



Building the Implementation of Digital Learning through Supportive Leadership of Principals and Professional Competencies of Teachers: The Role of Mediation of Self-Efficacy of Public Elementary School Teachers

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Abstract

Digital transformation in elementary education requires more than technological infrastructure; it also depends on leadership support, teacher competence, and teachers' confidence in using technology. This study examined the effects of supportive principal leadership and teacher professional competence on digital learning implementation, with teacher self-efficacy as a mediating variable in public elementary schools in Kecamatan Pulau Punjung, Kabupaten Dharmasraya. A quantitative explanatory design was employed involving 186 teachers selected from a population of 336 teachers through proportional random sampling. Data were collected using a five-point Likert-scale questionnaire and analyzed using Structural Equation Modeling-Partial Least Squares (SEM-PLS) to assess the measurement model, structural relationships, and mediation effects. The findings indicate that supportive principal leadership and teacher professional competence positively contribute to digital learning implementation. Teacher self-efficacy also plays an important role in strengthening teachers' implementation of digital learning. Furthermore, the mediation analysis indicates that teacher self-efficacy functions as an intervening mechanism through which supportive leadership and professional competence contribute to digital learning implementation. These findings suggest that successful digital learning in elementary schools cannot be achieved through technology provision alone. Schools need to combine supportive leadership, continuous development of teacher professional competence, and efforts to strengthen teachers' confidence in using digital technology. The study provides practical implications for principals and education authorities in designing integrated strategies for sustainable digital learning implementation.

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INTRODUCTION

Digital technology has become increasingly embedded in educational systems, yet its presence in schools does not automatically translate into meaningful digital learning practices (Bhutoria, 2022; Mhlongo et al., 2023; Mishra, 2025). This creates an important tension in contemporary education: schools may have access to digital devices and platforms while teachers still rely on technology mainly for presentation and information delivery rather than for interactive, adaptive, and learner-centered instruction. Emphasizes that digital technology can expand opportunities for interaction, collaboration, personalized learning, and access to educational resources, but its educational value depends strongly on how it is integrated into teaching practices (Alam & Mohanty, 2023; Mexhuani, 2025; Zou et al., 2025). The literature similarly indicates that digital teaching competence encompasses more than technical proficiency because teachers must connect technological resources with pedagogy, assessment, classroom management, and professional development (Althubyani, 2024; Nguyen & Habók, 2024a). Alptekin & Taneri (2025) further argue that teachers' digital competence requires the integration of pedagogical and professional dimensions rather than isolated technical skills. Consequently, digital transformation

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should not be understood merely as a process of introducing devices or platforms into schools. It represents an organizational and professional change that requires teachers to reconsider how learning is designed, delivered, assessed, and continuously improved. The central challenge, therefore, lies in understanding the human and organizational conditions that enable teachers to transform available technology into effective digital learning practices.

The challenge is particularly visible in elementary education, where teachers are expected to accommodate young learners while simultaneously responding to increasingly complex technological demands (Dumont & Ready, 2023; Leech et al., 2022; Moltudal et al., 2022). In the context of public elementary schools in Kecamatan Pulau Punjung, preliminary observations involving 58 teachers in the local Teacher Working Group indicated that approximately 40–60% of teachers had not yet integrated digital technology optimally into everyday instruction. Digital resources were commonly limited to PowerPoint presentations, instructional videos, and projectors, whereas interactive learning platforms, digital assessment, and systematic management of technology-supported learning were less consistently used (Chanwaiwit, 2025). At the planning stage, approximately 45% of teachers were not routinely preparing digitally oriented learning materials, while around 60% continued to rely primarily on basic digital media during classroom implementation. At the assessment stage, approximately 55% of teachers still relied on paper-based evaluation, suggesting that technology had not yet been integrated throughout the instructional cycle. These conditions indicate that the problem is not simply whether teachers possess access to technology, but whether they are able and willing to embed technology within pedagogically meaningful processes. Similar concerns have been identified internationally, where inadequate infrastructure, limited training, and uneven teacher competence remain barriers to sustained technology integration (Dinçer, 2024). Thus, the local situation provides a meaningful empirical context for investigating why digital learning implementation remains uneven even when digital resources are increasingly available.

The uneven implementation of digital learning also highlights the importance of school leadership in shaping teachers' responses to educational change. Digital transformation requires leaders to do more than provide infrastructure because teachers often need guidance, encouragement, professional learning opportunities, and practical assistance when incorporating unfamiliar technologies into instruction. Found that principals' technology leadership was positively associated with teachers' technology integration and emphasized the importance of leadership practices that support professional development and digital-age learning cultures. Similarly, Assefa & Mujtaba (2025) and Rasdiana et al. (2024) demonstrated that technology leadership contributes to the development of a school climate conducive to technology integration by strengthening trust and enabling supportive structures. Karakose et al. (2021), Quaicoe et al. (2023) and Singun (2025) also show that school leaders experience digital transformation as an organizational process requiring adaptation rather than as a simple technical intervention. In the present research context, however, approximately 60% of teachers reported that guidance and mentoring from principals concerning digital learning had not been provided regularly and systematically. Teachers also reported limited opportunities to communicate difficulties associated with technology use, while training, technological facilitation, and feedback were not consistently available. These conditions suggest that supportive principal leadership may be an important organizational mechanism for translating technological expectations into teachers' actual classroom practices.

Beyond leadership support, teachers' professional competence represents another critical condition for effective digital learning implementation (Jogezai et al., 2023). Professional competence determines whether teachers can move beyond operating digital tools toward selecting, adapting, and integrating them in ways that serve curriculum objectives and student learning needs. Tomczyk (2024) note that digital teaching competence involves the capacity to incorporate technology methodologically into teaching rather than merely possessing basic technical knowledge. ElSayary (2024) and Reisoğlu (2022) similarly found that applied digital competence training can strengthen teachers' knowledge and skills in using digital resources, organizing instructional activities, improving assessment, and supporting learners. Lindfors et al. (2021) and O'Dowd & Dooly (2022) further demonstrate that professional learning opportunities in which teachers exchange pedagogical experiences can strengthen professional digital competence and teachers' agency in using technology. Recent evidence from primary education also indicates that teachers' pedagogical

and professional competence is closely connected to their capacity to integrate digital technology into learning (Alptekin & Taneri, 2025; Kiryakova & Kozhuharova, 2024). Nevertheless, the problem observed in Kecamatan Pulau Punjung shows that approximately 63.3% of teachers experienced difficulties integrating digital applications into teaching, while 56.7% encountered difficulties developing learning materials systematically and innovatively. These findings reinforce the argument that digital learning implementation depends not only on technological access but also on the professional capacity of teachers to convert technology into pedagogically appropriate learning experiences.

An additional dimension that may explain the variation in digital learning implementation is teachers' psychological readiness, particularly self-efficacy (Mansor et al., 2021; Yang, 2021). Teacher self-efficacy refers to teachers' beliefs regarding their capability to organize and execute actions required to accomplish specific instructional tasks, and these beliefs can influence persistence, experimentation, and responses to challenging situations (Goddard et al., 2021; Zakariya, 2022). In technology-supported teaching, self-efficacy becomes particularly relevant because teachers must often manage uncertainty, learn new applications, adapt instructional strategies, and respond to technical or pedagogical difficulties simultaneously. Baroudi & Shaya (2022) and Gomez (2024) identify teacher self-efficacy as a critical component in technology integration because supportive environments, resources, policies, and professional experiences can shape teachers' confidence in using technology. Chiu (2022) likewise found that professional development and community support can generate mastery experiences that strengthen teachers' self-efficacy for technology-integrated teaching. More recent evidence indicates that teacher self-efficacy can directly support ICT utilization and technology-integrated pedagogy, suggesting that confidence is an important psychological pathway through which professional readiness becomes classroom behavior (Arviv Elyashiv & Rozenberg, 2024). In the present setting, preliminary observations showed that 56.7% of teachers remained uncertain about using varied instructional strategies, while 50% experienced difficulties in classroom management and some teachers lacked confidence in using digital learning media. Therefore, self-efficacy may serve not merely as another predictor of digital learning but as a psychological mechanism connecting organizational support and professional competence with teachers' actual implementation behavior.

Previous studies have generally established that school leadership, teacher competence, and psychological readiness are relevant to educational technology integration, although they have often examined these factors through separate analytical lenses. Peled & Perzon (2022), for example, demonstrated a positive relationship between principals' technology leadership and teachers' technology integration, emphasizing the organizational role of school leaders. Zhang et al. (2025) similarly reported an association between school heads' technological leadership and teachers' ICT integration in public elementary schools. Moorhouse & Wong (2022) found that school heads' technological leadership was relevant to teachers' technological proficiency and instructional innovation during the COVID-19 period. At the teacher level, Fernández-Batanero et al. (2022), Osorio Vanegas et al. (2025) and Revuelta-Domínguez et al. (2022) showed through a systematic review that digital teaching competence is multidimensional and closely related to teacher training and technology integration. Nguyen & Habók (2024) demonstrated that digital competence training can strengthen teachers' professional activities involving digital resources and assessment. Basantes-Andrade et al. (2022) further highlighted the importance of integrating pedagogical and professional elements when assessing teachers' digital competence. Together, these studies suggest a dominant pattern in the literature: effective digital learning is shaped by a combination of school-level support and teacher-level competence rather than by technology availability alone.

Nevertheless, important limitations remain in explaining the mechanism through which organizational and professional factors are translated into actual digital learning implementation. First, studies of technology leadership have predominantly focused on the direct association between principals' leadership practices and teachers' technology integration, with less attention to the psychological processes that may explain this relationship (Polatcan, 2024; Savaş & Demirkasimoğlu, 2024). Second, studies of teacher competence have frequently emphasized the measurement or development of digital competence without sufficiently positioning professional competence within a broader organizational and psychological model Wiziack & Santos (2021) and L. Zhang et al. (2026). Third, research on teacher self-efficacy has established its importance for technology integration, but

self-efficacy is often treated as an independent predictor rather than as an intervening mechanism connecting leadership and professional competence with classroom practice (Pan & Cheng, 2023). Fourth, much of the available evidence has been generated in contexts involving secondary education, teacher preparation, or technology-focused professional development, leaving comparatively limited evidence concerning public elementary schools in specific Indonesian regional contexts. Recent Indonesian studies have begun to address teacher digital competence and technology integration, but they remain fragmented across individual competencies, technology use, or school-level support (Noegroho & Zahra, 2024). The resulting gap is therefore not simply a lack of studies on each variable, but a lack of integrated empirical models explaining how supportive principal leadership and teacher professional competence jointly influence digital learning implementation through teachers' self-efficacy.

Addressing this gap is particularly important because digital transformation in elementary schools requires alignment between organizational conditions, professional capacity, and teachers' psychological readiness. Existing evidence suggests that leadership can create enabling conditions for technology integration, professional development can strengthen teachers' digital capabilities, and self-efficacy can increase teachers' willingness to engage in technology-supported instructional practices. However, these findings have not sufficiently clarified whether supportive principal leadership and professional competence exert their influence on digital learning implementation partly through teachers' confidence in their own capabilities (Masoumi & Noroozi, 2025). This issue is theoretically important because it shifts the explanation of digital learning from a simple resource-based perspective toward a more integrated organizational–professional–psychological perspective. It is also practically significant because schools may invest heavily in digital infrastructure and training without achieving sustainable classroom integration if teachers do not develop sufficient confidence to use technology meaningfully. Adamakis & Rachiotis (2025) similarly stresses that technology policies and investments should be accompanied by teacher preparation that enables educators to use technology appropriately for learning rather than merely operate specific tools. Recent research also reinforces the importance of school-level support and teacher self-efficacy in sustaining technology integration beyond initial adoption (Y. Zhang & Zhu, 2025). Accordingly, an integrated model that places teacher self-efficacy as a mediating mechanism can provide a more comprehensive explanation of digital learning implementation in elementary schools. Such an approach is particularly relevant for understanding the conditions faced by public elementary school teachers in Kecamatan Pulau Punjung, where preliminary evidence indicates simultaneous challenges in leadership support, professional competence, and teacher confidence.

Against this background, this study aims to examine the effects of supportive principal leadership and teacher professional competence on digital learning implementation and to determine the mediating role of teacher self-efficacy among teachers in public elementary schools in Kecamatan Pulau Punjung, Kabupaten Dharmasraya. The study specifically seeks to establish whether supportive principal leadership contributes to stronger digital learning implementation, whether teacher professional competence predicts the quality of digital learning practices, and whether teacher self-efficacy strengthens these relationships. Theoretically, the study contributes by integrating organizational, professional, and psychological perspectives into a single explanatory model of digital learning implementation at the elementary school level. The model positions supportive leadership as an organizational condition, professional competence as a teacher-level capability, and self-efficacy as a psychological mechanism that may translate these conditions into classroom practice. This integrated perspective extends previous research that has commonly examined leadership, competence, or self-efficacy as relatively independent determinants of technology integration. Practically, the findings are expected to provide school principals with evidence for designing more supportive leadership practices through mentoring, professional development, facilitation, and constructive feedback. The findings may also assist schools and education authorities in designing teacher development programs that combine digital pedagogical competence with strategies for strengthening teachers' confidence in applying technology. Ultimately, the study seeks to demonstrate that sustainable digital learning in elementary schools depends not simply on the availability of technology, but on the interaction between supportive leadership, professional competence, and teachers' belief in their capacity to use technology effectively.

METHOD

Research Design

This study employed a quantitative approach with an explanatory research design to examine the relationships among supportive principal leadership, teacher professional competence, teacher self-efficacy, and digital learning implementation in public elementary schools. The explanatory design was selected because the study aimed to investigate the direct effects of supportive principal leadership and teacher professional competence on digital learning implementation and to examine the indirect effects through teacher self-efficacy. The research model positioned supportive principal leadership and teacher professional competence as predictor variables, teacher self-efficacy as a mediating variable, and digital learning implementation as the outcome variable. A quantitative design was appropriate because the variables were measured using structured questionnaire responses and the hypothesized relationships were examined statistically. The study employed Structural Equation Modeling–Partial Least Squares (SEM-PLS) to examine the relationships among the latent constructs and to assess both direct and indirect effects within the proposed model. The analysis also enabled the researchers to evaluate the quality of the measurement instruments before examining the structural relationships among the variables. Accordingly, the research design provided an appropriate framework for explaining the organizational, professional, and psychological factors associated with digital learning implementation.

Research Setting and Participants

The research was conducted in public elementary schools (Sekolah Dasar Negeri) in Kecamatan Pulau Punjung, Kabupaten Dharma Raya, Indonesia. The setting was selected because preliminary observations indicated that the implementation of digital learning remained uneven and that teachers experienced challenges in integrating technology into different stages of instruction. Preliminary discussions with 58 teachers participating in the Teacher Working Group (Kelompok Kerja Guru/KKG) indicated that approximately 40–60% of teachers had not yet integrated digital technology optimally into their teaching practices. The observed challenges included limited use of interactive digital learning platforms, technology-based assessment, and systematic management of digital learning. At the planning stage, approximately 45% of teachers did not routinely prepare digitally oriented learning materials, while around 60% continued to rely primarily on basic digital media during classroom implementation. At the evaluation stage, approximately 55% of teachers still used paper-based assessment, indicating that digital technology had not yet been integrated consistently throughout the learning process. These empirical conditions provided the contextual basis for examining the factors associated with digital learning implementation in public elementary schools.

Population and Sampling

The population consisted of 336 teachers working in public elementary schools in Kecamatan Pulau Punjung, Kabupaten Dharma Raya. A sample of 186 teachers was selected using proportional random sampling. This technique was employed because the number of teachers varied across schools, requiring proportional representation of teachers from the respective schools. The sampling procedure was intended to provide an adequate representation of the population while maintaining the proportional distribution of respondents across the participating schools. The 186 selected teachers served as the respondents for measuring supportive principal leadership, teacher professional competence, teacher self-efficacy, and digital learning implementation. The original research document identifies the population, sampling technique, and final sample size but does not provide detailed inclusion and exclusion criteria or the questionnaire response rate. Therefore, these details should only be added to the final manuscript if they are available in the researchers' original field records.

Research Instruments

Data were collected using a structured questionnaire consisting of items representing four constructs in the research model: supportive principal leadership, teacher professional competence, teacher self-efficacy, and digital learning implementation. The questionnaire employed a five-point Likert scale to capture respondents' perceptions of each construct. Supportive principal leadership was measured through dimensions related to the principal's provision of guidance, motivation,

support, communication, facilitation, and feedback for teachers. Teacher professional competence concerned teachers' mastery of learning materials, curriculum understanding, development of learning resources, technology utilization, and learning assessment. Teacher self-efficacy represented teachers' beliefs regarding their capability to perform instructional tasks, manage classroom activities, use varied instructional strategies, and deal with challenges in the learning process. Digital learning implementation concerned the integration of digital technology into the planning, implementation, and evaluation of learning activities. These dimensions were aligned with the conceptualization of the four variables presented in the original research manuscript. The exact number of items and detailed item statements are not reported in the original document and should therefore be inserted from the actual questionnaire used in the study rather than inferred.

Instrument Validity and Reliability

Instrument quality was evaluated through the measurement model in the SEM-PLS analysis. The evaluation focused on determining whether the indicators adequately represented their respective latent constructs and whether the constructs demonstrated acceptable reliability. Convergent validity was assessed using indicator outer loadings and Average Variance Extracted (AVE), while construct reliability was evaluated using Composite Reliability. The original manuscript reports that the outer loading values of the indicators exceeded the recommended threshold and that the AVE and Composite Reliability values met the required criteria. These findings indicate that the indicators demonstrated adequate convergent validity and that the constructs possessed satisfactory internal consistency. However, the current manuscript does not present the numerical values of the individual outer loadings, AVE, or reliability coefficients. Therefore, the final Results section should report these values explicitly to provide transparent evidence concerning the quality of the measurement model.

Data Collection Procedure

The data collection procedure followed a sequential research process beginning with the identification of the research problem and review of relevant literature, followed by the development of the research model and preparation of the questionnaire. The research model was constructed around the relationships between supportive principal leadership, teacher professional competence, teacher self-efficacy, and digital learning implementation. Following instrument preparation, the population and sampling procedure were established, resulting in 186 teachers selected from the population of 336 teachers through proportional random sampling. The questionnaire was subsequently distributed to the selected teachers, and the completed responses were organized and prepared for statistical analysis. The overall methodological sequence, including the development of the research model, data collection, measurement model evaluation, structural model evaluation, mediation analysis, and hypothesis testing, is presented in Figure 1.

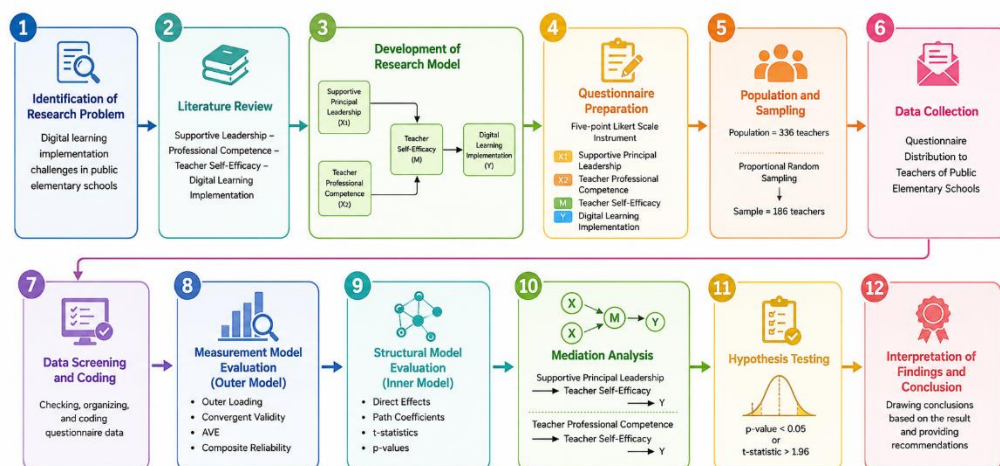


Figure 1. Research Procedure Flowchart

As illustrated in Figure 1, the research procedure was organized into twelve interconnected stages, beginning with the identification of the research problem and ending with the interpretation of findings and formulation of conclusions. The first stages established the conceptual foundation of

the study through problem identification, literature review, and research model development. The subsequent stages focused on questionnaire preparation, population and sampling, data collection, and data screening and coding. The analytical stages then consisted of measurement model evaluation, structural model evaluation, mediation analysis, and hypothesis testing. This sequence ensured that the quality of the measurement instruments was examined before the relationships among the constructs were interpreted. The mediation stage specifically addressed the role of teacher self-efficacy in explaining the relationships between supportive principal leadership, teacher professional competence, and digital learning implementation. Thus, the flowchart provides a concise visual representation of the methodological sequence used to answer the research objectives.

Data Analysis

The collected data were analyzed using Structural Equation Modeling–Partial Least Squares (SEM-PLS) to examine the relationships among supportive principal leadership, teacher professional competence, teacher self-efficacy, and digital learning implementation. The analysis consisted of two principal stages: evaluation of the measurement model (outer model) and evaluation of the structural model (inner model). The measurement model evaluation was conducted to assess the validity and reliability of the indicators representing each latent construct. The structural model evaluation was subsequently used to examine the direct relationships among the constructs. Hypothesis testing was based on the t-statistic and p-value, with a relationship considered statistically significant when $p\text{-value} < 0.05$ or $t\text{-statistic} > 1.96$ at the 95% confidence level. The analysis therefore considered both the magnitude and statistical significance of the relationships specified in the research model. The original manuscript reports that the SEM-PLS procedure was used to examine direct and indirect relationships among the variables, including the mediating role of teacher self-efficacy.

RESULTS AND DISCUSSION

Results

The results of this study were analyzed using the Structural Equation Modeling–Partial Least Squares (SEM-PLS) approach to examine the direct and indirect relationships among supportive principal leadership, teacher professional competence, teacher self-efficacy, and digital learning implementation in public elementary schools in Kecamatan Pulau Punjung. The analysis was conducted through two stages, namely the evaluation of the measurement model (outer model) and the evaluation of the structural model (inner model). The evaluation of the measurement model showed that all research indicators met the criteria for validity and reliability. The outer loading values of each indicator were above the recommended threshold, indicating that the indicators were able to represent their respective constructs. Furthermore, the Average Variance Extracted (AVE) values and Composite Reliability values met the required criteria, indicating that all constructs had good convergent validity and reliability.

The structural model analysis was conducted to examine the relationship between variables. The results showed that supportive principal leadership had a positive effect on digital learning implementation. This finding indicates that stronger support from principals contributes to better implementation of digital learning practices among teachers. Teacher professional competence also showed a positive relationship with digital learning implementation. This result indicates that teachers with stronger professional competence tend to have better abilities in planning, implementing, and evaluating digital-based learning activities. Furthermore, teacher self-efficacy was found to play an important role in strengthening digital learning implementation. Teachers who have higher confidence in their ability to use technology and manage learning processes are more likely to implement digital learning effectively. The mediation analysis showed that teacher self-efficacy mediates the relationship between supportive principal leadership and teacher professional competence toward digital learning implementation.

This finding indicates that leadership support and professional competence influence digital learning implementation not only directly but also indirectly through teachers' beliefs in their own abilities. The findings of this study confirm that supportive principal leadership is an important factor in encouraging digital learning implementation. Principals who provide guidance, motivation, communication, and professional support can create a school environment that encourages teachers

to adapt to technological changes. Supportive leadership reduces teachers' barriers in adopting digital learning because teachers receive direction, assistance, and encouragement during the transformation process. This finding is consistent with the concept of instructional leadership, which emphasizes that school leaders have an important role in improving teaching quality through professional support and continuous development. In the context of digital transformation, principals are not only administrative leaders but also agents of change who facilitate innovation and technology integration in schools.

Teacher professional competence also contributes significantly to digital learning implementation. Teachers who master learning materials, understand curriculum demands, are able to develop learning resources, and possess technological competence have greater opportunities to create meaningful digital learning experiences. Therefore, professional competence becomes an essential foundation for teachers to integrate technology into learning activities. The role of teacher self-efficacy provides an important explanation regarding how internal psychological factors influence digital learning implementation. Although schools provide technological facilities and principals provide support, teachers' confidence in their own abilities determines whether technology will actually be utilized effectively. Teachers with high self-efficacy tend to be more willing to experiment with new learning strategies, overcome technological challenges, and continuously improve their digital teaching practices. The mediation effect of teacher self-efficacy indicates that external factors, such as principal support and professional competence, need to be strengthened through teachers' internal beliefs. Supportive leadership and professional competence will produce greater impacts when teachers possess confidence and readiness to implement digital learning.

Overall, this study contributes to the understanding that successful digital learning implementation requires a combination of organizational support, teacher competence, and psychological readiness. Digital transformation in elementary schools cannot rely only on technology availability but must also involve leadership development, teacher capacity building, and strengthening teacher self-confidence. This study provides several theoretical and practical implications. Theoretically, the findings strengthen the understanding that digital learning implementation is influenced by both organizational and individual factors. The integration of supportive principal leadership, teacher professional competence, and teacher self-efficacy provides a comprehensive framework for explaining digital learning adoption in elementary schools. Practically, the findings imply that school principals need to strengthen supportive leadership practices through continuous mentoring, professional development programs, technology facilitation, and constructive feedback for teachers. Schools should also develop programs that improve teachers' professional competence, particularly in digital pedagogy and technology integration. For teachers, strengthening self-efficacy is essential through continuous learning, collaboration with colleagues, participation in digital training, and reflective teaching practices. Educational policymakers may use these findings as a consideration in designing digital transformation programs that emphasize not only infrastructure development but also human resource readiness.

This study has several limitations. First, the research was conducted only in public elementary schools in Kecamatan Pulau Punjung; therefore, the findings may have limited generalizability to other regions with different educational contexts. Second, the data were collected using self-reported questionnaires, which may be influenced by respondents' perceptions and personal assessments. Future studies may consider combining questionnaire data with observation, interviews, or documentation analysis to obtain more comprehensive findings. Third, this study focused on three main predictors, namely supportive principal leadership, teacher professional competence, and teacher self-efficacy. Other factors such as digital infrastructure, school culture, teacher digital literacy, and government policy may also influence digital learning implementation but were not examined in this study.

Based on the findings, several suggestions are proposed. First, principals are encouraged to strengthen supportive leadership practices by providing continuous assistance, facilitating digital learning development, and creating a school culture that supports innovation. Second, teachers are encouraged to improve their professional competence, particularly in digital pedagogy, through training, collaboration, and independent professional development activities. Third, schools and

education authorities should develop programs that strengthen teacher self-efficacy in implementing digital learning by providing adequate facilities, mentoring, and opportunities for teachers to practice technology-based learning. Future researchers are encouraged to expand this study by involving broader geographical areas, using mixed-method approaches, and examining other variables that may contribute to successful digital learning implementation.

Discussion

The findings demonstrate that digital learning implementation is shaped by the interaction of organizational, professional, and psychological factors rather than by technological availability alone. Supportive principal leadership, teacher professional competence, and teacher self-efficacy were all positively associated with digital learning implementation, indicating that technology becomes meaningful when teachers receive adequate organizational support and possess the capability and confidence to use it. This finding supports the systemic perspective of technology integration proposed by Peled and Perzon (2022), which emphasizes that successful technology adoption depends on the interaction between school conditions and teacher capabilities. It is also consistent with recent studies showing that digital competence and organizational support are important foundations for teachers' technology integration (Jogezai et al., 2023; Kiryakova & Kozhuharova, 2024). Thus, the present study extends the technology-integration perspective by demonstrating that digital learning should be understood as an organizational and human-capacity process rather than merely an infrastructure issue.

Supportive principal leadership was found to contribute positively to digital learning implementation, suggesting that principals have an important role in translating digital transformation policies into classroom practices. Leadership support through guidance, communication, facilitation, motivation, and feedback can reduce teachers' uncertainty when adopting unfamiliar technologies and encourage them to experiment with new instructional practices. This finding is consistent with Karakose et al. (2021), Peled and Perzon (2022), and Rasdiana et al. (2024), who emphasize the importance of digital and instructional leadership in creating conditions conducive to technology integration. The finding also reinforces the view that principals should act as change facilitators rather than merely administrative managers during digital transformation. Therefore, supportive leadership represents an organizational mechanism that enables teachers to respond more confidently and consistently to technological changes.

Teacher professional competence also showed a positive contribution to digital learning implementation. This finding indicates that effective technology integration depends on teachers' ability to connect digital resources with curriculum objectives, instructional strategies, learning materials, and assessment practices. The result is consistent with Fernández-Batanero et al. (2022), Reisoğlu (2022), and Alptekin and Taneri (2025), who demonstrate that digital competence is multidimensional and closely related to teachers' professional practice. It also supports Masoumi and Noroozi (2025), who emphasize the importance of developing professional digital competence through meaningful professional learning. Accordingly, professional development should move beyond technical training and focus on how teachers can pedagogically adapt technology to authentic classroom needs.

Teacher self-efficacy emerged as an important factor in strengthening digital learning implementation. Conceptually, self-efficacy explains why teachers with similar access to technological resources may demonstrate different levels of willingness to experiment, persist when difficulties occur, and integrate digital tools into instruction. This interpretation is supported by Chiu (2022) and Baroudi and Shaya (2022), who highlight the relationship between supportive learning environments and teachers' confidence in technology-supported teaching. The finding is also consistent with Yang (2021), who identified self-efficacy as an important psychological resource in online teaching contexts. Therefore, strengthening teachers' digital competence without simultaneously developing their confidence may produce limited changes in actual classroom practice.

The mediation findings provide a more important theoretical explanation because teacher self-efficacy connects supportive leadership and professional competence with digital learning implementation. In other words, organizational support and professional capability appear to become more influential when teachers perceive themselves as capable of applying technology

effectively. This interpretation is consistent with Chiu (2022) and Pan and Cheng (2023), who demonstrate that supportive professional environments and teacher learning can strengthen self-efficacy and subsequent professional engagement. The present finding therefore extends previous research by positioning self-efficacy not merely as an independent predictor but as a psychological mechanism through which organizational and professional resources are translated into teaching practice. This provides a more integrated explanation of why leadership and competence do not automatically produce effective digital learning unless teachers also possess sufficient psychological readiness.

The combined findings consequently support an organizational–professional–psychological framework for understanding digital learning implementation. Previous studies have frequently examined technology leadership, teacher competence, and self-efficacy separately, whereas this study integrates the three dimensions within one explanatory model. This integration is consistent with the systemic approach to technology integration (Peled & Perzon, 2022) and recent research emphasizing the interaction between leadership, professional development, and digital competence (Rasdiana et al., 2024; Osorio Vanegas et al., 2025). The contribution of the present study therefore lies in explaining not only what factors influence digital learning implementation, but also how organizational and professional conditions are psychologically translated into teachers' implementation behavior. This perspective addresses an important gap in previous research and provides a stronger conceptual basis for understanding digital transformation in elementary schools.

Nevertheless, the findings should be interpreted within the context of public elementary schools in Kecamatan Pulau Punjung, where digital learning implementation remains uneven and teachers continue to experience challenges in digital materials, interactive platforms, and technology-based assessment. The use of self-reported questionnaire data and the focus on a single geographical context may also limit the generalizability of the findings. Despite these limitations, the results have practical implications: digital transformation programs should integrate supportive principal leadership, continuous professional development, and deliberate strategies for strengthening teacher self-efficacy. Rather than focusing exclusively on technological infrastructure, schools and education authorities should create conditions in which teachers can learn, practice, receive feedback, and gradually develop confidence in applying digital pedagogy. Overall, the study suggests that sustainable digital learning is most likely to emerge when organizational support, professional competence, and psychological readiness operate together.

CONCLUSION

This study concludes that digital learning implementation in public elementary schools is shaped by the interaction of organizational, professional, and psychological factors, with supportive principal leadership and teacher professional competence contributing positively to teachers' ability to implement digital learning. Supportive leadership provides guidance, encouragement, communication, facilitation, and constructive support that can create a school environment conducive to technology adoption, while professional competence equips teachers with the knowledge and skills required to integrate digital resources into learning activities. The findings further indicate that teacher self-efficacy plays an important mediating role in the relationships between supportive principal leadership, teacher professional competence, and digital learning implementation, suggesting that organizational support and professional capability become more meaningful when teachers possess confidence in their ability to use technology and manage technology-supported learning. Teachers with stronger self-efficacy are more prepared to experiment with instructional strategies, overcome challenges, and sustain the use of digital resources in classroom practice. These findings demonstrate that digital transformation in elementary education should not be understood merely as the provision of technological infrastructure, but as an integrated process involving supportive leadership, professional capacity, and teachers' psychological readiness. Practically, schools should strengthen digital learning through continuous leadership support, professional mentoring, teacher collaboration,

technological facilitation, constructive feedback, and professional development in digital pedagogy, learning-resource development, technology use, and digital assessment, while education authorities should design digital transformation programs that place human capacity alongside technological infrastructure. Nevertheless, the findings should be interpreted within the study's limitations, particularly its focus on public elementary schools in Kecamatan Pulau Punjung, Kabupaten Dharmasraya, the use of self-reported questionnaire data, and the exclusion of other potentially relevant factors such as digital infrastructure, school culture, teacher digital literacy, and educational policy; therefore, future research should involve broader geographical contexts, multiple sources of evidence, and additional organizational and technological variables. Overall, the study provides an integrated perspective demonstrating that sustainable digital learning implementation requires the alignment of supportive leadership, professional competence, and teacher self-efficacy, thereby offering both theoretical insight and practical direction for strengthening digital transformation in public elementary schools.

AUTHOR CONTRIBUTIONS STATEMENT

Nila Prianti contributed to the conceptualization of the study, development of the research framework, data collection, data analysis, interpretation of findings, and preparation of the original manuscript. Merika Setiawati contributed to the supervision of the research, refinement of the research design and methodology, critical review of the manuscript, and coordination of the publication process. Nellitawati contributed to the development of the theoretical framework, methodological review, interpretation of the findings, and critical revision of the manuscript. Ahmad Sabandi contributed to the research methodology, review and interpretation of the data analysis, critical evaluation of the manuscript, and revision of the final version. All authors reviewed the manuscript critically, approved the final version, and agreed to be accountable for all aspects of the work.

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