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Instructional Digital Leadership for Strengthening Technology-Integrated Learning in Schools

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Abstract
The integration of digital technology into teaching and learning requires more than technological availability; it also depends on school leadership capable of creating supportive pedagogical and organizational conditions. This study examines how principal digital leadership advances technology-integrated learning in elementary education. A Systematic Literature Review (SLR) was conducted by identifying, screening, and synthesizing relevant empirical studies published between 2019 and 2025. Literature was retrieved from Google Scholar, ScienceDirect, and Dimensions, resulting in 14 studies selected for thematic analysis. The findings identify five interconnected dimensions of principal digital leadership: digital vision and strategic planning; teacher digital competence and professional development; technology infrastructure and organizational support; technology integration in teaching and learning; and barriers and enabling conditions for sustainable implementation. The synthesis indicates that principals contribute to technology-integrated learning by establishing strategic direction, strengthening teacher capacity, mobilizing technological resources, and supporting the pedagogical use of digital technologies. However, infrastructure limitations, connectivity, teacher competence, and leadership readiness may constrain implementation. The study positions principal digital leadership as an enabling mechanism that connects school-level digital transformation with technology-integrated pedagogy.

Keywords: Digital Leadership; Elementary Education; Principal Leadership; Technology Integration; Technology-Integrated Learning.

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INTRODUCTION

The transformation of education in the digital era has increasingly changed how teaching and learning are designed, implemented, and supported in schools. Educational quality is no longer determined solely by curriculum, teacher competence, or the availability of physical learning resources, but also by the capacity of schools to integrate digital technologies meaningfully into educational practices. Technology can expand access to learning resources, support interactive forms of instruction, facilitate communication and collaboration, and enable teachers to provide more flexible learning experiences. Therefore, digital transformation in education should not be understood merely as the adoption of technological devices or digital platforms, but as a process of integrating

technology into the broader teaching and learning ecosystem. This perspective places technology integration within a pedagogical context, where the value of technology is determined by how effectively it supports instructional processes and learning goals (Akram et al., 2022; Falloon, 2020; Fernández-Batanero et al., 2020).

Technology-integrated learning is particularly relevant in elementary education because technology can provide opportunities for students to engage with learning content through visual, interactive, and multimedia resources. Digital presentations, educational videos, interactive applications, and simulations can help teachers communicate concepts that may be difficult to explain through conventional approaches while also supporting students' digital literacy and engagement. However, the presence of digital technology does not automatically produce meaningful pedagogical change. Effective integration depends on teachers' digital competence, the availability of technological infrastructure, access to reliable connectivity, and the organizational support provided by schools. Previous research has indicated that limitations in infrastructure and teachers' digital competencies remain important barriers to the effective implementation of technology-supported learning, particularly where teachers have varying levels of technological readiness (Ajani, 2024; Le et al., 2025; Rawal, 2024). Consequently, technology-integrated learning requires not only technological resources but also an organizational environment capable of supporting teachers in adopting and using technology pedagogically (Woldemariam et al., 2025).

Within this context, school leadership becomes an important factor in advancing technology-integrated learning. The principal occupies a strategic position in shaping school policies, allocating resources, establishing organizational priorities, supporting teacher professional development, and creating conditions that encourage instructional innovation. Research on school leadership has demonstrated that leadership can influence school improvement by strengthening organizational capacity and promoting collaborative processes among school members (Hallinger & Heck, 2010a, 2010b). However, the increasing digitalization of education requires principals to extend these managerial responsibilities toward digital leadership, including developing a vision for technology use, supporting teacher digital competence, facilitating technological infrastructure, and guiding the integration of digital tools into instructional practices. Effective school leadership therefore needs to move beyond administrative management toward a form of leadership that enables schools to respond strategically to technological and pedagogical change (Constantinides, 2025; Ruloff & Petko, 2021).

Principal digital leadership can be understood through the ways in which school leaders establish a shared digital vision, formulate technology-related policies, facilitate professional learning, provide technological resources, and supervise the implementation of digital learning. Previous studies indicate that principals have been involved in planning school digitalization, organizing human and technological resources, implementing digital platforms, and evaluating technology-supported learning practices. Digital leadership also encompasses the capacity of principals to establish strategic priorities and create organizational conditions that enable teachers to use technology effectively (Karakose et al., 2021; Okunlola & Naicker, 2025). Other research emphasizes that school leaders can promote digital transformation through teacher development, technology-oriented planning, infrastructure development, and collaboration within the school community (Riski et al., 2023; Zeng et al., 2025). These practices indicate that principal leadership functions as an enabling mechanism through which technological resources can be translated into educational and instructional practices.

The role of principals is also closely associated with the development of teachers' capacity to integrate technology into learning. Teachers may possess access to digital tools but still experience difficulties in selecting, designing, and applying technology appropriately within instructional contexts. Consequently, professional development, mentoring, supervision, and continuous support are essential components of school-level digital transformation. The reviewed literature indicates that principals can contribute as instructional leaders, supervisors, facilitators, and motivators in strengthening teachers' digital competencies. Evidence from research on teacher digital competence emphasizes that effective technology integration requires not only basic digital literacy but also the ability to apply digital technologies appropriately within pedagogical contexts (Falloon, 2020; Skantz-Åberg et al., 2022). At the same time, professional development remains an important mechanism for strengthening teachers' capacity to integrate digital technologies into teaching (Fernández-Batanero

et al., 2020). These findings suggest that the contribution of digital leadership should be considered not simply in terms of technology provision but in terms of its capacity to strengthen teachers' ability to integrate technology into pedagogical practice (Luo et al., 2024).

Despite the growing recognition of digital leadership in schools, existing research remains fragmented across different dimensions of technology-supported education. Some studies emphasize principals' managerial roles in school digitalization, whereas others focus on teacher digital competence, online learning, digital leadership, ICT infrastructure, or the use of particular digital platforms. Several studies also examine broader school management and digital administration rather than the pedagogical processes through which technology influences teaching and learning. For example, digital technology has been used not only to support learning but also to improve administrative processes such as digital archiving. While such applications are important for school digital transformation, they do not necessarily explain how leadership contributes to the pedagogical integration of technology. This fragmentation makes it difficult to identify the common mechanisms through which principal digital leadership advances technology-integrated learning in elementary education (Apriani et al., 2025; Riski et al., 2023).

Existing studies provide evidence of both enabling and constraining conditions. Some studies report that digital leadership has contributed positively to teachers' technology integration, professional development, and digital learning practices, while other findings indicate that conventional leadership practices, inadequate infrastructure, unstable internet access, and limited digital competence can constrain digital transformation. Research conducted in different educational contexts has similarly highlighted the importance of visionary, collaborative, and transformational leadership in responding to digital change (AlAjmi, 2022; Dasruth et al., 2024; Schmitz et al., 2023). These variations indicate that the relationship between principal digital leadership and technology-integrated learning is not simply a matter of providing technological resources. Rather, it involves the interaction of leadership vision, organizational support, teacher competence, infrastructure, collaboration, and pedagogical implementation. A more integrated understanding of these dimensions is therefore necessary to explain how school leadership can facilitate meaningful technology integration in elementary learning (Isnani et al., 2026; Thahir, 2025).

Accordingly, this study examines the role of principal digital leadership in advancing technology-integrated learning in elementary education by synthesizing findings from relevant empirical studies. The analysis focuses particularly on how principals contribute to digital vision and strategic planning, teacher digital competence and professional development, technological infrastructure and organizational support, and the implementation of technology within teaching and learning. By bringing these dimensions together, the study seeks to reposition school leadership as an important enabling condition for technology-integrated pedagogy rather than treating technology merely as an administrative or infrastructural resource. The guiding research question is: How does principal digital leadership advance technology-integrated learning in elementary education?

RESEARCH METHODS

This study employed a systematic literature review (SLR) to synthesize empirical evidence concerning how principal digital leadership advances technology-integrated learning in elementary education. The methodological design was organized to identify relevant studies, systematically screen and select eligible publications, extract evidence related to digital leadership and technology-integrated learning, and synthesize the findings into cross-study themes. Particular attention was given to the way’s principals support digital vision and strategic planning, teacher digital competence and professional development, technological infrastructure and organizational support, and the integration of technology into teaching and learning. The overall research process consisted of five interconnected stages: research design, identification of the review subjects, systematic literature searching and selection, data extraction, and thematic data analysis.

Research Design

The study adopted a Systematic Literature Review (SLR) design. An SLR was selected because it enables researchers to identify, evaluate, compare, and synthesize findings from relevant empirical studies using an explicit and structured procedure. The approach is appropriate for the present study because research on principal digital leadership and technology-integrated learning has been conducted across different educational contexts and has examined different dimensions, including digital leadership, teacher digital competence, online learning, technology integration, infrastructure, and school-level digital transformation.

The research question was operationalized into four analytical dimensions: (1) digital vision and strategic planning, (2) teacher digital competence and professional development, (3) technological infrastructure and organizational support, and (4) technology integration in teaching and learning. A fifth dimension, namely barriers and enabling conditions, was included to identify contextual factors that strengthen or constrain the implementation of technology-integrated learning.

The systematic review process was organized according to the identification, screening, eligibility, and inclusion stages. The original study searched Google Scholar, ScienceDirect, and Dimensions and initially identified 53 records from Google Scholar, 57 from ScienceDirect, and 62 from Dimensions. Following the screening process, 14 studies were retained for detailed analysis.

Research Subject

The subjects of this study were published empirical research articles, rather than individual participants. The unit of analysis was each article that provided evidence concerning principal leadership, digital leadership, technology use, or technology-integrated learning in elementary education. The original search was restricted to publications from 2019 to 2025 and focused on studies addressing the role of school principals in the use of digital technology for learning. Based on the final screening, 14 articles were included as the review corpus. These studies represented different dimensions of digital transformation in elementary schools, including digitalization of teaching and learning, teacher digital competence, digital leadership, online learning, technology-supported professional development, technological infrastructure, and school-level technology integration. To strengthen the alignment between the review corpus and the present research question, the eligibility criteria were organized into inclusion and exclusion criteria as shown in Table 1.

Table 1. Inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Publication period	Studies published between 2019 and 2025	Studies published outside the specified period
Research focus	Principal/school leadership related to digital technology and teaching-learning	Studies focusing exclusively on general school leadership without a digital or technology-related dimension
Educational context	Elementary/primary education or studies with findings directly applicable to elementary learning	Studies unrelated to elementary/primary education
Technology dimension	Digital technology, ICT, digital platforms, online learning, digital literacy, or technology integration	Studies without a substantive technology-related component
Pedagogical relevance	Studies addressing teaching, learning, teacher digital competence, or technology-supported educational practices	Studies concerned exclusively with non-pedagogical administrative digitalization
Evidence	Empirical findings reported in scholarly publications	Publications without relevant empirical evidence or insufficient information for analysis

The final corpus consisted of 14 articles that met the relevance requirements and provided evidence that could contribute to understanding the relationship between principal digital leadership and technology-integrated learning. The characteristics of these studies were subsequently extracted and synthesized according to the analytical dimensions established in the research design.

Research Procedure

The research procedure consisted of four major stages: identification, screening, eligibility assessment, and final inclusion, followed by evidence extraction and thematic synthesis. The identification stage began with searches of Google Scholar, ScienceDirect, and Dimensions. The original search used the keyword "peran kepala sekolah dalam pemanfaatan teknologi digital" and limited the publication period to 2019–2025. The initial search produced 53 records from Google Scholar, 57 from ScienceDirect, and 62 from Dimensions. The second stage involved screening the retrieved publications according to their topical relevance. Studies were examined to determine whether they addressed the relationship between school leadership, digital technology, and teaching or learning. The original screening process identified a smaller group of potentially relevant studies, followed by further exclusion of publications that did not meet the specified focus. The final screening resulted in 14 articles for detailed analysis.

The third stage involved eligibility assessment. At this stage, the selected studies were examined more closely in terms of their educational context, leadership dimension, technology dimension, and relevance to teaching and learning. Particular attention was given to evidence describing how principals contributed to digital transformation through policy development, strategic planning, teacher development, infrastructure provision, supervision, motivation, and support for technology-based instruction. The fourth stage involved extracting evidence from the 14 eligible studies and organizing the findings according to the analytical framework. Rather than treating each study as an isolated description, the review compared findings across studies to identify recurring mechanisms through which principal digital leadership supports technology-integrated learning. The complete selection process is presented in Figure 1. PRISMA-Based Literature Selection Flow, which should be retained as the principal visual representation of the review procedure.

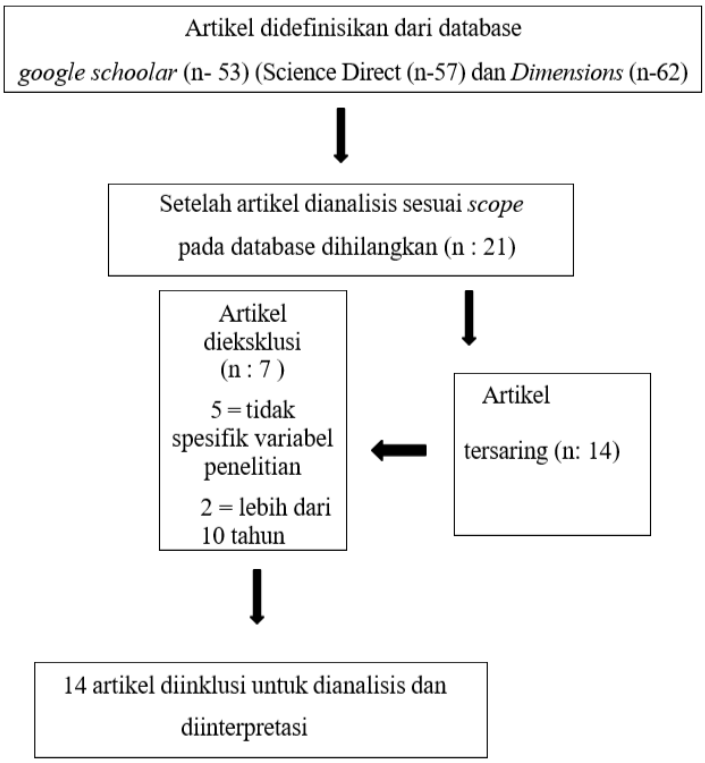

Figure 1. PRISMA-Based Flow of Literature Identification, Screening, Eligibility Assessment, and Inclusion

Instruments and Data Collection Techniques

Because this study was a systematic literature review, the principal research instrument was a structured literature extraction matrix. The matrix was used to record and organize information from each of the 14 included studies. Data extraction focused not only on bibliographic characteristics but also on evidence directly relevant to the relationship between principal digital leadership and technology-integrated learning.

The extracted information included author and publication year, research context, educational level, leadership dimension, technology dimension, teacher-related support, form of technology integration, major findings, barriers or enabling conditions, and implications for technology-integrated learning. This procedure enabled findings from different studies to be compared using a common analytical structure.

Table 2. Literature data extraction matrix

Data Category	Information Extracted
Study identification	Author(s) and publication year
Educational context	Country/context and elementary education setting
Leadership dimension	Digital leadership, instructional leadership, managerial leadership, supervisory role, motivational role, or innovation leadership
Digital vision and strategy	Digital policies, strategic planning, school digitalization programs, and technology-oriented vision
Teacher development	Training, mentoring, supervision, professional development, and digital competence
Technology and infrastructure	ICT facilities, digital platforms, connectivity, and technological resources
Technology-integrated learning	Digital learning platforms, online learning, digital media, technology-supported instruction, and curriculum integration
Organizational support	Collaboration, school culture, stakeholder involvement, and institutional support
Barriers	Infrastructure limitations, internet access, teacher competence, device availability, and other contextual constraints
Principal contribution	Specific mechanisms through which principals enable technology integration
Main findings	Key findings relevant to the research question

The original manuscript demonstrates that the 14 selected studies include evidence concerning digitalization of teaching and learning, teacher training, curriculum development, ICT infrastructure, online learning, digital leadership, and technology integration. Data collection was conducted through systematic reading and extraction of relevant evidence from each included article. Findings were recorded in the extraction matrix and subsequently grouped according to conceptual similarities. This procedure allowed the study to move beyond a descriptive summary of individual publications toward an integrated interpretation of the mechanisms connecting principal digital leadership with technology-integrated learning.

Data Analysis Technique

The data were analyzed using thematic synthesis to systematically integrate findings from studies with diverse research designs, contexts, and analytical perspectives on digital transformation in elementary education. This approach was considered appropriate because it enables heterogeneous findings to be compared, coded, categorized, and synthesized while retaining their substantive meanings. The analysis focused specifically on identifying recurring patterns concerning the role of principal digital leadership in supporting technology-integrated teaching and learning.

The thematic synthesis was conducted in three sequential stages. First, relevant findings from each included study were extracted and coded according to their substantive meaning. The coding process focused on statements related to principal leadership practices, teacher digital capacity,

technological infrastructure, organizational support, technology use in teaching and learning, and contextual factors affecting digital transformation. Second, codes representing similar concepts were compared and grouped into descriptive categories. This stage reduced conceptual overlap while preserving distinctions among different dimensions of digital leadership and technology integration. Third, related descriptive categories were synthesized into higher-order analytical themes that addressed the review question and enabled relationships across the included studies to be interpreted systematically.

Through this process, five analytical themes were developed. The first theme, Digital Vision and Strategic Planning, covered leadership practices related to digital policy formulation, the development of technology-oriented school visions, strategic planning for digital transformation, resource organization, and the development of school programs that support technology-integrated learning. The second theme, Teacher Digital Competence and Professional Development, encompassed leadership practices associated with teacher training, mentoring, supervision, motivation, guidance, and professional development aimed at strengthening teachers' pedagogical use of digital technologies. The third theme, Technology Infrastructure and Organizational Support, addressed the provision and management of ICT infrastructure, internet access, digital platforms, institutional resources, collaboration mechanisms, and organizational conditions required to support digital transformation. The fourth theme, Technology Integration in Teaching and Learning, focused on the pedagogical application of digital technologies, including digital learning platforms, online learning, digital instructional resources, and other technology-supported teaching practices. The fifth theme, Barriers and Enabling Conditions for Sustainable Technology-Integrated Learning, captured contextual factors that could facilitate or constrain sustainable digital pedagogy, including device availability, internet connectivity, teacher digital competence, leadership capacity, collaboration, school culture, and institutional support.

The five themes were subsequently examined relationally rather than as independent categories. The final stage of synthesis sought to identify an interpretive pathway connecting principal digital leadership with technology-integrated learning. The resulting analytical logic positioned Principal Digital Leadership as an enabling leadership mechanism that shapes Digital Vision and Strategic Planning, which subsequently supports the development of Teacher Digital Competence and Organizational Support and facilitates Technology Integration in Teaching and Learning, ultimately contributing to Technology-Integrated Learning. Infrastructure, connectivity, school culture, collaboration, institutional capacity, and other contextual conditions were treated as factors that could strengthen or constrain these relationships.

Accordingly, the analytical framework did not treat principal digital leadership as a pedagogical outcome in itself. Instead, it conceptualized principal digital leadership as an organizational and instructional enabling mechanism through which strategic direction, teacher capacity development, technological resources, and institutional support can facilitate meaningful and sustainable technology integration in elementary teaching and learning.

RESULTS AND DISCUSSION

RESULTS

The systematic review identified 14 empirical studies that provided evidence concerning principal digital leadership and the integration of digital technology into teaching and learning in elementary education. The reviewed studies covered several interconnected dimensions, including school digitalization, digital leadership, teacher digital competence, online learning, ICT infrastructure, digital platforms, and technology-supported instructional practices. Rather than treating these findings as isolated evidence, the studies were synthesized thematically to identify the mechanisms through which principal digital leadership supports technology-integrated learning.

The synthesis produced five interrelated themes: (1) digital vision and strategic planning, (2) teacher digital competence and professional development, (3) technology infrastructure and organizational support, (4) technology integration in teaching and learning, and (5) barriers and enabling conditions for sustainable technology-integrated learning. The distribution of the reviewed

studies across these themes is summarized in Table 3.

Table 3. Thematic synthesis of the reviewed studies

Theme	Main Focus	Evidence Identified in the Reviewed Studies	Contribution to Technology-Integrated Learning
Digital Vision and Strategic Planning	Digital policies, strategic planning, school digitalization, and leadership orientation	Principals planned digitalization programs, developed technology-oriented school visions, organized digital resources, and formulated strategies for responding to digital transformation	Establishes strategic direction and organizational priorities for technology integration
Teacher Digital Competence and Professional Development	Training, mentoring, supervision, motivation, and teacher digital literacy	Principals organized training and webinars, provided guidance and supervision, and supported teachers' digital competence	Strengthens teachers' capacity to use technology in instructional practice
Technology Infrastructure and Organizational Support	ICT facilities, digital platforms, connectivity, collaboration, and school support	Principals supported ICT infrastructure, digital platforms, technology-related programs, and collaboration with stakeholders	Creates the organizational and technological conditions required for implementation
Technology Integration in Teaching and Learning	Digital platforms, online learning, digital resources, curriculum integration, and technology-supported instruction	Studies reported digitalization of classroom activities, online learning, digital platforms, technology-oriented curricula, and teacher technology integration	Connects digital resources with actual teaching and learning practices
Barriers and Enabling Conditions	Infrastructure limitations, internet access, digital competence, leadership capacity, and institutional support	Studies reported limited devices, unstable internet, insufficient digital competence, and differences in digital leadership practices	Determines the sustainability and quality of technology-integrated learning

The synthesis indicates that principal digital leadership operates through several interconnected mechanisms rather than through a single leadership function. Strategic direction provides the initial basis for digital transformation, while teacher professional development and technological infrastructure translate this direction into organizational capacity. Technology integration then represents the pedagogical manifestation of these leadership-supported conditions. At the same time, infrastructure limitations, connectivity, and variations in teacher and leadership competence influence the extent to which technology can be integrated sustainably into learning.

Digital Vision and Strategic Planning

The first theme concerns the role of principals in establishing strategic direction for school digitalization. The reviewed studies indicate that principals were involved in planning digitalization programs, organizing technological and human resources, developing technology-oriented school visions, and formulating strategies for responding to digital transformation. Primansyah et al. (2025), for example, reported that the principal's managerial role in digitalizing teaching and learning involved planning, organizing resources and teachers, implementing digital platforms, and evaluating the sustainability and effectiveness of technology implementation. The study also described an integrated Google Sites-based system used to support digital learning activities.

Other studies similarly identified principals as strategic actors in school digital transformation. Muslim (2021) found that principals developed technology-oriented school visions involving technology-based school management, strategic planning, technology-supported discussion forums, periodic evaluation, and program development. Kurniawan et al. (2023) identified several strategies for responding to the digital era, including strengthening ICT infrastructure, remaining open to technological developments, emphasizing processes and outcomes, and supporting competencies associated with critical thinking, creativity, communication, and collaboration. The findings therefore indicate that principal digital leadership begins with the establishment of a clear organizational direction. Digital technology was not presented merely as an additional resource but as part of school-level planning and transformation. This strategic function provides the organizational basis for subsequent teacher development and technology integration.

Teacher Digital Competence and Professional Development

The second theme concerns the principal's role in developing teachers' capacity to use digital technology. Across the reviewed studies, teacher training, mentoring, supervision, motivation, and professional development repeatedly emerged as important leadership practices. Nurrochman et al. (2023) reported that principals supported digital transformation through educator, managerial, supervisory, and motivational roles. These included training and webinars for teachers, provision of supporting infrastructure, supervision of digital learning, and motivational support. Suhendra et al. (2022) further demonstrated that principal support was associated with the development of teachers' digital literacy in online learning. The study identified improvements in teachers' digital learning capabilities while also revealing continuing weaknesses in particular digital competencies, including the management and organization of digital information and the development of academic and instructional content.

Similarly, Fitra et al. (2022) reported improvements in teachers' online-learning capabilities following principal intervention. Teacher performance increased from 62.65% in the first cycle to 82.35% in the second cycle, while student activity increased from 45.6% to 78.4%. The study identified the principal's roles as educator, innovator, and motivator as important components of the intervention. These findings indicate that technology integration depends substantially on teachers' capacity to translate available digital resources into instructional practice. Principal digital leadership therefore operates not only through technology provision but also through continuous professional learning and instructional support.

Technology Infrastructure and Organizational Support

The third theme concerns the technological and organizational conditions created by principals to support digital learning. The reviewed evidence indicates that principals were involved in providing ICT infrastructure, facilitating access to digital platforms, organizing technology-related programs, and strengthening collaboration within and outside the school.

Masdiana et al. (2025) reported that principals planned the integration of technology into learning, organized digitalization workshops, prepared IT facilities, recruited IT operators, and encouraged the integration of technology into meaningful learning. The study also highlighted student involvement and collaboration with school committees as supporting elements.

Primansyah et al. (2025) similarly demonstrated the importance of resource organization and digital platform implementation in supporting the digitalization of teaching and learning. The Google Sites-based system represented an example of how organizational planning and technological resources could be combined to structure digital learning activities.

The reviewed literature also shows that technology-related organizational support extends beyond classroom applications. Apriani et al. (2025), for example, examined the principal's role in implementing ICT for digital archive management through the “Molah Gati” system. The findings included policy development, infrastructure provision, staff training, system supervision, and data security. Although this application was administrative rather than directly instructional, it demonstrates the broader organizational capacity required for school-level digital transformation.

Taken together, the findings indicate that technology-integrated learning requires an organizational environment in which infrastructure, human resources, digital systems, and institutional support are aligned. Infrastructure therefore functions as a foundational condition, while leadership determines how these resources are organized and connected to educational priorities.

Technology Integration in Teaching and Learning

The fourth theme represents the central pedagogical dimension of the review. The findings indicate that principal digital leadership is associated with the implementation of digital platforms, online learning, technology-supported instructional activities, technology-oriented curricula, and teacher technology integration. Primansyah et al. (2025) reported that digitalization of teaching and learning involved the implementation of digital platforms and an integrated Google Sites system. The principal's role extended across planning, resource organization, implementation, and evaluation of digital learning activities. Nurrochman et al. (2023) found that digital transformation involved teacher training, infrastructure provision, supervision of digital learning, and motivational support. Fitra et al. (2022) similarly demonstrated that principal-led support was associated with improvements in teachers' online-learning capabilities and student learning activity.

The review also identified evidence that principal digital leadership can influence teachers' actual technology use. Kasim and Surya (2025) found that principals demonstrated high levels of digital leadership, particularly in visionary leadership and professional development, with positive effects on teachers' technology use, particularly in communication and administrative activities. AlAjmi (2022), based on 113 principals and 404 teachers in public elementary schools in Kuwait, similarly reported a positive relationship between principal digital leadership and teacher technology integration during the COVID-19 pandemic.

However, the reviewed studies also reveal that technology integration does not occur uniformly. Dasruth et al. (2024) found that leadership practices in the studied school district remained largely conventional and had not sufficiently encouraged digital leadership. The study emphasized the need for stronger digital leadership knowledge and broader systemic changes to support schools in becoming digital learning environments. Thus, the results indicate that principal digital leadership is most visible pedagogically when leadership practices are translated into teacher technology use and technology-supported teaching and learning. The findings support a progression from leadership vision and organizational support toward actual instructional technology integration.

Barriers and Enabling Conditions for Sustainable Technology-Integrated Learning

The fifth theme identifies conditions that facilitate or constrain technology-integrated learning. Although most reviewed studies reported positive contributions of principal digital leadership, several studies identified persistent barriers involving technological access, connectivity, teacher competence, and differences in leadership readiness. Suhendra et al. (2022) identified several challenges in online learning, including students' lack of devices, unstable internet connections, limited ability of teachers and students to purchase internet data, and difficulties in ensuring student learning outcomes. The study also identified weaknesses in teachers' digital competencies that required continued support.

The evidence also indicates that digital leadership capacity varies across contexts. Dasruth et al. (2024) reported that conventional leadership practices remained dominant in some schools, limiting the development of digital leadership and the transformation of schools into digital learning environments. Wiyana et al. (2024), however, identified democratic and transformational leadership as dominant characteristics in digital-era school leadership, with problem solving, collaboration, learning orientation, and student-centeredness emerging as important characteristics.

These findings demonstrate that technology-integrated learning depends on more than the availability of digital tools. Leadership readiness, teacher competence, infrastructure, connectivity, collaboration, and broader institutional support jointly influence whether technology can be incorporated meaningfully and sustainably into learning.

Cross-Study Synthesis of Principal Digital Leadership and Technology-Integrated Learning

The five themes reveal a sequential but interconnected pattern across the reviewed studies. Principal digital leadership initially operates through vision and strategic planning, which establishes the direction of school digital transformation. This direction is translated into teacher professional development and organizational support, enabling teachers and schools to develop the capacity required to use digital technologies. The provision of technological infrastructure and digital platforms then creates the material conditions for implementation. These conditions become pedagogically meaningful when teachers apply digital technology in teaching and learning. Finally, the sustainability of this process is influenced by barriers and enabling conditions, particularly infrastructure, connectivity, teacher competence, leadership capacity, and institutional support. The cross-study relationship is summarized in Figure 2.

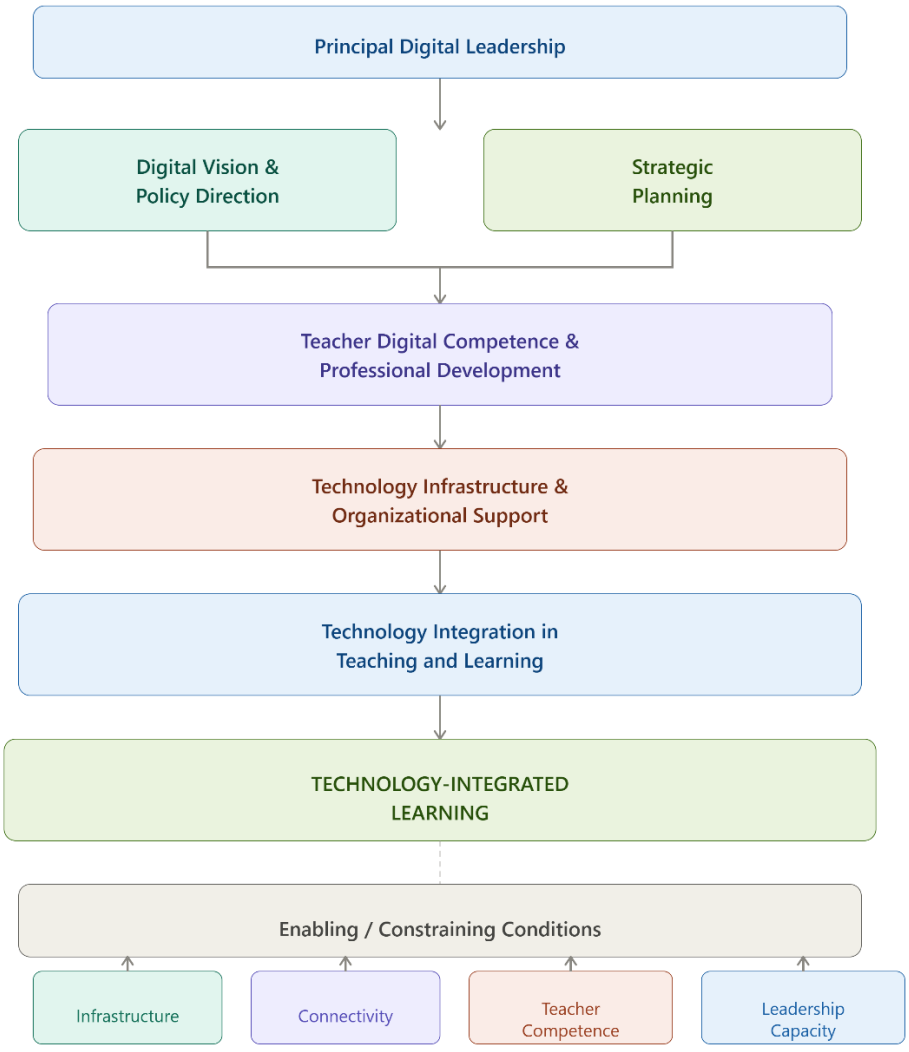

Figure 2. Principal Digital Leadership as an Enabling Pathway for Technology-Integrated Learning

Figure 2 illustrates that principal digital leadership does not operate as a direct pedagogical intervention. Instead, it functions as an enabling mechanism that connects strategic leadership with the organizational, human, and technological conditions required for technology-integrated learning.

Summary of Evidence Across the 14 Studies

Table 4 summarizes the principal contributions identified across the 14 reviewed studies. The table retains the substantive evidence reported in the original manuscript while reorganizing it according to the new analytical orientation.

Table 4. Summary of evidence on principal digital leadership and technology-integrated learning

Study	Principal Digital Leadership Contribution	Technology/Learning Dimension	Main Evidence
Primansyah et al. (2025)	Managerial planning, organization, implementation, and evaluation	Digitalized teaching and learning; Google Sites	Principal leadership supported structured digital learning
Ritonga (2024)	Innovation leadership and teacher development	Technology-oriented curriculum and learning innovation	Training, curriculum development, and external collaboration
Ritajib et al. (2025)	Managerial, supervisory, educator, leader, and motivational roles	School quality and teacher competence	Principal leadership supported school improvement and teacher development
Nurrochman et al. (2023)	Educator, manager, supervisor, and motivator	Digital learning after the pandemic	Training, infrastructure, supervision, and motivation
Suhendra et al. (2022)	Digital-literacy support and teacher development	Online learning	Principal support improved digital competence but barriers remained
Kurniawan et al. (2023)	Strategic leadership for digital transformation	ICT and digital-era competencies	Infrastructure, openness to digital change, and 4C competencies
Apriani et al. (2025)	Policy, infrastructure, training, supervision	Digital administration	ICT strengthened digital archive management
Fitra et al. (2022)	Educator, innovator, and motivator	Online learning	Teacher and student activity improved following principal intervention
Masdiana et al. (2025)	Strategic planning and organizational support	Technology-integrated learning	IT infrastructure, training, meaningful learning, and collaboration
Muslim (2021)	Digital vision and strategic planning	Technology-based school management and programs	Digital vision, planning, discussion, evaluation, and program development
Kasim & Surya (2025)	Visionary leadership and professional development	Teacher technology integration	Positive association with teachers' technology use
Wiyana et al. (2024)	Democratic and transformational leadership	Digital-era school resilience	Problem solving, collaboration, learning orientation, and student focus
Dasruth et al. (2024)	Digital leadership capacity	Teacher technology integration	Conventional leadership remained a constraint
AlAjmi (2022)	Digital leadership	Teacher technology integration	Positive relationship between digital leadership and teacher technology integration

The cross-study evidence demonstrates that principal digital leadership is consistently associated with several organizational and pedagogical mechanisms supporting technology integration. However, the strength and form of this contribution vary across contexts. The evidence is strongest for leadership activities involving strategic planning, teacher development, infrastructure support, and organizational coordination, while the direct pedagogical effects of specific digital leadership practices are less consistently documented across the reviewed studies.

DISCUSSION

The findings of this review indicate that principal digital leadership should not be understood simply as the ability of school principals to manage digital resources, but as an enabling mechanism connecting strategic school leadership with the organizational, human, and technological conditions required for technology-integrated learning. Across the reviewed studies, principals' contributions were reflected in strategic planning, teacher professional development, infrastructure provision, supervision, motivation, and support for digital learning. Digital leadership therefore operates at the intersection of organizational leadership and educational technology, becoming educationally meaningful when it improves the conditions that enable teachers to integrate technology into teaching and learning rather than treating technology merely as an administrative resource (Constantinides, 2021; Costa, 2025; Jongyung, 2024).

This interpretation highlights the importance of strategic direction in digital transformation. In digital education, principals must determine how technologies can be aligned with educational priorities through digital visions, technology-related policies, resource organization, professional development, and supervision. Muslim (2021), for example, identified technology-based school management, strategic planning, technology-supported discussion, periodic evaluation, and program development as components of digital leadership. Similarly, Primansyah et al. (2025) demonstrated that principals were involved in planning, organizing, implementing, and evaluating teaching and learning digitalization, including the use of an integrated Google Sites-based system. These findings suggest that digital transformation begins with strategic direction rather than technology acquisition, because the principal's digital vision determines how technology is positioned within educational priorities.

The findings also reinforce the distinction between technology adoption and meaningful technology integration. The availability of digital platforms, ICT facilities, or online systems does not automatically produce technology-integrated learning. Technology becomes pedagogically meaningful when it is connected to instructional objectives and learning processes. Effective integration also requires appropriate technological and pedagogical knowledge so that teachers can determine how digital tools should be incorporated into instruction (Deb & Sofal, 2026). Principal digital leadership consequently functions as a bridge between technological availability and pedagogical utilization. This distinction is particularly important in elementary education, where technology should contribute not merely to the quantity of digital resources but to meaningful learning experiences, student engagement, access to learning resources, and digital competence.

Teacher digital competence represents a critical mechanism through which principal digital leadership is translated into classroom practice. The reviewed studies consistently identify training, mentoring, supervision, motivation, and professional development as important leadership practices. Nurrochman et al. (2023) reported that principals supported digital transformation through educator, managerial, supervisory, and motivational roles, including teacher training, webinars, infrastructure provision, supervision, and motivational support. Suhendra et al. (2022) similarly found that principal support contributed to teachers' digital literacy in online learning, although weaknesses remained in several areas of competence. Fitra et al. (2022) also reported improvements in teachers' online-learning capabilities following principal intervention, with principals functioning as educators, innovators, and motivators. Thus, teachers serve as the translational mechanism between leadership intentions and pedagogical implementation because they ultimately determine how technologies are selected, adapted, and incorporated into instruction.

Accordingly, professional development should not be reduced to technical training on operating digital tools. It needs to strengthen teachers' capacity to make pedagogical decisions about why, when, and how technologies should be integrated into teaching and learning. Principals therefore need to function not only as technology managers but also as facilitators of teacher learning and instructional innovation. Ritonga (2024) highlights the role of principals in encouraging instructional innovation, while Isnani et al. (2026) emphasizes the contribution of digital leadership to teacher professionalism and learning innovation. Perveen et al. (2026) further indicates that principal digital leadership can be associated with teacher performance. These findings demonstrate that digital leadership becomes more significant when policies and resources are accompanied by continuous mentoring, supervision, collaboration, and professional development that connects technological competence with pedagogical practice.

Teacher capacity, however, cannot be separated from technological infrastructure and broader organizational support. Principals contribute to the provision of ICT facilities, digital platforms, IT personnel, training programs, and collaborative structures. Masdiana et al. (2025) reported that principals planned technology integration, organized digitalization workshops, prepared IT facilities, recruited IT operators, and encouraged meaningful learning and collaboration with stakeholders. Primansyah et al. (2025) likewise demonstrated the importance of resource organization and digital platforms in supporting teaching and learning digitalization. Kurniawan et al. (2023) further emphasized strategic leadership responses to the challenges of the digital revolution. Technology-integrated learning is therefore embedded within an organizational ecosystem in which infrastructure, human resources, digital systems, and institutional support must be aligned.

Nevertheless, infrastructure should be viewed as necessary but insufficient for meaningful technology integration. Sophisticated digital systems do not guarantee pedagogical use. Apriani et al. (2025), for example, examined the principal's role in ICT-based digital archive management through the “Molah Gati” system and identified policy development, infrastructure provision, staff training, system supervision, and data security as elements of organizational digitalization. Although digital administration can strengthen organizational readiness, it does not itself constitute technology-integrated learning. This establishes an important conceptual boundary between school digital transformation and technology-integrated pedagogy: administrative digitalization becomes educationally significant only when digital capacity is translated into teaching and learning practices (Apriani et al., 2025; Costa, 2025).

Technology integration can consequently be understood as the pedagogical expression of principal digital leadership. Several studies associate leadership support with digitalized classroom activities, online learning, technology-oriented curricula, digital platforms, and teachers' technology use. Primansyah et al. (2025) reported the use of an integrated Google Sites system to support digital learning, while Nurrochman et al. (2023) documented leadership practices involving teacher training, infrastructure, supervision, and motivation. Kasim and Surya (2025) found that visionary leadership and professional development were prominent dimensions of digital leadership and were positively associated with teachers' technology use. AlAjmi (2022), based on principals and teachers in public elementary schools in Kuwait, likewise reported a positive relationship between principal digital leadership and teacher technology integration during the COVID-19 pandemic. Collectively, these findings suggest that the principal's most important contribution is not direct technology provision but the creation of conditions that enable teachers to incorporate technology into instructional practice (AlAjmi, 2022; Kasim & Surya, 2025; Primansyah et al., 2025).

The evidence further demonstrates that digital leadership is context-dependent. It does not operate independently of infrastructure, connectivity, teacher competence, institutional readiness, or educational policy. Dasruth et al. (2024) found that leadership practices in the studied school district remained largely conventional and had not sufficiently encouraged digital leadership, highlighting the need to strengthen principals' digital knowledge and systemic support. Suhendra et al. (2022) similarly identified lack of student devices, unstable internet connections, financial limitations, and teacher digital competence as continuing challenges. Thus, principals cannot independently overcome structural constraints; leadership effectiveness depends partly on available resources, capacities, and institutional conditions (Dasruth et al., 2024; Suhendra et al., 2022).

Differences in leadership orientation also shape digital transformation. Wiyana et al. (2024) identified democratic and transformational leadership as important characteristics of school leadership in the digital era, emphasizing problem solving, collaboration, learning orientation, and student-centeredness. Effective digital leadership therefore requires more than technical knowledge; it also requires adaptive, relational, collaborative, and learning-oriented capabilities. Ritajib et al. (2025) similarly emphasizes the importance of school leadership in improving educational quality. Digital leadership should consequently be understood as a broader leadership capacity connecting organizational direction, collaboration, and educational improvement (Ritajib et al., 2025; Wiyana et al., 2024).

The synthesis supports a conceptualization of principal digital leadership as a multi-layered enabling mechanism. At the strategic level, principals establish digital visions and policies; at the human level, they develop teacher competence through professional learning, mentoring, and supervision; at the organizational and technological level, they facilitate infrastructure, platforms, connectivity, collaboration, and institutional support; and at the pedagogical level, these conditions enable teachers to integrate technology into teaching and learning. Contextual conditions, including infrastructure limitations, teacher competence, leadership readiness, and institutional support, can strengthen or constrain this process. The resulting relationship can therefore be represented as: principal digital leadership → strategic direction → teacher capacity and organizational-technological support → technology integration → technology-integrated learning.

This conceptualization extends the conventional boundary between educational leadership and educational technology. School leadership can function as an organizational mechanism through which educational technology becomes pedagogically actionable. Principals do not necessarily design digital instruction directly; rather, they create conditions under which teachers can design and implement technology-supported learning. This interpretation is supported by research emphasizing the strategic role of school leadership in responding to technological and organizational change (Constantinides, 2021; Kurniawan et al., 2023). It reinforces the view that digital leadership should connect organizational priorities with instructional innovation rather than remain confined to technological administration.

The findings have theoretical and practical implications. Theoretically, principal digital leadership should be examined as an enabling construct connecting organizational leadership with technology-integrated pedagogy. Technology integration is a multi-condition process involving leadership, teacher competence, infrastructure, organizational culture, and pedagogical practice. Research on school management and organizational climate also suggests that leadership strategies can influence the performance of the educational community (Costa, 2025). Future research should therefore examine not only whether principals possess digital leadership characteristics but also how specific leadership practices influence teachers' pedagogical use of technology.

Practically, principals should develop digital transformation strategies beginning with educational objectives rather than technology acquisition. Professional development should combine technical competence with pedagogical decision-making, while infrastructure planning should prioritize accessible, sustainable, and instructionally relevant technologies. Schools should establish collaborative mechanisms involving principals, teachers, ICT personnel, and other stakeholders to continuously evaluate technology integration. At the policy level, school leadership requires systemic support involving infrastructure, connectivity, professional development, and digital education policy (Constantinides, 2021; Isnani et al., 2026; Masdiana et al., 2025).

CONCLUSION

This review concludes that principal digital leadership plays a strategic enabling role in advancing technology-integrated learning in elementary education. Across the 14 reviewed studies, its contribution operates through interconnected mechanisms involving digital vision and strategic planning, teacher digital competence and professional development, technological infrastructure and organizational support, and the facilitation of technology integration into teaching and learning. The findings further indicate that technology integration is not determined by technological availability

alone but depends on how effectively school leadership aligns digital resources, teacher capacity, and organizational conditions with pedagogical needs.

The review also demonstrates that principal digital leadership is most meaningful when it moves beyond technology management toward technology-pedagogical enablement. Principals function as strategic leaders, professional learning facilitators, resource mobilizers, and instructional supporters who create conditions for teachers to use digital technologies purposefully. However, the sustainability of technology-integrated learning remains dependent on contextual factors, including infrastructure, connectivity, teacher digital competence, leadership readiness, and institutional support.

The findings position principal digital leadership as an important bridge between school-level digital transformation and technology-integrated pedagogy. Future research should examine specific leadership practices and their relationships with teachers' pedagogical use of technology and students' learning experiences across diverse elementary education contexts.

REFERENCES

Ajani, O. A. (2024). Teachers' competencies in digital integration of learning contents in dynamic classroom practices: A review of teacher professional development needs. *Acta Educationis Generalis, 14*, 18–40. https://doi.org/10.2478/atd-2024-0016

Akram, H., Abdelrady, A., Al-Adwan, A., & Ramzan, M. (2022). Teachers' perceptions of technology integration in teaching-learning practices: A systematic review. *Frontiers in Psychology, 13*. https://doi.org/10.3389/fpsyg.2022.920317

AlAjmi, M. K. (2022). The impact of digital leadership on teachers' technology integration during the COVID-19 pandemic in Kuwait. *International Journal of Educational Research, 112*, 101928. https://doi.org/10.1016/j.ijer.2022.101928

Apriani, B. K., Handayani, R., & Mustari, M. (2025). Peran kepala sekolah dalam pemanfaatan teknologi informasi dan komunikasi untuk pengelolaan arsip digital di SDN 23 Ampenan. *Jurnal Ilmiah Profesi Pendidikan, 10*(1), 210–217. https://doi.org/10.29303/jipp.v10i1.2921

Constantinides, M. (2021). Understanding the complexity of system-level leadership in the English schooling landscape. *Journal of Educational Administration*. https://doi.org/10.1108/jea-09-2020-0200

Constantinides, M. (2025). Continuous improvement and educational innovation in Scotland: The crucial role of school leadership. *School Leadership & Management, 46*, 64–82. https://doi.org/10.1080/13632434.2025.2597268

Costa, K. F. V. (2025). School management and organizational climate: How strategic leadership impacts educational community performance. *Brazilian Journal of Development*. https://doi.org/10.34117/bjdv11n12-023

Dasruth, J., Naicker, S. R., & Smith, C. (2024). Teachers' perceptions of principals' digital leadership practices in a school district in a developing country. *Social Sciences & Humanities Open, 10*, 101192. https://doi.org/10.1016/j.ssaho.2024.101192

Deb, J., & Sofal, F. (2026). TAM-TPACK nexus: A conceptual and empirical examination of Technology Acceptance Model (TAM) and Technological Pedagogical Content Knowledge (TPACK) in teaching-learning. *International Journal for Multidisciplinary Research*. https://doi.org/10.36948/ijfmr.2026.v08i01.66913

Falloon, G. (2020). From digital literacy to digital competence: The teacher digital competency (TDC) framework. *Educational Technology Research and Development, 68*, 2449–2472. https://doi.org/10.1007/s11423-020-09767-4

Fernández-Batanero, J., Montenegro-Rueda, M., Fernández-Cerero, J., & García-Martínez, I. (2020). Digital competences for teacher professional development: Systematic review. *European Journal of Teacher Education, 45*, 513–531. https://doi.org/10.1080/02619768.2020.1827389

Fitra, A., Panggabean, E., & Sitorus, M. (2022). Peran kepala sekolah dalam upaya peningkatkan kemampuan pembelajaran daring guru. *Jurnal Penelitian Bidang Pendidikan, 28*(2), 1. https://doi.org/10.24114/jpbp.v28i2.37011

Hallinger, P., & Heck, R. (2010a). Collaborative leadership and school improvement: Understanding the impact on school capacity and student learning. *School Leadership & Management, 30*, 110–95. https://doi.org/10.1080/13632431003663214

Hallinger, P., & Heck, R. (2010b). Leadership for learning: Does collaborative leadership make a difference in school improvement? *Educational Management Administration & Leadership, 38*, 654–678. https://doi.org/10.1177/1741143210379060

Isnani, T., Hasanah, U., Cahyani, D., & Ali, M. (2026). School principals' digital leadership in advancing teacher professionalism and learning innovation: A qualitative literature-based analysis. *SOSIOEDUKASI: Jurnal Ilmiah Ilmu Pendidikan dan Sosial*. https://doi.org/10.36526/sosioedukasi.v15i2.6762

Jongyung, T. (2024). Components and indicators of educational leadership. *Journal of Education and Learning Reviews*. https://doi.org/10.60027/jelr.2024.793

Karakose, T., Polat, H., & Papadakis, S. (2021). Examining teachers' perspectives on school principals' digital leadership roles and technology capabilities during the COVID-19 pandemic. *Sustainability*. https://doi.org/10.3390/su132313448

Kasim, M., & Surya, P. (2025). Dampak kepemimpinan digital kepala sekolah terhadap integrasi teknologi guru di sekolah dasar. *Jurnal Pendidikan dan Kebudayaan, 10*(1), 1–18. https://doi.org/10.24832/jpnk.v10i1.5662

Kurniawan, K., Kusumawati, K., Hurriyati, S. D., Amirrasyid, A. F., & Mugni, M. (2023). Strategi kepemimpinan kepala sekolah dalam menghadapi revolusi digital 4.0. *Journal on Education, 5*(2), 2238–2247. https://doi.org/10.31004/joe.v5i2.876

Le, H., Huynh, D., & Nguyen, T. (2025). Technology integration in English language teaching: Assessing the digital readiness of Vietnamese high school teachers. *The International Journal of Information and Learning Technology*. https://doi.org/10.1108/ijilt-03-2025-0085

Luo, H., Sun, D., Zhang, L., Wiyono, B., Imron, A., Rahma, L., Arifah, N., Azhari, R., E., Sibula, I., & Maharmawan, M. A. (2024). Elevating teachers' professional digital competence: Synergies of principals' instructional e-supervision, technology leadership and digital culture for educational excellence in digital-savvy era. *Education Sciences*. https://doi.org/10.3390/educsci14030266

Masdiana, M., Mulawarman, W. G., & Komariyah, L. (2025). Manajemen kepemimpinan kepala sekolah dalam menghadapi era revolusi industri 4.0 untuk peningkatan mutu sekolah negeri Kota Bontang. *Jurnal Manajemen Pendidikan Dasar, Menengah dan Tinggi (JMP-DMT), 6*(2), 231–239. https://doi.org/10.30596/jmp-dmt.v6i2.22229

Muslim, M. (2021). Visi kepemimpinan digital kepala sekolah dasar di era teknologi digital. *Elementeris: Jurnal Ilmiah Pendidikan Dasar Islam, 3*(1), 1. https://doi.org/10.33474/elementeris.v3i1.8796

Nurrochman, T., Darsinah, D., & Wafroaturrohmah, W. (2023). Peran kepemimpinan pembelajaran kepala sekolah melalui transformasi digital pasca pandemi di sekolah dasar. *Jurnal Tarbiyah dan Ilmu Keguruan Borneo, 4*(3), 299–310. https://doi.org/10.21093/jtikborneo.v4i3.6905

Okunlola, J. O., & Naicker, S. (2025). Principals' digital leadership competencies in the Fourth Industrial Revolution: Teachers' perspectives. *Education Sciences*. https://doi.org/10.3390/educsci15060656

Perveen, S., Bashir, T., & Abbas, S. Z. (2026). The impact of principals' digital leadership on teachers' performance in secondary school. *Contemporary Journal of Social Science Review*. https://doi.org/10.63878/cjssr.v4i2.2364

Primansyah, A., Bunyamin, B., & Nugrahani, D. (2025). Peran kepala sekolah sebagai manajer dalam digitalisasi kegiatan belajar mengajar (KBM) di sekolah dasar. *SOCIAL: Jurnal Inovasi Pendidikan IPS, 5*(1), 127–134. https://doi.org/10.51878/social.v5i1.4688

Rawal, D. M. (2024). Mapping of school teachers' digital competency in the context of digital infrastructure: A systematic review and empirical study of India. *Journal of Professional Capital and Community*. https://doi.org/10.1108/jpcc-01-2024-0016

Riski, A., Nurdin, D., Hartini, N., & Prajuri, M. D. H. (2023). Implementation of digital leadership of school principals in Indonesia: Systematic literature review. *JUPIIS: Jurnal Pendidikan Ilmu-Ilmu Sosial*. https://doi.org/10.24114/jupiis.v15i2.51553

Ritajib, Suma, K., & Ardana, I. M. (2025). Peran kepemimpinan kepala sekolah dalam meningkatkan mutu pendidikan di sekolah dasar. *PENDASI: Jurnal Pendidikan Dasar Indonesia, 9*(1), 126–134. https://ejournal2.undiksha.ac.id/index.php/jurnal_pendas/article/view/5304/1884

Ritonga, E. (2024). Peran kepala sekolah dalam mendorong inovasi pembelajaran. *Edukatif, 2*(2), 324–330. https://doi.org/10.65311/je.v2i2.659

Ruloff, M., & Petko, D. (2021). School principals' educational goals and leadership styles for digital transformation: Results from case studies in upper secondary schools. *International Journal of Leadership in Education, 28*, 422–440. https://doi.org/10.1080/13603124.2021.2014979

Schmitz, M.-L., Antonietti, C., Consoli, T., Cattaneo, A. A. P., Gonon, P., & Petko, D. (2023). Transformational leadership for technology integration in schools: Empowering teachers to use technology in a more demanding way. *Computers & Education, 204*, 104880. https://doi.org/10.1016/j.compedu.2023.104880

Skantz-Åberg, E., Lantz-Andersson, A., Lundin, M., & Williams, P. (2022). Teachers' professional digital competence: An overview of conceptualisations in the literature. *Cogent Education, 9*. https://doi.org/10.1080/2331186X.2022.2063224

Suhendra, D. J., Noor, M., & AM, S. (2022). Peran kepala sekolah dalam meningkatkan literasi digital pada pembelajaran daring di masa pandemi COVID-19 di sekolah dasar. *POACE: Jurnal Program Studi Administrasi Pendidikan, 2*(1), 24–38. https://doi.org/10.24127/poace.v2i1.1388

Thahir, I. (2025). Digital leadership of school principals in enhancing technology-based learning quality. *International Journal of Studies in International Education, 2*(4). https://doi.org/10.62951/ijsie.v2i4.417

W., Fatimah, F., & Jamilah, S. (2025). Teacher readiness analysis in integrating digital technology in elementary schools: A case study at SDN Cinangka 4 Depok. *International Journal of Applied Science and Research*. https://doi.org/10.56293/ijasr.2025.6718

Wiyana, A., Hidayati, D., Suyata, S., & Hasanah, E. (2024). Kepemimpinan kepala sekolah dalam resiliensi sekolah di era digital. *Manajemen Pendidikan,* 169–182. https://doi.org/10.23917/jmp.v19i1.3999

Woldemariam, M., Ergado, A., & Jimma, W. (2025). Factors influencing effective integration of educational technology in the colleges of teacher education in Ethiopia: A constructivist grounded theory. *Australasian Journal of Educational Technology*. https://doi.org/10.14742/ajet.9993

Zeng, M., Cheah, K. S. L., & Abdullah, Z. (2025). The influence of school principals' digital leadership on teachers' competency in integrating artificial intelligence: A systematic thematic review. *Frontiers in Education*. https://doi.org/10.3389/feduc.2025.1655967