-based video media for classroom learning, and Ferdiansyah et al. (2022) built smartphone-based 3D objects for a hologram pyramid on the human movement system. Abdi et al. (2022) designed a 3D hologram as an information medium for introducing mammals. In mathematics education, Lukman et al. (2020) reported improvements in students' mathematical visual abilities through the use of Holo-Math media. Research by Mawardani et al. (2021) indicated that hologram simulation could support students' mathematical representation abilities. These findings suggest that hologram media can support learning, particularly the visualization of complex concepts.

Advances in hologram technology allow learning materials to be presented as three-dimensional images. Ahmad et al. (2021) described how hologram technology can present educational content in a fuller visual form and reported positive user acceptance of holographic displays as an alternative to conventional two-dimensional materials. Similarly, Sugiharto (2020) developed an Android-based 3D hologram application that gives a more realistic representation than static textbook illustrations. In science education, Agustian and Setiawan (2024) developed hologram media on the motion of objects for junior high school physics to improve learning outcomes, and Salloum et al. (2024) examined the adoption of 3D holograms in science classrooms. Turk and Seckin-Kapucu (2021) examined students' attitudes and perspectives toward digital holography as an educational medium. These studies suggest that holographic visualization can make abstract content more concrete, engaging, and accessible to students.

Previous research has also explored the use of hologram-based media across different educational contexts. Mohammad et al. (2023) discussed how holograms may enhance learning experiences and student interaction and identified issues to consider when institutions adopt them. At the secondary school level, Nurrahman et al. (2024) found that the use of 3D hologram pyramid media significantly influenced students' interest in learning about volcanism. Yulita and Aryani (2025) introduced a simple hologram learning medium made from recycled materials as an alternative for elementary science instruction, particularly in schools with limited access to projectors.

Reviews point in the same direction but add cautions. Cantikasari and Widarti (2024) reviewed 20 studies published between 2018 and 2024 on hologram technology in education and described both opportunities and challenges for its use. Yulita and Aryani (2025) showed that a hologram display can be made cheaply, which matters for schools with limited equipment. Evidence from augmented reality, a related form of three-dimensional visualization, is stronger for geometry: Nadzeri et al. (2024) reported gains in primary pupils' spatial visualization, and a review of 29 studies found that augmented reality in elementary education was associated with better motivation, understanding and thinking skills (Tarmidzi et al., 2025). In contrast, Fokides and Bampoukli (2024) found that pyramid hologram projections raised primary pupils' enjoyment but not their knowledge acquisition compared with conventional videos.

Three gaps follow from this literature. Most hologram studies concern science topics or information display rather than mathematics. The mathematics studies were conducted in junior high school (Lukman et al., 2020) or did not test reasoning against a comparison group (Septiana et al., 2020). Few studies have therefore designed 3D hologram media specifically for sixth-grade students' mathematical reasoning about cubes and rectangular prisms and tested them against regular instruction. This study therefore develops Holokulo 3D Hologram Media, consisting of a hologram pyramid and visualization videos presenting cubes and rectangular prisms from multiple perspectives. The media are designed to help students understand spatial relationships and to strengthen their mathematical reasoning.

This study aims to develop Holokulo 3D hologram media using the ADDIE model and to examine its validity, practicality, and effectiveness in supporting sixth-grade students' mathematical reasoning. It addresses three questions: what students and teachers need from such media, whether experts and users judge the media valid and practical, and whether students who learn with the media gain more in mathematical reasoning than students in a control group. The study is expected to contribute to technology-based learning media for elementary mathematics, particularly geometry.

LITERATURE REVIEW

In elementary schools, lessons on cubes and rectangular prisms are often limited to two-dimensional representations. This makes it difficult for students to understand spatial relationships and to develop mathematical reasoning. Visual representations support mathematical understanding (Aurelia et al., 2026). In this study, reasoning is understood as identifying relevant concepts, thinking logically and systematically, formulating arguments, and drawing and justifying conclusions, which are the aspects measured by the reasoning test.

Holokulo 3D Hologram Media is proposed as an alternative. By presenting cubes and rectangular prisms through three-dimensional holographic visualization, the media are expected to facilitate students' spatial understanding and mathematical reasoning. Previous studies have reported the potential of hologram media to support mathematical visualization and representation (Lukman et al., 2020; Mawardani et al., 2021; Septiana et al., 2020).

The media were developed with the ADDIE model and evaluated in terms of validity, practicality, and effectiveness.

The conceptual framework illustrates the relationship between the development of Holokulo 3D hologram media and the improvement of students' mathematical reasoning in solid geometry. The ADDIE model provides a systematic instructional design process through which learning needs are identified, media are designed and developed, and their implementation and effectiveness are evaluated. Three-dimensional holographic visualization is intended to help students understand the spatial characteristics of cubes and rectangular prisms: their faces, edges, vertices, and the relationships among them. This approach is supported by Yang et al. (2025), who stressed the importance of spatial skills in mathematics learning. They identified augmented reality as a promising way to develop spatial skills, although its effectiveness depends on instructional design and context. Walkington et al. (2025) found that immersive three-dimensional representations can support students' initial understanding of geometric shapes and noted the importance of aligning visualization tools with specific reasoning objectives. Octaria et al. (2025) reported that elementary students' difficulties in three-dimensional geometry are associated with visualization, reasoning, and conceptual understanding. This indicates a need for teaching approaches that combine visual representations with reasoning activities. Accordingly, Holokulo 3D hologram media are conceptualized as a way to connect three-dimensional visualization with mathematical reasoning, developed and evaluated systematically.

Research Objectives

This study aims to identify the needs for developing Holokulo 3D hologram media for cube and rectangular prism visualization in sixth-grade elementary mathematics, develop the media using the ADDIE model, and determine its validity and practicality based on expert assessments and user responses. It also evaluates the effectiveness of Holokulo 3D hologram media in improving sixth-grade students' mathematical reasoning abilities in learning cube and rectangular prism visualization.

RESEARCH METHOD

Research Design

This study employed a Research and Development (R&D) approach to develop Holokulo 3D hologram media on cubes and rectangular prisms to improve sixth-grade students' mathematical reasoning. The development process followed the ADDIE model (Branch, 2009), which consists of five stages: analysis, design, development, implementation, and evaluation. The study also examined the validity, practicality, and effectiveness of the developed media.

Research Procedures

The research procedures were organized according to the ADDIE model. In the analysis stage, observations and interviews were conducted to identify students' learning needs, initial mathematical reasoning abilities, and difficulties in visualizing cubes and rectangular prisms. The design stage involved planning the learning media, including the hologram pyramid and four-sided visualization videos. During the development stage, the media were produced and validated by material and media experts, followed by revisions based on their feedback. In the implementation stage, the media were tested in mathematics learning with sixth-grade students. Finally, the evaluation stage assessed the validity, practicality, and effectiveness of the media, and improvements were made based on the data.

Sources and Types of Data

The data sources consisted of primary and secondary data. Primary data were obtained from the sixth-grade teacher, school principal, material expert, media expert, and students of SD 1 Sadang, Kudus Regency. The participants were 26 sixth-grade students. Secondary data were collected from relevant literature, previous studies, books, articles, school documents, and students' learning records. The study used both quantitative and qualitative data. Quantitative data included expert validation scores, questionnaire responses, and mathematical reasoning test scores, while qualitative data consisted of interview transcripts, observation notes, and suggestions from experts and research participants.

Data Collection Techniques

Data were collected through literature review, observation, interviews, questionnaires, and mathematical reasoning tests. The literature review provided theoretical foundations for media development. Observations were conducted to examine students' learning characteristics, classroom activities, and difficulties during implementation. Interviews with the school principal and teacher were used to identify learning needs and curriculum-related considerations. Questionnaires were administered to material and media experts to assess product validity and to students and teachers to evaluate practicality. Mathematical reasoning tests were given before and after the implementation to measure students' improvement.

Research Instruments

The research instruments included interview guides, expert validation questionnaires, student response questionnaires, observation sheets, and mathematical reasoning tests. The material expert questionnaire assessed instructional suitability and content accuracy, while the media expert questionnaire evaluated visual presentation and technical aspects. The student questionnaire consisted of 20 items addressing motivation, attractiveness, ease of use, and perceived benefits. Observation sheets were used to record students' activities, difficulties, and implementation challenges. The mathematical reasoning test measured students' abilities to understand mathematical concepts, think logically and systematically, formulate arguments, determine strategies, and draw conclusions.

Data Analysis

Quantitative and qualitative data were analyzed descriptively and statistically. Qualitative data from interviews, observations, and expert suggestions were analyzed descriptively to identify learning needs, implementation challenges, and opportunities for product revision.

Product validity was analyzed using expert assessment scores on a Likert scale. The validity percentage was calculated by comparing the obtained scores with the maximum possible scores. The results were interpreted with the following feasibility criteria: 68–100% (feasible without revision), 34–67% (feasible with revision), and 0–33% (not feasible).

Practicality was analyzed using questionnaire responses from teachers and students. The practicality percentage was calculated as:

$$P = \frac{F}{N} \times 100\%$$

where P represents the practicality percentage, F is the obtained score, and N is the maximum score. The results were categorized as very practical (81–100%), practical (61–80%), moderately practical (41–60%), less practical (21–40%), and impractical (0–20%).

The effectiveness of the media was examined using normalized gain (N-Gain) based on pretest and posttest mathematical reasoning scores:

$$g = \frac{\text{Posttest score} - \text{Pretest score}}{\text{Maximum score} - \text{Pretest score}}$$

The N-Gain scores were used to assess students' improvement in mathematical reasoning and were categorized as low (< 0.3), moderate (0.3–0.7), or high (> 0.7) (Hake, 1998). The differences in learning gains between the control and experimental groups were analyzed using an independent-samples t-test. Normality and homogeneity tests were performed first to check the assumptions of the t-test. A significance level of 0.05 was applied to determine whether the differences between groups were statistically significant.

RESULTS

This section reports the effectiveness of Holokulo 3D hologram media for sixth-grade students' mathematical reasoning about cubes and rectangular prisms. The analysis focused on pretest equivalence, learning improvement measured by N-Gain, and differences in learning gains between the control and experimental groups.

Table 1. Summary of research findings

Analysis	Results	Interpretation
Pretest normality	Data were normally distributed	Normality assumption was satisfied
Pretest homogeneity	Data were homogeneous	Homogeneity assumption was satisfied
Pretest comparison	P = 0.414 > 0.05	No significant difference in initial mathematical reasoning ability
Mean N-Gain of the control group	0.439	Moderate improvement
Mean N-Gain of the experimental group	0.628	Moderate improvement
N-Gain comparison	P = 0.017 < 0.05	Significant difference in learning gains
Overall effectiveness	Experimental group showed higher improvement	Holokulo 3D hologram media supported mathematical reasoning development

The pretest analysis indicated that the control and experimental groups had comparable initial mathematical reasoning abilities. The independent-samples t-test produced a significance value of 0.414, which exceeded the 0.05 threshold. After the intervention, both groups showed moderate improvement, but the experimental group achieved a higher mean N-Gain of 0.628 than the control group, which obtained 0.439. The difference was statistically significant (p = 0.017), indicating greater improvement in mathematical reasoning among students who used Holokulo 3D hologram media.

DISCUSSION

The findings suggest that Holokulo 3D hologram media contributed to students' improvement in mathematical reasoning about cubes and rectangular prisms. The absence of a significant pretest difference (p = 0.414) suggests that the groups had comparable initial abilities. The higher N-Gain of the experimental group can therefore be attributed, at least in part, to the hologram-based intervention. Because the groups were intact classes and the group sizes are not reported, this attribution remains tentative.

The experimental group's mean N-Gain of 0.628 was higher than that of the control group (0.439), although both were categorized as moderate. This difference may be related to the media's ability to show three-dimensional objects from several perspectives. Such representations can help students interpret spatial relationships and develop a more meaningful understanding of geometric structures. Similar reasoning lies behind Hakiki et al. (2022), who combined augmented reality and holograms to make three-dimensional molecular

shapes visible in chemistry, and behind Aurelia et al. (2026), who linked primary students' use of visual representations to their success with fraction word problems.

The statistically significant difference in N-Gain ($p = 0.017$) supports the effectiveness of Holokulo for developing mathematical reasoning. This finding is consistent with previous research on hologram-based mathematics learning. Lukman et al. (2020) reported that Holo-Math media improved junior high school students' mathematical visual abilities, while Mawardani et al. (2021) described the contribution of hologram simulation to mathematical representation ability. These studies support the use of holographic visualization as a learning resource for mathematical concepts.

A likely mechanism lies in what the four-sided videos let students do. In a textbook drawing, some faces, edges and vertices of a cube are hidden, and students must infer them. In the hologram, the object rotates and every face can be seen in turn, so students can count and compare its parts directly and then explain why a cube and a rectangular prism differ. These are the steps of reasoning the test measured: identifying concepts, arguing logically and drawing conclusions. This interpretation is consistent with Octaria et al. (2025), who traced elementary students' errors in three-dimensional geometry to weak visualization and reasoning, and with Walkington et al. (2025), who found that three-dimensional displays helped students' early understanding of shapes but that the benefit depended on matching the display to the reasoning task. Yang et al. (2025) reached a similar conclusion for spatial skills, noting that the effect of three-dimensional technology depends on instructional design.

Nevertheless, the findings should be interpreted within the context of the study. Fokides and Bampoukli (2024) found that pyramid hologram projections increased students' enjoyment and motivation, although they did not produce significantly higher knowledge acquisition than conventional videos. This suggests that the effect of hologram media may depend on how it is integrated with learning activities and objectives as much as on the visual technology itself.

Nadzeri et al. (2024) found that augmented reality applications improved primary school pupils' spatial visualization abilities in geometry, with the experimental group achieving higher mean scores than the control group. Similarly, Buchori et al. (2023) reported that interactive augmented reality-based GeoGebra media contributed to improved geometry learning outcomes, as indicated by a higher N-Gain score in the experimental group compared with the control group. Izzati et al. (2026), through a systematic review of augmented reality in primary mathematics education, identified positive effects on spatial visualization, mental rotation, and spatial reasoning. The review stressed the value of interactive visual representations for geometric understanding. A review of 29 studies likewise found that augmented reality in elementary schools was associated with gains in understanding and thinking skills (Tarmidzi et al., 2025). These findings are consistent with the present study, in which the experimental group showed a significantly higher N-Gain than the control group.

The size of the gain also deserves comment. Under the criteria of Hake (1998), an N-Gain of 0.628 is moderate and close to the upper limit of that band, whereas 0.439 lies in its middle. Other elementary development studies report gains of a similar order: Putri et al. (2026) found a moderate N-Gain of 0.38 in critical thinking after discovery learning with 17 sixth-grade students, and Firman et al. (2024) reported a high N-Gain of 0.77 for a problem-solving e-module with 26 fifth-grade students. Neither of these studies used a control group, so the present design, which compares an experimental group with a control group that started at the same level, gives a firmer basis for attributing the difference to the media. The control group also improved moderately, which shows that regular instruction on cubes and rectangular prisms produced learning; the hologram media added to that gain rather than producing it alone.

These results have practical implications for elementary schools in Kudus and similar settings. A hologram pyramid is inexpensive and can be used with a smartphone or tablet, so teachers do not need specialized equipment (Yulita & Aryani, 2025). However, the evidence from Fokides and Bampoukli (2024) suggests that projection alone is not enough. Teachers should pause the videos, ask students to count and name faces, edges and vertices, and ask them to justify how the two solids differ. Principals and teacher groups can support this by

sharing the media and lesson plans across classes, since the media cover the sixth-grade content on cubes and rectangular prisms.

Overall, Holokulo 3D hologram media offer an alternative for elementary mathematics instruction, particularly for teaching spatial visualization. Its use may help students move beyond static two-dimensional representations toward a more comprehensive understanding of three-dimensional geometric objects. Several limitations should be noted. The sample was small and came from one school, and the size of each group is not reported. The groups were intact classes rather than randomly assigned. The length of the intervention is not reported, and no delayed posttest was given, so the durability of the gain is unknown. This paper reports N-Gain means and p-values but not the pretest and posttest means, standard deviations, t values or effect sizes. The expert validity and teacher and student practicality results, which the method describes, are also not reported here. Future studies should use larger samples from several schools, report full descriptive statistics and effect sizes, include a delayed test, and examine whether the media also improve spatial visualization measured with a separate instrument.

CONCLUSION AND RECOMMENDATIONS

The findings indicate that Holokulo 3D hologram media can support elementary school students' mathematical reasoning when they visualize cubes and rectangular prisms. The pretest analysis showed that the control and experimental groups had comparable initial mathematical reasoning abilities ($p = 0.414 > 0.05$). The experimental group achieved a higher mean N-Gain score (0.628) than the control group (0.439), with both scores categorized as moderate. The significant difference in N-Gain scores ($p = 0.017 < 0.05$) indicates that students who learned with Holokulo 3D hologram media improved more in mathematical reasoning than those who received conventional instruction. These results suggest that three-dimensional holographic visualization can facilitate students' understanding of geometric structures and support the development of spatial visualization and mathematical reasoning skills. Holokulo 3D hologram media may therefore serve as an alternative resource for elementary mathematics, particularly geometry.

Based on the research findings, Holokulo 3D hologram media are recommended for use by elementary school teachers as a supplementary instructional resource for teaching cubes and rectangular prisms. Teachers are encouraged to integrate holographic visualization with guided inquiry, mathematical discussions, and problem-solving activities so that students understand geometric concepts rather than only memorize formulas. Future studies should involve larger and more diverse samples, longer implementation periods, and different mathematical topics to examine the broader applicability of hologram-based learning media. Further research should also investigate students' spatial visualization skills, learning engagement, and long-term retention of mathematical concepts. Holokulo 3D hologram media should also be improved in visual quality, instructional design, accessibility, and ease of classroom use.

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REFERENCES

Abdi, D. H., Rismayanti, R., & Harliana, P. (2022). Rancang bangun 3 dimensi hologram sebagai media informasi mengenal hewan mamalia. Algoritma: Jurnal Ilmu Komputer dan Informatika, 6(1). https://doi.org/10.30829/algoritma.v6i1.11571

Agustian, N. Z., & Setiawan, A. M. (2024). The development of hologram media on the motion of object in physics to improve students learning outcomes in junior high school. Jurnal Penelitian Pendidikan IPA, *10*(6), 3404–3413. https://doi.org/10.29303/jppipa.v10i6.5853

Ahmad, A. S., Alomaier, A. T., Elmahal, D. M., Abdlfatah, R. F., & Ibrahim, D. M. (2021). EduGram: Education development based on hologram technology. International Journal of Online and Biomedical Engineering (iJOE), 17(14), 32–49. https://doi.org/10.3991/ijoe.v17i14.27371

Aurelia, D. … Ekawati, R. (2026). The role of visual representation in primary students' ability to solve fraction word problems. *Beta: Jurnal Tadris Matematika*, *19*(1), 21–38. https://doi.org/10.20414/betajtm.v19i1.729

Branch, R. M. (2009). Instructional design: The ADDIE approach. Springer. https://doi.org/10.1007/978-0-387-09506-6

Buchori, A. … Osman, S. (2023). Interactive learning media with augmented reality (AR) GeoGebra for teaching geometry in elementary school. Profesi Pendidikan Dasar, *10*(3), 17–30. https://doi.org/10.23917/ppd.v10i3.4469

Cantikasari, Y., & Widarti, E. (2024). Tinjauan literatur teknologi hologram dalam pendidikan: Peluang, tantangan, dan arah masa depan. *Seminar Nasional Sistem Informasi* (SENASIF), 5158–5167.

Ferdiansyah, Z. D. … Soepriyanto, Y. (2022). Pengembangan objek 3D memanfaatkan piramida hologram berbasis smartphone materi sistem gerak manusia. *JKTP: Jurnal Kajian Teknologi Pendidikan*, *5*(1), 72–80. https://doi.org/10.17977/um038v5i12022p072

Firman, S., Nurlina, Rahmawati, Ma'ruf, & Imran, M. E. (2024). The effectiveness of developing problem-solving oriented digital e-modules on Theme 7: Events in life for grade V elementary school. Didaktika: Jurnal Kependidikan, 13(4). https://doi.org/10.58230/27454312.1045

Fokides, E., & Bampoukli, I. (2024). Are hologram-like pyramid projections of an educational value? Results of a project in primary school settings. *Journal of Computers in Education*, *11*(1), 215–235. https://doi.org/10.1007/s40692-022-00255-7

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. American Journal of Physics, 66(1), 64–74. https://doi.org/10.1119/1.18809

Hakiki, R. … Febriana, A. (2022). The development of learning media based on augmented reality, hologram, and Ludo game on the topic of molecular shapes. International Journal of Interactive Mobile Technologies (iJIM), *16*(4), 70–84. https://doi.org/10.3991/ijim.v*16*i04.28989

Hs, A. M., Wiryanto, W., & Mariana, N. (2023). Systematics literature review: Mathematics reasoning in elementary school. Jurnal Pamator: Jurnal Ilmiah Universitas Trunojoyo, 16(4). https://doi.org/10.21107/pamator.v16i4.22626

Imran, A. … Iswanto, M. R. (2022). Pengembangan media pembelajaran berbasis video hologram 3D. Remik: Riset dan E-Jurnal Manajemen Informatika Komputer, 6(4), 1024–1034. https://doi.org/10.33395/remik.v6i4.11973

Izzati, A. A. T. … Ekawati, R. (2026). Integrating augmented reality in mathematics: A mixed-methods systematic review of spatial and geometric learning. *Jurnal Inovasi Teknologi Pendidikan*, *13*(2), 143–159. https://doi.org/10.21831/jitp.v13i2.85197

Lukman, A., Hairi, A. P., Rahmi, A., Fadli, A., Dongoran, S. B., & Nasution, A. A. (2020). Penerapan media pembelajaran Holo-Math (Hologram Mathematics) dalam meningkatkan kemampuan visual matematis siswa di SMP Negeri 8 Percut Sei Tuan. *Jurnal Fibonaci*: Jurnal Pendidikan Matematika, 1(2), 1–11. https://doi.org/10.24114/jfi.v1i2.21902

Mawardani, A., Dwandaru, W. S. B., Nugroho, M. P., & Surtini. (2021). Multimedia learning module (MLM) with hologram simulation to improve students' mathematical representation ability. In *Proceedings of the 6th International Seminar on Science Education (ISSE 2020)* (pp. 522–527). Atlantis Press. https://doi.org/10.2991/assehr.k.210326.075

Mohammad, H., Almarabeh, T., & Rajab, L. (2023). A rapid review of learning using hologram in higher education. International Journal of Emerging Technologies in Learning (iJET), *18*(12), 242–247. https://doi.org/10.3991/ijet.v*18*i12.38913

Nadzeri, M. B. … Ismail, I. M. (2024). The effects of augmented reality geometry learning applications on spatial visualization ability for lower primary school pupils. *International Journal of Interactive Mobile Technologies*, *18*(16), 104–118. https://doi.org/10.3991/ijim.v18i16.47079

Nurrahman, F. A. … Sucahyanto. (2024). Pengaruh media pembelajaran 3D piramida hologram terhadap minat belajar siswa pada materi vulkanisme kelas X SMAN 54 Jakarta. *JPIG (Jurnal Pendidikan Dan Ilmu Geografi)*, *9*(2), 148–159. https://doi.org/10.21067/jpig.v9i2.10175

Octaria, D. … Hiltrimartin, C. (2025). Spatial literacy and error patterns in elementary 3D geometry: Foundations for local instructional theory. *Edumatica Jurnal Pendidikan Matematika*, *16*(1), 19–39. https://doi.org/10.22437/edumatica.vl6i1.48212

Putri, M. Y., Miftakhuddin, & Adiyan, F. (2026). Pengaruh model discovery learning terhadap kemampuan berpikir kritis di sekolah dasar. Jurnal Tunas Pendidikan, 9(1), 209–217. https://doi.org/10.52060/pgsd.v9i1.4422

Safitri, F. E., & Djuniadi. (2021). Pengembangan media berbasis hologram 3D dalam pembelajaran tanaman kelapa. *JEP Jurnal Eksakta Pendidikan*, *5*(1), 87–94. https://doi.org/10.24036/jep/vol5-iss1/577

Salloum, S. A. … Alfaisal, A. M. (2024). Adoption of 3D holograms in science education: Transforming learning environments. *IEEE Access*, *12*, 70984–70998. https://doi.org/10.1109/ACCESS.2024.3402549

Septiana, A. I. … Syawanodya, I. (2020). Pengembangan multimedia interaktif menggunakan piramida hologram untuk media pembelajaran bangun ruang di sekolah dasar. *Jurnal Instek Informatika Sains Dan Teknologi*, *5*(2), 261–268.

Sugiharto, A. B. (2020). Aplikasi pengenalan tata surya menggunakan 3D hologram berbasis Android. *J-INTECH*, *08*(2), 72–76.

Tarmidzi, T., Andari, K. D. W., Sari, A., Nuryanti, M., Arfiyanti, R., & Noto, M. S. (2025). Augmented reality and its use in elementary school education: A systematic literature review. Jurnal Prima Edukasia, 13(1), 128–145. https://doi.org/10.21831/jpe.v13i1.75094

Turk, H., & Seckin-Kapucu, M. (2021). Innovative technology applications in science education: Digital holography. *Journal of Education in Science, Environment and Health*, *7*(2), 156–170. https://doi.org/10.21891/jeseh.748662

Walkington, C. … Schenck, K. (2025). Comparing learning geometry using a tablet to head-mounted display augmented reality: How and when dimensionality matters. *Education and Information Technologies*, *30*(4), 5397–5426. https://doi.org/10.1007/s10639-024-13008-z

Yang, Y. … Geraniou, E. (2025). Spatial skill development through augmented reality in mathematics education: A scoping review. *Digital Experiences in Mathematics Education*. https://doi.org/10.1007/s40751-025-00187-8

Yu, Q., Li, B., & Wang, Q. (2024). The effectiveness of 3D holographic technology on students' learning performance: A meta-analysis. *Interactive Learning Environments*, 32(5), 1629–1641. https://doi.org/10.1080/10494820.2022.2124424

Yulita, S. R., & Aryani, Z. (2025). Mika hologram sebagai media pembelajaran IPA di SD. *Jurnal Inovasi Wawasan Akademik*, *1*(1), 71–79.

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PROGRAM PASCASARJANA UNIVERSITAS MURIA KUDUS
Jl. Lingkar Utara UMK, Gondangmanis, Bae, Kudus, Jawa Tengah, Indonesia
pascasarjana@umk.ac.id · pascasarjana.umk.ac.id · Instagram: pascasarjana_umk