

The Role of Principals' Leadership in Advancing Technology-Based Learning in the Digital Era

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Abstract: This study aims to provide a comprehensive analysis of the principal's role in enhancing the implementation of technology-based learning in the digital era, while also examining the challenges encountered and the strategies employed throughout the transformation process. Conducted in primary and secondary schools in West Kalimantan that have engaged in digital transformation initiatives through the Merdeka Belajar program, this research employs a descriptive qualitative approach. Data were collected from principals, teachers, and educational staff using purposive sampling. The primary data sources consisted of in-depth semi-structured interviews, participatory observations, and document analysis of school policy reports and internal records. To ensure data validity, methodological and source triangulation were applied, supported by member-checking and audit trail documentation. The data were analyzed using thematic analysis to identify recurring patterns and relationships. Findings reveal that school principals play a crucial role as change agents, facilitators, and innovators in promoting technology integration within instructional practices. Visionary and collaborative leadership—particularly through coaching-based supervision—significantly enhances teachers' digital competencies, strengthens a culture of innovation, and increases student learning motivation. Nonetheless, persistent barriers such as limited technological infrastructure and low digital literacy, especially in remote regions, continue to hinder implementation. The study highlights the importance of continuous digital literacy training, infrastructure improvement, and comprehensive policy support to facilitate equitable and sustainable digital transformation across educational institutions.

Keywords: Digital Leadership; Digital Transformation; Educational Innovation; Principal's Leadership; Technology-Based Learning

Introduction

Over the last twenty years, the rapid evolution of digital technology has advanced at an exceptional pace, fundamentally transforming nearly all spheres of human activity, including the educational sector. Globally, the integration of information technology has become a crucial foundation for improving learning quality and widening equitable access to education (McCarthy et al., 2023). Educational institutions across nations are increasingly engaged in adopting diverse digital innovations, ranging from online learning platforms and data-driven management systems to the application of artificial intelligence to enhance instructional practices (AlAjmi, 2022).

In the Indonesian context, similar efforts are being pursued through the Freedom of Learning initiative and the digital school policies launched by the Ministry of Education, Culture, Research, and Technology. Nevertheless, these developments have not eliminated the persistent disparities between schools situated in urban centers and those located in rural regions, especially in terms of infrastructure readiness, digital competence, and the availability of qualified human resources (Di Pietro et al., 2020). Such inequalities underscore the pressing need for visionary and adaptive educational leadership to ensure that digital transformation in schools moves beyond political discourse and becomes a concrete endeavor that supports high-quality and inclusive learning experiences (Niță & Guțu, 2023).

A growing body of empirical research indicates that the success of digital transformation in education is closely tied to the leadership capacity of school principals. AlAjmi (2022), for instance, reported that principals who exhibit strong digital leadership significantly enhance teachers' ability to incorporate technological tools into their instructional practices, particularly during the COVID-19 pandemic. Likewise, a mixed-methods study conducted by Hidayat (2024) with 623 teachers across Indonesia showed that although digital leadership dimensions could be effectively evaluated and validated, many schools continued to struggle in developing practical competencies such as digital communication, coaching, and resilience in real-world implementation. In addition, findings from a comparative study by Okunlola (2025) revealed that the impact of principals' digital leadership is influenced not only by available technological resources but also by supportive structural systems and active stakeholder collaboration—factors that remain challenging in many developing countries.

Taken together, these studies strengthen the argument that leadership serves as a critical driver in enhancing teachers' readiness, digital proficiency, and the overall culture of innovation within schools (Schmitz et al., 2023). Nevertheless, schools in Indonesia, particularly those situated in rural and remote regions, still encounter substantial barriers associated with inadequate infrastructure and limited digital skills among both teachers and students (Leithwood & Sun, 2020).

Previous research has predominantly focused on evaluating the effects of technology integration on students' academic outcomes, whereas far fewer investigations have examined the specific contributions of school leadership in advancing the adoption of educational technologies (Bass & Avolio, 1994). In addition, studies addressing principals' leadership within the framework of digital transformation have been largely conducted in developed countries, resulting in a noticeable lack of inquiry into comparable circumstances in developing contexts such as Indonesia (Mariana, 2021; Tondeur et al., 2021). Consequently, a substantial gap remains in empirical evidence concerning the actual leadership practices, core challenges, and strategic responsibilities undertaken by school principals in guiding technology-based learning initiatives, especially within rural Indonesian schools characterized by limited technological infrastructure and persistent systemic inequities.

In light of the identified research gap, this study aims to offer an in-depth examination of the leadership practices exercised by school principals that effectively accelerate the implementation of technology-based learning. This research specifically seeks to determine the leadership strategies that facilitate digital transformation within schools, to assess the obstacles faced throughout the process, and to investigate how digital leadership influences improvements in teacher performance and student motivation. The results of this study are anticipated to provide both theoretical and practical contributions to the ongoing discourse on digital leadership, as well as to deliver valuable guidance for policymakers in formulating sustainable models for educational transformation.

Method

This research employs a descriptive qualitative approach aimed at providing a comprehensive understanding of the role of school principals in managing education that emphasizes technology-based learning. This method was selected because it aligns closely with the study's primary objective—to deeply explore real-world phenomena through the collection of narrative, contextual, and exploratory data (McCarthy et al., 2023). The data utilized in this research comprise both primary and secondary sources. Primary data were gathered through in-depth interviews with principals, teachers, and educational staff from several schools that have implemented technology integration within their teaching and learning processes (Raptis, 2024). Meanwhile, secondary data were obtained from official school documents, government regulations related to educational digitalization, and relevant scientific literature, including prior research reports (OECD, 2021).

The participants in this study consisted of school principals, teachers, and educational personnel from institutions that have adopted technology-based learning. Informants were selected using purposive sampling techniques, based on specific considerations relevant to the research objectives. The criteria for participant selection included

individuals who have firsthand experience in their schools' digital transformation, possess a solid understanding of educational technology policies and their implementation, and are willing to share detailed insights during interviews. The number of informants was determined proportionally until reaching a saturation point, meaning that the collected data were deemed sufficient to represent the entire phenomenon under investigation. This sampling method allowed the researcher to obtain a rich, contextualized understanding of leadership practices among principals in managing technology-oriented education (Cavanaugh et al., 2021).

In line with qualitative research principles, the researcher functioned as the primary instrument—or human instrument—responsible for designing, collecting, analyzing, and interpreting the data. To enhance data validity, several supporting instruments were employed, including semi-structured interview guides, participatory observation sheets, and document analysis templates, all developed based on the theoretical framework of transformational leadership and technology-based educational management (Ruloff et al., 2024). The interview guide consisted of core questions related to principals' strategies for leading digital transformation, the support provided to teachers, and the policies implemented within their schools. Observation sheets were used to document behaviors, interactions, and activities occurring within the school environment, while document analysis was applied to review reports, internal policies, and other relevant records. The integration of these various tools was intended to ensure that the collected data were comprehensive, credible, and scientifically valid (Mthanti & Mthethwa, 2023).

Data collection was carried out using three primary techniques: semi-structured interviews, participatory observation, and document analysis. The semi-structured interviews aimed to capture informants' perspectives and firsthand experiences regarding how school principals lead the digital transformation process within their institutions. Participatory observations were conducted by the researcher's direct involvement in school activities to observe how technology is implemented in classroom instruction and supported through managerial decisions. Additionally, document analysis was performed to examine school policy documents and reports that reflect practices in managing technology-based education.

The data were analyzed using a thematic analysis approach, which involved systematically reducing, categorizing, and synthesizing information to identify emerging themes. Data from interviews, observations, and document reviews were examined in depth to uncover recurring patterns and relationships that highlight the principals' role in advancing technology-based educational management. To ensure the validity and reliability of the findings, triangulation of data sources and methods was conducted. Subsequently, conclusions were drawn inductively, based on thematic patterns and conceptual relationships that emerged throughout the analytical process.

The findings of this research are expected to provide a detailed depiction of leadership strategies employed by school principals to promote the use of technology within educational management. Furthermore, this study aspires to contribute both theoretically and practically to the development of effective and adaptive leadership models that can respond to the dynamic challenges of the digital era.

Results and Discussion

This study yielded several significant findings that provide a comprehensive understanding of how school principals' leadership contributes to the advancement of technology-based learning, the obstacles encountered during its implementation, and the resulting effects on both teacher and student performance. The analysis was conducted using a thematic approach, drawing upon data collected from in-depth interviews, on-site observations, and reviews of official documents from multiple schools that have integrated technology into their instructional practices (Leithwood & Jantzi, 2021).

1. The Role of School Principals in Improving Technology-Based Learning

The integration of technology in education refers to the utilization of digital devices, software applications, and online platforms that are specifically designed to support teaching and learning activities. This technological adoption broadens access to information, fosters a more interactive learning environment, and provides greater flexibility in terms of when and where learning can occur (Chen et al., 2022). Findings from interviews indicate that the school principal plays a pivotal role in ensuring the successful implementation of these innovations. For instance, the principal of SMA Negeri 01 Nanga Tayap stated, "We try to lead by example for teachers by applying technology in school management. If the principal does not initiate, teachers are often hesitant to adopt it." Similarly, a teacher from SD Negeri 26 Nanga Tayap noted, "The training provided by the principal helped us understand how to use learning applications. Now I am able to create my own digital teaching materials."

These testimonies illustrate that school principals function not only as administrative leaders but also as innovators who actively cultivate a digital culture within their schools (Damanik, 2021). Concrete actions taken by principals include the provision of essential technological infrastructure, such as internet connectivity and digital devices, expanding access to online platforms like Google Classroom and Moodle, and organizing training programs through Learning Management Systems (LMS) (Susanto & Azzahra, 2023). Furthermore, principals implement coaching-oriented academic supervision and conduct workshops focused on data security and digital ethics, thereby enhancing teachers' competencies in managing technology-driven learning (Fitria et al., 2023).

2. Challenges of Implementing Technology-Based Learning

This situation is further corroborated by data from the Ministry of Education and Culture (2022), which reports that only around 39% of schools in Indonesia possess adequate technological infrastructure to support digital learning (World Bank, 2021). A teacher from SD Negeri 39 Nanga Tayap added, “We want to use digital applications, but not all teachers are familiar with them. Sometimes the training is too brief, so we cannot apply it optimally.”

The constraints of limited infrastructure and short training duration significantly hinder the development of teacher competencies. This observation aligns with Rahman’s (2021) report, which highlights that most Indonesian schools lack ongoing technology training programs. Consequently, some teachers continue to feel insecure about using digital devices in classroom instruction (Prasetyo & Sari, 2022).

Beyond challenges related to teachers and infrastructure, students’ limited digital skills also present a substantial barrier. In several rural schools, students often lack access to technological devices at home, making it difficult for them to adapt to digital learning environments. This situation exacerbates the digital divide, creating a gap between urban students who are more familiar with technology and their counterparts in remote areas where access remains limited (Putra, 2022).

3. Collaborative Leadership in Facing Challenges

Field observations further reveal that school principals who possess a clear and strong digital vision are able to address these challenges effectively by employing collaborative strategies. The principal of SD Negeri 26 Nanga Tayap stated, “We collaborate with parents and the school committee to find solutions, such as acquiring devices through BOS funds or community contributions.” This testimony underscores the critical role of collaborative leadership in sustaining school digitalization initiatives (Handayani & Rachman, 2023). In this capacity, the principal serves as a bridge among various stakeholders, ensuring that essential resources are available while fostering active engagement and participation from all educational community members.

4. Impact of Leadership on Teachers and Students

Moreover, the leadership demonstrated by school principals has a direct impact on both teacher performance and student learning motivation. Teachers who perceive that they receive consistent moral and professional support tend to exhibit greater creativity and openness in integrating technology into their instructional practices (Mariana, 2021). A teacher from SMA Negeri 01 Nanga Tayap remarked, “Since our school adopted a digital learning platform, students have become more engaged. They enjoy learning through videos and interactive quizzes.” Similarly, the principal of SD Negeri 26 Nanga Tayap explained, “We track student learning outcomes using a digital system, which allows teachers to promptly adjust their teaching strategies based on real-time data.”

This data-driven approach has been shown to enhance both the evaluation process and reflective practices in learning (Simamora, 2023). Within the framework of transformational leadership theory as proposed by Bass and Avolio (1994), effective leaders inspire and motivate their subordinates to achieve their highest potential. In educational settings, principals who possess a clear digital vision not only cultivate teachers' innovative spirit but also reinforce a culture of collaboration (Gunawan & Susanti, 2024).

Additionally, the study highlights that school principals play a crucial role in facilitating ongoing teacher training. Consistent with Puspitasari's (2023) findings, professional development initiatives led directly by principals have proven effective in enhancing teachers' capacity to design digital instructional materials. Principals who actively engage in coaching and reflective practices with teachers foster a work environment that supports continuous innovation and lifelong learning within the school (Wijaya & Ningsih, 2024).

Nevertheless, persistent challenges such as access disparities and limited infrastructure remain significant, particularly in underdeveloped regions. Rahayu and Pratama (2023) noted that constraints in internet connectivity and digital devices continue to impede efforts to provide equitable educational opportunities. Consequently, the effectiveness of principals' leadership in promoting digital transformation heavily relies on supportive government policies and active participation from the private sector to expand access to educational technology across all regions (Syahrul et al., 2023).

A summary of the results of the thematic analysis that the researcher has described narratively can be seen in the following table:

Table 1. Main Themes and Research Findings

Main Themes	Description of Findings	Example of an Informant Quote
The role of the principal as an innovator	School principals play an active role in encouraging teachers to use technology and setting an example of digital practices in school management.	"If the principal doesn't start, the teacher is also reluctant to try." – Principal of SMA N 01 Nanga Tayap ¹
Infrastructure limitations	Schools in rural areas face internet network constraints and the availability of digital devices.	"We only have a few computers, and the connection is often disconnected." – Principal of SD N 17 Nanga Tayap ¹
Collaborative leadership	Principals work closely with teachers, parents, and school	"We are working with the school committee for the procurement of the devices."

		committees to support digitalization.	– Principal of SD N 26 Nanga Tayap ¹
Impact on teachers and students		Teachers become more confident, students are more active and motivated through interactive digital learning.	"Students become more active because they learn through videos and quizzes." – Teacher of SMA N 01 Nanga Tayap ¹

¹Researcher's processed data (2025)

Table 1 highlights four major themes that comprehensively capture how school principals' leadership contributes to enhancing the implementation of technology-based learning within the school environment.

The first theme, "The role of school principals as innovators," emphasizes that school leadership extends beyond mere administrative duties and has evolved into a catalyst for digital innovation. Principals who actively model the use of technology can inspire teachers to be more creative and willing to experiment with various digital applications and media in teaching and learning activities. These findings align with Schmitz et al. (2023), who underscore the significance of transformational leadership in fostering an innovative learning culture. Consequently, principals emerge as pivotal agents in cultivating an adaptive and productive digital ecosystem within schools.

The second theme, "Infrastructure limitations," illustrates that the digital divide between urban and rural schools remains a persistent challenge. Issues such as insufficient devices, unstable internet connectivity, and the lack of skilled technical personnel hinder the smooth progress of digital transformation. This observation is consistent with the World Bank (2021), which reports that only a small proportion of schools in Indonesia possess adequate technological facilities. Therefore, even when principals demonstrate a strong digital vision and commitment, the successful implementation of technology-based initiatives heavily depends on the availability of sufficient infrastructure.

The third theme, "Collaborative leadership," highlights that school principals cannot advance the digitalization agenda in isolation. The effective implementation of digital transformation requires coordinated support from teachers, parents, and the wider community. In this context, principals act as mediators and negotiators, capable of integrating both internal and external resources efficiently. This collaborative approach reflects the concept of distributed leadership described by Leithwood & Jantzi (2021), in which leadership responsibilities are shared collectively to enhance the effectiveness and efficiency of educational organizations.

The fourth theme, "Impact on teachers and students," demonstrates the positive outcomes associated with digital leadership. Teachers gain greater competence, creativity, and confidence in utilizing learning technologies, while students exhibit

increased motivation and engagement due to a more interactive and stimulating learning environment. These findings reinforce Bass & Avolio's (1994) transformational leadership theory, which posits that leaders who inspire their teams can cultivate a culture of innovation and strong organizational commitment.

In summary, the data presented in Table 1 not only reflect empirical evidence but also reveal the intricate interplay between leadership vision, resource readiness, and the effects of digital transformation on educational practices in schools.

Figure 1. Conceptual Model of the Leadership Role of School Principals in the Digital Transformation of Education¹



¹Researcher's processed data (2025)

Figure 1 illustrates the systematic interplay between school principals' visionary and collaborative leadership, the enhancement of teachers' digital competencies, the implementation of technology-based learning, and the resulting improvements in student motivation and academic performance.

The findings of this study demonstrate that school principals function as key agents of change, significantly influencing the success of digital transformation within educational institutions. Leadership that is visionary, collaborative, and oriented toward innovation has been shown to enhance teachers' professional competencies, boost students' motivation to learn, and establish a learning environment that adapts

effectively to ongoing technological advancements (Rahmawati & Setiawan, 2024). Nevertheless, for digital transformation to achieve its full potential and be implemented equitably, strong collaboration is required among school principals, government authorities, and the broader community. Such synergy is essential to ensure the availability of adequate infrastructure, the provision of continuous professional development programs, and the enactment of policies that facilitate equitable access to technology-based education across Indonesia.

Conclusion

This study clearly demonstrates that the objective of examining the leadership role of school principals in promoting technology-based learning has been successfully achieved. The findings reveal that school principals occupy a highly strategic position in shaping an educational ecosystem that is responsive to technological advancements. Principals who possess a strong digital vision, implement transformational leadership practices, and consistently provide support for teacher professional development have proven effective in fostering an innovative school culture, which plays a crucial role in facilitating the successful integration of technology into the learning process.

From an academic perspective, this research contributes significantly to the advancement of educational leadership theory in the digital era. The results expand the understanding that transformational leadership not only influences the managerial and administrative functions of schools but also serves as a vital mechanism for enhancing teachers' technological competencies and boosting students' motivation to learn. Consequently, this study enriches the discourse on digital leadership within the Indonesian educational context, particularly amid challenges such as disparities in infrastructure and differences in technological proficiency across regions.

Nevertheless, the study also underscores that the effectiveness of principals in implementing technology-based learning relies heavily on systemic support from multiple stakeholders. Active participation from the government, community, and private sector is essential for strengthening infrastructure, expanding internet access, and ensuring the provision of sustainable professional development programs for teachers. The collaboration and synergy among these stakeholders form the foundation for the long-term sustainability of digital transformation in education.

As a recommendation, further research is encouraged to explore in greater depth effective models of digital leadership across different educational levels, as well as to examine contextual factors that influence the success of technology integration in schools. Additionally, future studies are expected to develop more comprehensive and measurable instruments for evaluating digital leadership, which can support the implementation of national education policies aimed at transforming learning toward 21st-century competencies.

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The author acknowledges that this work still has certain limitations. Therefore, constructive criticism and suggestions are highly welcomed to enhance the quality of this research in the future. It is the hope of the author that the findings of this study will offer meaningful benefits and make a positive contribution to the advancement of knowledge, particularly in the areas of technology-based education and educational leadership.

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