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Teacher Learning Innovation in the Perspective of Principal Academic Supervision and Digital Literacy: An Empirical Study of State Junior High School in Tanah Datar Regency

Wirda Nengsih
Universitas Negeri Padang, Indonesia

Sulastri
Universitas Negeri Padang, Indonesia

Rusdinal
Universitas Negeri Padang, Indonesia

Irsyad
Universitas Negeri Padang, Indonesia

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Abstract

Teacher learning innovation is increasingly important as schools respond to curriculum transformation and the growing use of digital technologies. However, innovative learning practices among public junior high school teachers remain uneven, indicating the need to examine both organizational support and teachers' digital capabilities. This study investigates the effects of principal academic supervision and teacher digital literacy on learning innovation among public junior high school teachers in Tanah Datar Regency, Indonesia. A quantitative correlational design was employed involving 296 teachers selected from a population of 619 teachers through proportionate stratified random sampling. Data were collected using a five-point Likert questionnaire measuring academic supervision, digital literacy, and learning innovation, and were analyzed using prerequisite tests and multiple linear regression with IBM SPSS Statistics. The findings indicate that principal academic supervision was positively and significantly associated with teacher learning innovation, with an R^2 value of 0.481. Teacher digital literacy also showed a positive and significant relationship with learning innovation, with an R^2 value of 0.514. When examined simultaneously, the two predictors produced an R value of 0.762 and explained 58.1% of the variance in teacher learning innovation. The findings suggest that strengthening learning innovation requires more than improving teachers' individual digital capabilities; it also depends on supportive academic supervision that encourages professional reflection and instructional improvement. The study highlights the importance of integrating instructional leadership and continuous digital competence development in efforts to strengthen innovative teaching practices.

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INTRODUCTION

Educational quality is increasingly determined not simply by the availability of technology or the adoption of new curricula, but by teachers' capacity to translate educational change into meaningful classroom practice (Buabeng & Amo-Darko, 2025; Fitrah et al., 2025; Twining et al., 2021). Contemporary education systems expect teachers to move beyond the transmission of content and to design learning experiences that are adaptive, collaborative, creative, and responsive to students' needs. This expectation has become more pressing as digital technologies, online learning platforms, and artificial intelligence increasingly reshape teaching and learning environments (Cheung et al., 2021; Zou et al., 2025). Interestingly, however, greater access to digital technology does not automatically produce more innovative teaching. Adamakis & Rachiotis (2025) and Almuhanna (2025) emphasizes that technology itself is not a transformative force unless teachers possess the competencies needed to integrate it pedagogically and meaningfully. In this sense, teacher learning innovation should be understood as a professional capacity involving the development and application of new pedagogical strategies, learning resources, assessment practices, and technology-supported approaches. Such innovation is particularly important because teachers operate at the point where educational policies and technological changes are ultimately translated into students' everyday learning experiences. Therefore, understanding the conditions

*** Corresponding author:**
Nengsih et al, Universitas Negeri Padang, Indonesia
sulastri_aip@fip.unp.ac.id

that enable teachers to innovate has become an important issue in contemporary educational management.

The Indonesian education system provides a particularly relevant context for examining this issue because educational transformation has been accompanied by curriculum reform, digitalization initiatives, and growing expectations concerning 21st-century competencies. The 2025 Education Report presents education quality through interconnected dimensions, including learning outcomes, learning processes, school climate, teacher competence, and educational facilities, indicating that improvements in learning quality require attention to both classroom and organizational factors (Dutta & Sahney, 2021). At the school level, however, the transition toward more innovative learning practices does not always occur at the same pace as policy and technological development. Evidence from Indonesian studies indicates that teachers' readiness to use ICT depends not only on operational skills but also on their ability to plan, select, integrate, and use digital resources appropriately for instructional purposes. Similarly, digital literacy has been associated with teachers' capacity to design and manage technology-supported learning environments, although competence levels and implementation practices remain uneven (Al-Khresheh et al., 2025; Ramdana et al., 2026a). This situation creates an important tension between the policy expectation that schools should become increasingly adaptive and the practical reality that teachers may still rely on familiar instructional routines. The issue is therefore not whether technology is present in schools, but whether teachers have sufficient professional and organizational support to convert available resources into pedagogical innovation. This distinction provides an important basis for investigating teacher learning innovation beyond the simple availability of digital infrastructure.

Preliminary observations in public junior high schools in Tanah Datar Regency illustrate this tension at the local level. The initial observation reported in the present study indicated that approximately 63% of teachers continued to rely predominantly on lecture-based instruction, while only about 37% consistently utilized digital learning media such as instructional videos, educational applications, or online learning platforms. The observation also suggested that the implementation of innovative approaches, including Problem-Based Learning, Project-Based Learning, and Cooperative Learning, remained relatively limited (Asfani & Chen, 2025; Meng et al., 2023). Classroom activities that require students to discuss, collaborate, solve authentic problems, and produce learning products were not yet consistently embedded in everyday teaching practice. These conditions are important because learning innovation is not equivalent to occasional use of digital devices; rather, it involves meaningful changes in how teachers organize learning, engage students, and respond to diverse learning needs (Gudoniene et al., 2025; Rapanta et al., 2021; Skrbinjek et al., 2024a). The preliminary evidence further showed that around 60% of teachers perceived academic supervision as being more strongly oriented toward checking instructional administration than toward developing innovative pedagogy and technology integration (Zhang et al., 2025). Such a pattern suggests that limitations in teacher innovation may reflect a combination of individual competence and the quality of professional support available within schools. Consequently, the Tanah Datar context provides an empirically relevant setting for examining how school-level support and teacher-level digital capacity jointly relate to learning innovation.

Academic supervision is particularly important in this context because the role of the principal extends beyond administrative management to include the development of teaching quality and professional learning (Lamatenggo & Suking, 2026; Siagian et al., 2025). Effective instructional leadership can provide teachers with opportunities to reflect on classroom practices, receive constructive feedback, discuss instructional problems, and experiment with alternative pedagogical strategies (Bellibaş et al., 2022; Ghamrawi et al., 2024). Recent evidence indicates that instructional leadership can contribute to teacher professional development and strengthen the conditions under which teachers improve their instructional practices (Dorukbaşi & Cansoy, 2024) Similarly, research on instructional leadership in digital learning environments suggests that mentoring, collaboration, and reflective supervision can create a supportive context for teacher innovation (Efendi, 2024). However, the effectiveness of supervision depends substantially on how it is enacted in practice (Urbancová et al., 2021). Supervision that emphasizes compliance and administrative completeness may have a different effect from supervision that involves classroom observation, professional dialogue, feedback, and follow-up. This distinction is consistent with research showing that school

support can influence teacher innovation through motivational and professional mechanisms, although the effects of different sources of support are not necessarily uniform (Butera et al., 2021; Qin et al., 2025). Thus, academic supervision deserves attention not merely as an evaluative activity but as an organizational mechanism that may enable teachers to reconsider established practices and develop new approaches to learning.

Alongside organizational support, teacher digital literacy represents an important individual-level resource for learning innovation. Digital literacy involves more than the technical ability to operate devices; it encompasses the capacity to locate, evaluate, create, communicate, and use digital information and resources appropriately for particular purposes. Recent scholarship has increasingly shifted from the narrow concept of digital literacy toward broader notions of professional digital competence, emphasizing the integration of technological knowledge with pedagogical decision-making (Ramdana et al., 2026a; Syahruddin & Agus, 2026). Teachers with stronger digital competence are generally better positioned to select appropriate digital resources, design technology-enhanced activities, and adapt learning materials to different instructional situations. Research on technology-enhanced teaching further indicates that teachers' digital competence-related beliefs are associated with the quality of technology-supported instructional practices (Mouw et al., 2023; Qian, 2025). In Indonesia, evidence from rural schools likewise demonstrates that teachers require competencies in planning, selecting, and integrating ICT rather than merely operating digital devices (Rasdiana et al., 2024; Sepadi et al., 2025). Nevertheless, digital literacy should not be assumed to produce innovation independently because technology use can remain superficial when teachers lack pedagogical direction or institutional support. This suggests that teacher digital literacy and academic supervision may represent complementary dimensions of learning innovation, with the former providing individual capacity and the latter creating an enabling organizational environment.

Existing studies generally support the importance of both leadership and teacher digital competence, but they have tended to examine these factors through partially separated research streams. Studies of school leadership have shown that leadership practices are associated with teacher professional collaboration, professional development, and innovative behavior (Ma & Marion, 2024). Hsieh et al. (2026), for example, found evidence of a relationship between school leadership and teacher innovativeness using multilevel data from the Taiwan TALIS context, reinforcing the argument that teacher innovation is partly shaped by school-level conditions. Other research has demonstrated that supportive school environments can strengthen teacher innovation through psychological and professional mechanisms, rather than through direct administrative control alone (Messmann et al., 2022). At the same time, research on teacher digital competence has consistently emphasized its importance for technology integration, professional development, and technology-enhanced teaching (Demissie et al., 2022; Rasdiana et al., 2024). Studies in Indonesia have also reported relationships between digital competence and teachers' technology-related pedagogical capabilities (Mintasih et al., 2024). These findings establish a strong theoretical basis for considering organizational leadership and individual digital competence together. Nevertheless, the dominant literature still provides limited direct evidence concerning how these two factors jointly explain teachers' learning innovation, particularly at the public junior high school level.

A more critical examination of the literature reveals several unresolved gaps (Bécue et al., 2024). First, studies of academic supervision and instructional leadership have frequently focused on teacher performance, professional development, or instructional quality rather than treating teacher learning innovation as the principal outcome (Huang, 2021; Li et al., 2023). Second, studies of digital literacy have often emphasized technology readiness, ICT utilization, TPACK, or digital competence rather than directly examining teachers' capacity to innovate their learning practices (Ramdana et al., 2026). Third, although emerging research has begun to examine the interaction between leadership and digital competence, the evidence remains limited, particularly in Indonesian public junior high schools; a recent Indonesian study, for instance, found that teachers' digital competence and principals' instructional leadership jointly predicted TPACK, but the dependent construct was technology-pedagogical knowledge rather than learning innovation itself (Ramdana et al., 2026). Fourth, the contextual dimension remains underexplored because findings from other national or educational settings cannot automatically be assumed to represent the organizational realities of public junior high schools in Indonesian regions (Khatib et al., 2026). The literature

therefore leaves an important empirical question unresolved: whether academic supervision and teacher digital literacy can simultaneously explain meaningful variation in teachers' learning innovation within a specific Indonesian school context. Addressing this gap is important because teacher innovation is likely to emerge from the interaction between what teachers are capable of doing and the professional environment in which they work (Skrbinjek et al., 2024). Accordingly, the present study positions academic supervision as an external organizational factor and digital literacy as an internal professional capacity within an integrated empirical model.

Against this background, this study aims to examine the effects of principal academic supervision and teacher digital literacy on learning innovation among public junior high school teachers in Tanah Datar Regency, Indonesia. More specifically, the study investigates whether academic supervision significantly influences teacher learning innovation, whether teacher digital literacy significantly influences learning innovation, and whether both predictors jointly explain variation in teachers' innovative learning practices (Wu et al., 2026). The study is designed to move beyond a fragmented examination of school leadership and teacher competence by considering the two dimensions simultaneously within one analytical framework. Theoretically, the study contributes to educational management research by positioning teacher learning innovation as an outcome shaped by the interaction of organizational support and individual digital capacity. It also extends the discussion of digital transformation by emphasizing that technology-related competence becomes more meaningful when accompanied by instructional leadership that supports reflection, experimentation, and professional improvement. Practically, the findings may assist principals in developing academic supervision practices that emphasize professional guidance, classroom feedback, and follow-up rather than administrative inspection alone. The results may also provide schools and policymakers with evidence for designing professional development programs that strengthen teachers' digital literacy while connecting digital competence with actual pedagogical innovation. In this way, the study seeks to provide both contextual empirical evidence from Tanah Datar and a more integrated understanding of the organizational and individual conditions that support teacher learning innovation.

METHOD

Research Design

This study employed a quantitative approach with a correlational and associative research design to examine the effects of principal academic supervision and teacher digital literacy on teacher learning innovation in public junior high schools in Tanah Datar Regency, West Sumatra, Indonesia. A quantitative approach was selected because the study sought to measure the relationships among the research variables numerically and test the proposed effects using statistical procedures. The correlational design was appropriate because the study examined naturally occurring relationships among principal academic supervision, teacher digital literacy, and learning innovation without manipulating the variables. The associative orientation was used to determine whether the independent variables were significantly related to and contributed to variation in the dependent variable. The research model consisted of principal academic supervision (X_1) and teacher digital literacy (X_2) as independent variables and teacher learning innovation (Y) as the dependent variable. Multiple linear regression was subsequently employed because the research involved two predictor variables and one outcome variable. This design allowed the study to examine both the individual effects of each predictor and their simultaneous contribution to teacher learning innovation. Accordingly, the selected design was considered appropriate for empirically examining the extent to which organizational support and teachers' digital competence were associated with innovative learning practices.

Research Setting and Time

The research was conducted in public junior high schools (Sekolah Menengah Pertama Negeri) in Tanah Datar Regency, West Sumatra, Indonesia. The participating schools were distributed across 14 sub-districts, representing the geographical and educational characteristics of public junior high schools within the regency. The research setting was selected because the study specifically focused on learning innovation among teachers working in public junior high schools. The participants were teachers who were actively involved in instructional activities at the time of

data collection. Data collection was conducted after the researcher obtained permission from the relevant educational authorities and the participating schools. The original research document does not provide the precise dates or months of data collection; therefore, the exact research period should be inserted in the final manuscript based on the documented fieldwork schedule. Stating the research period explicitly is important for methodological transparency and for enabling future researchers to understand the temporal context of the findings.

Population and Sample

The population consisted of 619 teachers working in public junior high schools in Tanah Datar Regency. The sample size was determined using the Slovin formula with a 5% margin of error, resulting in 296 teachers as research respondents. The sampling process employed proportionate stratified random sampling, in which the number of respondents selected from each school was determined proportionally according to the number of teachers in that school. This procedure was used to ensure that schools with different teacher populations received proportional representation in the sample. The inclusion criterion was that respondents were active teachers in public junior high schools in Tanah Datar Regency and were directly involved in teaching activities. Teachers who were not actively engaged in teaching during the data-collection period were excluded from participation. The use of proportionate stratified random sampling increased the representativeness of the sample across the participating schools and provided a stronger basis for generalizing the findings to the target population.

Research Instruments

Data were collected using a structured closed-ended questionnaire consisting of three principal constructs: principal academic supervision, teacher digital literacy, and teacher learning innovation. All items were measured using a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree. The academic supervision construct focused on the extent to which teachers experienced academic guidance and supervision related to instructional planning, classroom observation, feedback, professional development, and follow-up activities. The digital literacy construct measured teachers' ability to access, understand, evaluate, and utilize digital information and technology for educational purposes. The learning innovation construct measured teachers' implementation and development of innovative instructional practices, including the use of varied teaching strategies, learning media, technology, and learning activities designed to improve student engagement and learning quality. The development of the instruments was guided by relevant theoretical perspectives on academic supervision, digital literacy, and learning innovation, including the concepts discussed by Fischer et al. (2021), Lambert & Newman (2023), as reflected in the original manuscript. The exact number of items and detailed indicators for each construct should be reported according to the final questionnaire used in the field study.

Validity and Reliability of the Instruments

The quality of the research instruments was considered through validity and reliability procedures before the data were used for hypothesis testing. Content validity was established by ensuring that each questionnaire item corresponded to the theoretical dimensions and operational definitions of the respective construct. The items were reviewed for their relevance to the research objectives and their ability to represent the dimensions of academic supervision, digital literacy, and learning innovation. Construct validity was considered through the consistency between the theoretical definitions, indicators, and questionnaire items used to measure each variable. Reliability testing was conducted to assess the internal consistency of the items within each construct. Because the original research document does not report the number of experts involved in instrument validation, the detailed validation procedure, or the resulting reliability coefficients, these details should be added from the actual instrument-testing records rather than estimated. Reporting the actual validity and reliability results is necessary to demonstrate that the instruments provide sufficiently consistent and appropriate measurements for subsequent statistical analysis.

Data Collection Procedure

The data collection was conducted systematically through several sequential stages. First, the researcher identified the research problem and reviewed relevant literature concerning academic supervision, teacher digital literacy, and learning innovation. Second, the research instruments were

prepared according to the operational dimensions of the three variables. Third, the researcher obtained the necessary research permission from the relevant educational authorities and coordinated with the participating public junior high schools. Fourth, the selected teachers were contacted and the structured questionnaires were distributed according to the predetermined sampling allocation. Respondents were informed about the purpose of the study and were asked to provide responses based on their actual experiences and perceptions. Participation was voluntary, and the questionnaire responses were treated as research data for statistical analysis. After completion, the questionnaires were collected and checked to identify incomplete or unusable responses. Finally, the valid responses were coded, organized, and entered into statistical software for further analysis. This procedure was intended to maintain consistency throughout the data-collection process and to ensure that the dataset was sufficiently complete for subsequent statistical testing.

Research Procedure Flowchart

To provide a clear overview of how the research was conducted, the complete research procedure is presented in Figure 1. The flowchart summarizes the major stages beginning with the identification of the research problem and literature review, followed by research design, population and sample determination, instrument preparation, data collection, data screening, statistical analysis, and hypothesis testing. The sequence is intended to demonstrate the logical connection between the methodological stages and the procedures used to address the research objectives.

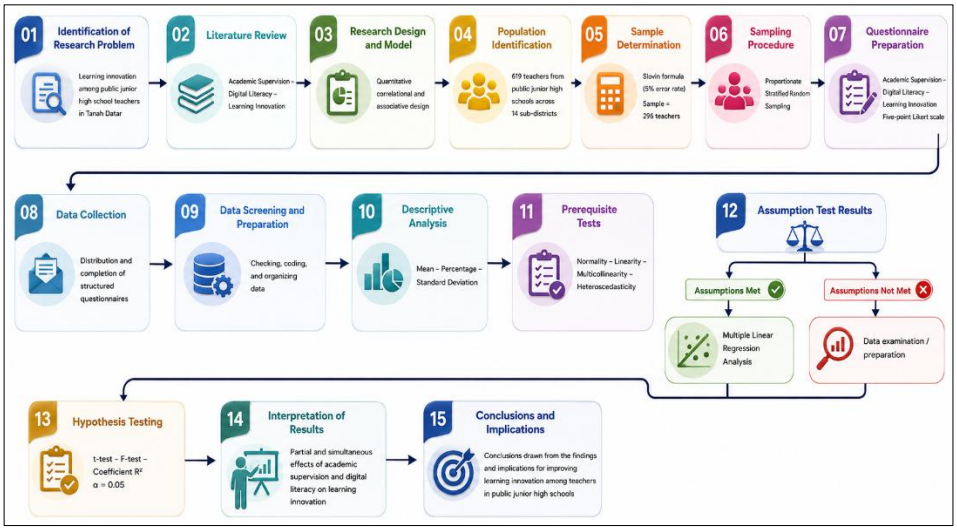

Figure 1. Research Procedure for Examining the Effects of Principal Academic Supervision and Teacher Digital Literacy on Teacher Learning Innovation

The flowchart demonstrates that the study followed a structured quantitative procedure in which sampling and questionnaire administration preceded systematic data preparation and statistical testing. After the prerequisite assumptions were examined, multiple linear regression was used to determine the partial and simultaneous effects of principal academic supervision and teacher digital literacy on learning innovation. The final hypothesis-testing stage used the t-test, F-test, and coefficient of determination (R^2) at a significance level of 0.05, consistent with the analytical procedures described in the study.

Data Analysis

The collected data were analyzed using IBM SPSS Statistics through descriptive and inferential statistical procedures. Descriptive analysis was initially performed to describe the characteristics and distribution of the research variables using mean values, percentages, and standard deviations. Before hypothesis testing, prerequisite analyses were conducted to determine whether the data met the assumptions required for multiple linear regression. These tests included normality, linearity, multicollinearity, and heteroscedasticity. The normality test was used to assess whether the data met the distributional requirements of parametric analysis, while the linearity test examined whether the relationships between the independent variables and learning innovation

were linear. Multicollinearity was evaluated using tolerance and Variance Inflation Factor (VIF) values to determine whether the independent variables showed excessive intercorrelation. Heteroscedasticity testing was conducted to assess whether the residual variance remained consistent across the predicted values. Once the prerequisite assumptions were established, multiple linear regression analysis was conducted to examine the effects of principal academic supervision and teacher digital literacy on teacher learning innovation. The t-test was used to examine the partial effect of each independent variable, whereas the F-test was used to examine their simultaneous effect on learning innovation. Statistical decisions were made at a significance level of $\alpha = 0.05$, with p-values below 0.05 interpreted as statistically significant. The coefficient of determination (R^2) was used to determine the proportion of variance in teacher learning innovation explained by the independent variables.

RESULTS AND DISCUSSION

Results

This study aims to analyze the influence of principal academic supervision and teachers' digital literacy on learning innovations of State Junior High School teachers in Tanah Datar Regency. Before hypothesis testing, the research data is first analyzed through an analysis requirements test which includes normality, homogeneity, multicollinearity, and linearity tests. The results of the normality test using Kolmogorov-Smirnov showed that all research variables had a significance value of 0.054 (>0.05), so that the data was declared to be normally distributed. Furthermore, the results of the homogeneity test showed that the data had the same variance (homogeneous), with a significance value of the principal academic supervision variable of 0.109 and digital literacy of 0.130 (>0.05). The results of the multicollinearity test showed that the variables of academic supervision of school principals and digital literacy had a tolerance value of 0.880 and a VIF value of 1.136. This shows that there is no high correlation between independent variables. In addition, the results of the linearity test show that the relationship between the free variable and the bound variable meets the assumption of linearity, so that regression analysis can be performed.

The results of the first hypothesis test show that the academic supervision of the principal has a positive and significant effect on teacher learning innovation. The results of the correlation analysis showed a correlation coefficient value of 0.694 with a significance value of 0.000 (<0.05). The determination coefficient value of 0.481 shows that the academic supervision of the principal contributes 48.1% to teacher learning innovation. The second hypothesis test shows that teachers' digital literacy has a positive and significant effect on teacher learning innovation. The results of the analysis obtained a correlation coefficient value of 0.717 with a significance value of 0.000 (<0.05). The determination coefficient of 0.514 shows that digital literacy contributes 51.4% to teacher learning innovation. Furthermore, the results of the third hypothesis test show that the principal's academic supervision and digital literacy simultaneously have a positive and significant effect on teacher learning innovation. The results of the double regression analysis obtained a correlation coefficient value of 0.762 with a determination coefficient of 0.581. This means that the two independent variables together contribute 58.1% to teacher learning innovation, while the other 41.9% are influenced by other factors outside the study. The results of the study show that the academic supervision of school principals has an important role in increasing the learning innovation of State Junior High School teachers in Tanah Datar Regency. This significant influence shows that academic supervision carried out in a planned, systematic, and continuous manner is able to encourage teachers to make improvements and development in the learning process.

Effective academic supervision is not only oriented to the examination of learning administration, but also a means of professional development for teachers. Through learning observation, feedback, and follow-up on supervision results, school principals can help teachers identify learning weaknesses as well as find new strategies to improve the quality of learning. This is in line with the view of Glickman, Gordon, and Ross-Gordon (2018) who explain that supervision is a professional assistance process that aims to help teachers improve the quality of learning. The findings of this study show that the role of school principals as learning leaders is one of the factors that support the emergence of teacher innovation. When school principals are able to create an

academic culture that supports professional development, teachers will be more open to change, try new learning methods, and develop various more creative learning media.

In addition to academic supervision, this study also proves that digital literacy has a significant influence on teacher learning innovation. Teachers' ability to utilize digital technology is an important factor in creating more interesting, interactive, and appropriate learning in accordance with current educational developments. Digital literacy is not only related to the ability to use technological devices, but also includes the ability to search, evaluate, process, and utilize digital information for the purpose of learning. Teachers who have good digital literacy will find it easier to develop digital teaching materials, use various learning platforms, and apply more varied learning strategies. These findings reinforce the opinion of Ng (2012) that digital literacy is an important competency that allows a person to use technology effectively and critically in various contexts, including education.

The results of the study also showed that the academic supervision of principals and digital literacy together contributed greater to teacher learning innovation than the influence of each variable partially. This shows that learning innovation is not only influenced by the individual abilities of teachers, but also requires the support of the school environment. Academic supervision provides external support through coaching and mentoring, while digital literacy is an internal factor that allows teachers to develop various learning innovations. The combination of these two factors creates conditions that support teachers to make changes in learning practices. Thus, increasing teacher learning innovation needs to be carried out through a comprehensive strategy, namely strengthening the role of school principals in academic supervision while improving teachers' digital skills in a sustainable manner. This research provides implications for the development of education management, especially in an effort to improve teacher learning innovation. The results of the study show that school principals need to develop an academic supervision model that is more coaching and mentoring, not just administrative evaluation. For schools, the results of this research are the basis for developing teacher professional development programs through training activities, learning communities, and strengthening learning technology skills. Meanwhile, for teachers, improving digital literacy needs to be part of professional competency development in order to be able to create learning that is more creative and relevant to the needs of students.

This research has several limitations. First, the research was only conducted on State Junior High School teachers in Tanah Datar Regency so that the results of the research could not be widely generalized to other areas or levels of education. Second, data collection uses questionnaires so that the information obtained is still based on respondents' perceptions. This condition allows for a difference between the teacher's perception and the learning practices that actually occur in the classroom. Third, this study only examines two variables that affect teacher learning innovation, namely the principal's academic supervision and digital literacy. There are still other factors that may have an influence, such as teachers' work motivation, school culture, principal's leadership, pedagogic competence, and the school organizational environment.

Further research is suggested to expand the scope of research by involving schools from different educational levels and regions in order to obtain a more comprehensive picture of the factors influencing teacher learning innovation. In addition, the next research can use a mixed approach (mixed methods) by combining quantitative and qualitative data so that it can describe the learning innovation process in more depth. For education practitioners, increasing learning innovation needs to be done through synergy between strengthening the academic supervision of school principals and improving teachers' digital literacy. Schools need to provide space for teachers to collaborate, share good practices, and develop technology-based learning on an ongoing basis.

Discusion

The findings demonstrate that principal academic supervision has a positive and statistically significant relationship with teacher learning innovation, indicating that innovation is partly shaped by the quality of instructional support provided within the school. The relatively substantial contribution of academic supervision suggests that teachers are more likely to reconsider established instructional routines when principals provide structured guidance, classroom observation, constructive feedback, and follow-up rather than merely monitoring administrative compliance. Conceptually, this finding is consistent with the instructional leadership perspective,

which positions school leaders as agents who influence teaching quality by creating conditions for professional learning and instructional improvement (Bellibaş et al., 2022; Dorukbaşi & Cansoy, 2024). Recent evidence further indicates that instructional leadership can influence teachers' instructional practices through professional learning processes, while emerging research has directly associated school leadership with teacher innovativeness (Hsieh et al., 2026). This result therefore supports and extends the supervision perspective of Glickman et al. (2018) by suggesting that academic supervision is not simply a control mechanism but can function as an organizational resource that stimulates teachers to experiment with alternative pedagogical practices. In the context of Tanah Datar, the implication is particularly important because the preliminary condition described in the study indicated that supervision was often perceived as more administrative than developmental, suggesting that a shift toward coaching-oriented supervision could provide greater space for instructional innovation.

The significant effect of academic supervision can be further understood through the mechanism of professional reflection and teacher agency. When supervision involves dialogue about classroom problems, feedback on instructional decisions, and opportunities to formulate improvements, teachers are not positioned merely as recipients of directives but as active participants in professional problem solving. This interpretation is compatible with research showing that instructional leadership is associated with teacher practices through shared professional practice and teacher agency (Bellibaş et al., 2022), while teacher autonomy and collective innovativeness can constitute important pathways linking instructional leadership to instructional practices (Demir, 2025). The present finding also resonates with Messmann et al. (2022), who argue that supportive leadership can facilitate innovative work behavior by creating conditions in which teachers' psychological and professional needs are more adequately supported. At the same time, the result should not be interpreted as evidence that supervision automatically generates innovation, because the effectiveness of supervision depends on its enactment, relational quality, and connection to teachers' actual instructional problems. This distinction is particularly relevant given the study's own recognition that supervision focused primarily on administrative checking may have a different effect from supervision emphasizing observation, feedback, and follow-up. Thus, the contribution of the present study lies not simply in confirming the importance of principal supervision, but in reinforcing the argument that its developmental character is central to converting leadership into observable instructional innovation.

Teacher digital literacy also emerged as a significant predictor of learning innovation, with a somewhat stronger explanatory contribution than academic supervision. This finding indicates that teachers' capacity to access, evaluate, process, and apply digital information provides an important individual-level foundation for developing new instructional practices. The result is theoretically consistent with contemporary conceptions of digital literacy, which increasingly move beyond operational technology skills toward critical, pedagogical, and context-sensitive digital competence (Ramdana et al., 2026; Syahruddin & Agus, 2026). Recent empirical work similarly reports a meaningful relationship between teachers' digital literacy and innovative ability, suggesting that digital competence can influence innovation through the capacity to recognize technological possibilities and translate them into instructional applications. The finding is also compatible with Demissie et al. (2022), Mouw et al. (2023), and Rasdiana et al. (2024), who emphasize that effective technology integration depends not merely on access to devices but on teachers' ability to make informed pedagogical decisions about technology. Importantly, the present result challenges a narrow understanding of digital literacy as simple technical proficiency because innovation requires teachers to select, adapt, and creatively integrate digital resources according to instructional objectives. Therefore, digital literacy should be viewed as a form of professional capacity that expands teachers' repertoire of pedagogical possibilities rather than as an isolated technological skill.

The stronger contribution of digital literacy should nevertheless be interpreted cautiously because technological competence does not necessarily translate into meaningful pedagogical innovation in every context. Teachers may possess adequate operational skills while continuing to reproduce conventional lecture-based practices if institutional expectations, professional cultures, or supervisory mechanisms do not encourage experimentation. This argument is consistent with the literature emphasizing that technology availability alone does not guarantee transformative teaching, particularly when teachers lack pedagogical competence and organizational support

(Twining et al., 2021; Fitrah et al., 2025). Studies of technology integration likewise indicate that teachers' digital competence must be connected to instructional decision-making rather than treated as an independent technical attribute (Demissie et al., 2022; Mouw et al., 2023). In the Indonesian context, Rasdiana et al. (2024) similarly highlight the importance of combining teachers' professional digital competence with instructional e-supervision, technology leadership, and digital culture. This perspective provides a useful explanation for the current findings because the observed contribution of digital literacy may represent not only what teachers know about technology but also their ability to transform that knowledge into classroom practice. Consequently, the study extends the digital literacy literature by positioning digital competence as a potential mechanism through which teachers become capable of instructional experimentation, while simultaneously recognizing that such capacity requires a supportive organizational environment to become consistently visible in practice.

The most theoretically significant finding is that academic supervision and digital literacy jointly explained 58.1% of the variance in teacher learning innovation, exceeding the explanatory contribution of either predictor considered independently. This result suggests that teacher innovation is better conceptualized as the product of complementary individual and organizational conditions rather than as a consequence of teacher competence or leadership alone. From a socio-organizational perspective, digital literacy provides teachers with the capability to identify and use technological and pedagogical possibilities, whereas academic supervision provides external reinforcement, feedback, direction, and legitimacy for experimenting with those possibilities. This interpretation is supported by recent Indonesian evidence showing that principals' intellectual stimulation, teachers' digital literacy, and self-efficacy are simultaneously associated with teachers' innovative behavior, with digital literacy emerging as a particularly strong predictor (Noviyanti et al., 2025). It also corresponds with research demonstrating that school leadership and teacher collaboration can shape the professional conditions necessary for innovation (Ma & Marion, 2024; Qin et al., 2025). The present study therefore contributes a more integrated conceptual explanation by bringing together an organizational resource and an individual professional resource within a single empirical model, addressing the fragmented treatment of these factors identified in the literature review.

The combined effect also provides an important explanation for why digital transformation in schools cannot be reduced to teacher training in technology. If professional development increases digital skills without changing the supervisory environment, teachers may acquire new competencies without consistently incorporating them into instructional routines. Conversely, supervision that encourages innovation without strengthening teachers' digital capacity may generate willingness to innovate but leave teachers without sufficient resources or confidence to implement technology-supported approaches. This complementarity is consistent with recent work proposing coaching-oriented academic supervision supported by digital platforms as a means of strengthening teachers' digital literacy and innovation simultaneously. It is also compatible with research showing that principal support and academic supervision can serve as strategic mechanisms for developing teachers' digital literacy rather than treating digital competence as an exclusively individual responsibility. Accordingly, the present findings modify a purely individualistic interpretation of teacher innovation by demonstrating that professional competence and organizational support should be developed as mutually reinforcing components. Practically, this means that schools should move from isolated technology workshops toward sustained professional learning systems in which principals observe implementation, provide feedback, facilitate teacher collaboration, and support teachers in applying digital competencies to authentic classroom problems.

Despite the relatively high explanatory power of the combined model, the unexplained 41.9% indicates that teacher learning innovation remains a multidimensional phenomenon that cannot be adequately accounted for by academic supervision and digital literacy alone. Factors such as teacher self-efficacy, professional motivation, organizational culture, collaboration, pedagogical competence, autonomy, and leadership style may account for additional variation in innovative practices. This interpretation is supported by recent research showing that teacher collaboration can influence innovation through teaching motivation and teaching efficacy (Qin et al., 2025), while leadership effects may operate through teacher autonomy and collective innovativeness rather than solely

through direct influence. The finding also highlights an important limitation of the present model: because the research employed a cross-sectional questionnaire design, the statistical relationships should be interpreted as associations rather than definitive causal mechanisms. Moreover, the study relied on teachers' self-reported perceptions, which may not fully correspond to observable classroom behavior; the manuscript itself acknowledges this limitation and notes the restricted geographical and educational scope of the sample. Thus, the relatively high R^2 should not be interpreted as evidence that the model exhaustively explains teacher innovation, but rather as evidence that organizational supervision and digital literacy constitute substantial components of a broader explanatory framework.

Taken together, the findings position teacher learning innovation as a phenomenon emerging at the intersection of organizational leadership and individual professional capability. The study supports established instructional leadership and professional competence perspectives while extending them by demonstrating their combined relevance to learning innovation among public junior high school teachers in an Indonesian regional context. This contribution is important because previous research has frequently examined leadership in relation to teacher performance or instructional quality and digital competence in relation to technology integration, whereas fewer studies have integrated both dimensions with learning innovation as the principal outcome. The evidence from Tanah Datar consequently suggests that educational innovation should be approached as an organizationally enabled form of professional practice rather than as an individual teacher attribute alone. At the practical level, principals should redesign academic supervision toward continuous coaching, classroom-based feedback, collaborative reflection, and follow-up, while schools should provide sustained digital professional development connected directly to pedagogical applications. Such an integrated strategy is more consistent with the realities of contemporary educational transformation because teachers need both the competence to innovate and an institutional environment that legitimizes, supports, and sustains innovation. The study therefore fills an important contextual and conceptual gap by showing that strengthening teacher learning innovation requires simultaneous attention to what teachers are capable of doing and to the organizational conditions that enable them to do it.

CONCLUSION

The findings demonstrate that teacher learning innovation in public junior high schools in Tanah Datar Regency is significantly associated with both principal academic supervision and teacher digital literacy. Academic supervision showed a positive and significant relationship with learning innovation, indicating that professional guidance, classroom observation, constructive feedback, and follow-up can create conditions that encourage teachers to improve their instructional practices. Teacher digital literacy also demonstrated a positive and significant effect, suggesting that teachers with stronger digital capabilities are better positioned to select and use technological resources, develop varied learning materials, and introduce more engaging instructional approaches. When considered simultaneously, academic supervision and digital literacy explained 58.1% of the variation in teacher learning innovation, while the remaining 41.9% was attributable to other factors outside the model. These findings indicate that strengthening teacher innovation cannot rely solely on individual digital competence or school-level supervision in isolation, but requires the two to operate in a complementary manner. In practical terms, school principals should orient academic supervision toward continuous professional support rather than administrative inspection, while schools should provide sustained opportunities for teachers to strengthen their digital competencies and apply them pedagogically. Overall, the study highlights that combining supportive instructional leadership with teachers' digital capacity provides a meaningful foundation for developing more adaptive and innovative learning practices in public junior high schools.

AUTHOR CONTRIBUTIONS STATEMENT

Wirda Nengsih contributed to the conceptualization of the study, development of the research design and methodology, data collection, data analysis, interpretation of the findings, and preparation of the original manuscript. Sulastri contributed to the conceptual development of the study, methodological supervision, critical review of the manuscript, interpretation of the findings, and overall academic supervision of the research. Rusdinal contributed to the development and refinement of the research methodology, interpretation of the results, and critical revision of the manuscript for important intellectual content. Irsyad contributed to the literature review, interpretation of the research findings, manuscript review, and refinement of the final version. All authors participated in reviewing and approving the final manuscript and agreed to be accountable for the accuracy and integrity of the work.

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