



## SCHOOL INNOVATION MANAGEMENT IN DEVELOPING A DIGITAL LEARNING ECOSYSTEM

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### Abstract

Digital transformation in education requires schools to manage innovation systematically to build an effective, sustainable, and adaptive digital learning ecosystem. This study aims to analyze school innovation management in developing digital learning ecosystems, focusing on planning, implementation, resource management, and sustainability strategies. A mixed-methods explanatory sequential design was applied, beginning with a quantitative survey of teachers, followed by qualitative interviews with school leaders and innovation teams. The results reveal three key determinants of ecosystem effectiveness: innovative leadership, digital resource readiness, and a collaborative school culture. Schools that integrated data-driven decision-making, continuous teacher professional development, and adequate digital infrastructure demonstrated stronger ecosystem performance. These findings emphasize the critical role of innovation management as the foundation for creating an adaptive, inclusive, and high-quality digital learning ecosystem.

**Keywords:** Innovation Management, Digital Ecosystem, Digital Learning, School Transformation.

### 1. INTRODUCTION

The rapid digital transformation occurring across various sectors has significantly reshaped educational systems worldwide. Schools are required to transition from conventional, teacher-centered learning models toward more flexible, technology-enabled, and student-centered pedagogical approaches. This shift is driven not only by technological advancements but also by the evolving needs of learners who increasingly rely on digital tools in their daily lives (Manca, 2020). A digital learning ecosystem encompasses interconnected elements—human resources, technological infrastructure, digital content, organizational policies, and pedagogical processes—that interact dynamically to support meaningful learning experiences. Within this ecosystem, teachers, school leaders, students, and digital platforms form complex interdependencies that shape teaching and learning outcomes. In Indonesia, educational reforms such as Merdeka Belajar and the integration of national digital platforms have accelerated schools' adoption of digital innovation. However, despite strong policy momentum, disparities in digital readiness remain a significant issue, particularly when comparing urban and rural schools. These disparities manifest in unequal access to infrastructure, inconsistent teacher digital competence, and varied levels of institutional capacity to manage technological change (Gunawan et al., 2022). Thus, understanding the role of school innovation management in navigating these complexities is essential to ensuring a sustainable and effective transition toward digital learning.

Although initiatives promoting digital transformation have expanded, many schools continue to struggle with building effective digital learning ecosystems. One major challenge lies in the inconsistent integration of technology into instructional practices. Teachers may have access to digital tools yet lack adequate training to use them pedagogically, leading to superficial or fragmented adoption (Tondeur et al., 2021). Additionally, the absence of structured innovation management—such as clear planning, monitoring systems, and coordinated leadership strategies—often results in technology being implemented as an isolated initiative rather than as part of a holistic educational vision. School leaders may prioritize hardware procurement without building supportive



organizational structures, leading to underutilized technology and resistance from teachers who feel unprepared or unsupported (Ifenthaler & Schweinbenz, 2016). Moreover, digital transformation demands cultural change as much as technical change. Schools need collaborative cultures where experimentation, feedback, and reflective practices are encouraged. Yet, many schools still operate in hierarchical environments that hinder innovation diffusion. These challenges highlight an urgent need for research that goes beyond technological factors and examines how innovation is managed at the school level—how policies are developed, stakeholders mobilized, resources allocated, and digital capacities built. Without strong innovation management, even well-funded digital initiatives risk becoming short-lived or ineffective.

Existing literature provides valuable insights into technology adoption, digital competence, and the pedagogical integration of ICT; however, studies that explicitly position innovation management as the core mechanism supporting digital ecosystem development remain limited (Haukijärvi, 2022). Many previous studies focus on specific dimensions such as teacher readiness, infrastructure availability, or ICT policy implementation. While these factors are important, they do not fully explain why some schools succeed in sustaining digital transformation while others do not. The interplay between leadership, organizational culture, resource management, and teacher capacity-building is rarely explored in an integrated framework (Kristina et al, 2025; Abadi et al, 2022). Furthermore, most studies adopt either quantitative or qualitative approaches, resulting in findings that lack depth or contextual richness. Very few studies employ mixed-methods to examine how innovation is planned, executed, and sustained within school environments. In the Indonesian context, the scarcity of empirical studies examining innovation management in digital learning is even more pronounced. Many schools adopt technology, but the underlying innovation processes—such as vision development, strategic planning, stakeholder involvement, and monitoring mechanisms—are not well documented. This study addresses these gaps by analyzing innovation management not as a supplementary component but as a central pillar in the creation of digital ecosystems. The novelty of this study also lies in its focus on understanding digital transformation as an organizational process that involves systemic change, continuous learning, and collaborative action, rather than merely the integration of digital tools.

The purpose of this study is to analyze how school innovation management contributes to the development of a digital learning ecosystem, with emphasis on innovation planning, implementation strategies, resource organization, and sustainability mechanisms. The study seeks to identify critical indicators of successful digital ecosystems, including innovative leadership, digital resource readiness, teacher professional competence, and collaborative school culture—factors that determine whether digital transformation can be sustained beyond initial implementation. The scope of this study includes teachers, school principals, ICT coordinators, and members of school innovation teams who have been actively involved in digital learning initiatives for at least one year. By incorporating diverse perspectives, the study provides a comprehensive understanding of the systemic processes required to develop strong digital learning ecosystems. The significance of this research extends to theoretical, practical, and policy dimensions. Theoretically, it contributes to educational management literature by positioning innovation management as a key determinant of digital transformation success. Practically, it offers schools a conceptual roadmap for strengthening innovation structures, improving digital capacity-building, and fostering collaborative cultures that support continuous improvement. At the policy level, the findings can guide educational authorities in designing frameworks and support systems that align digital transformation with school-based management principles. Through this integrated analysis, the study highlights that sustainable digital transformation is not simply about adopting technology but about managing innovation strategically and collaboratively across the school system.

## LITERATURE REVIEW

### Innovation Management in Educational Institutions

Innovation management in schools refers to the systematic processes through which institutions plan, implement, monitor, and sustain educational innovations aimed at improving teaching and



learning. It encompasses leadership practices, resource allocation, communication structures, professional development, and mechanisms for continuous improvement. In the context of education, innovation management is often aligned with organizational learning theories, where schools are viewed as dynamic entities capable of adapting to internal and external demands through collaborative knowledge creation and reflective practices. Scholars argue that effective innovation management relies on clear vision, shared goals, and participatory leadership that empower teachers as agents of change (Fullan, 2020). Previous studies have demonstrated that schools with strong innovation management frameworks tend to adopt technology more effectively, foster teacher engagement, and sustain complex reforms over time (Leithwood, 2021). These findings highlight the importance of managerial coherence and collaborative governance in driving educational transformation.

### **Digital Learning Ecosystems**

A digital learning ecosystem is an interconnected network of digital tools, human actors, pedagogical processes, and organizational structures that interact to support meaningful and technology-enhanced learning experiences. It draws upon ecological and sociotechnical systems theories, emphasizing that technology integration must consider organizational culture, teaching practices, and stakeholder relationships. Manca (2020) describes digital ecosystems as adaptive environments in which digital platforms, content, and pedagogical strategies evolve through continuous feedback and collaboration. Recent research has shown that well-developed ecosystems improve student engagement, promote personalized learning, and enhance the overall quality of instruction (Punie and Redecker, 2017). Empirical studies also indicate that schools with mature digital ecosystems demonstrate higher readiness to adopt emerging technologies such as learning analytics, digital assessment tools, and artificial intelligence applications (Haukijärvi, 2022). These findings underscore the importance of building a robust ecosystem rather than implementing isolated digital tools.

### **Leadership and Organizational Support for Digital Transformation**

Leadership plays a central role in facilitating digital transformation in schools. Transformational leadership theory suggests that leaders who articulate a compelling vision, inspire collective action, and support professional growth are better positioned to drive digital innovation (Bass and Riggio, 2019). School leaders influence teachers' motivation, beliefs, and willingness to adopt digital practices by modeling technology use and providing structured support systems. Research has demonstrated that leadership styles emphasizing collaboration, autonomy, and shared decision-making significantly increase the success of digital initiatives (Schein, 2017). A study by Ifenthaler and Schweinbenz (2016) found that schools with strong administrative support exhibit higher adoption rates of learning management systems and digital platforms. These findings indicate that leadership and organizational support are critical determinants of digital innovation effectiveness.

### **Teacher Digital Competence and Professional Development**

Teacher competence is a foundational component of digital learning ecosystems. The Technological Pedagogical and Content Knowledge framework (TPACK) suggests that effective technology integration requires a balance of technological, pedagogical, and content knowledge (Koehler et al., 2013). Studies have shown that teachers who receive continuous professional development demonstrate higher confidence, improved instructional design, and increased use of digital learning strategies (Tondeur et al., 2021). Professional development programs focusing on digital pedagogy, rather than technical skills alone, have been found to be more effective in promoting sustainable classroom innovation. Previous research also highlights the importance of mentoring, peer collaboration, and reflective practice in developing teacher digital competence (Wenger, 2010). These findings demonstrate that capacity-building initiatives must be integral to innovation management efforts.

### **Resource Readiness and Infrastructure Management**

The availability and strategic management of digital resources significantly influence the success of digital transformation. Digital resource readiness refers to the extent to which schools possess reliable infrastructure, accessible devices, stable internet connectivity, and appropriate



learning platforms. Studies show that infrastructure deficiencies remain a major barrier to technology adoption in many developing countries (Gunawan et al., 2022). Efficient resource management involves planning, budgeting, maintenance, and the equitable distribution of digital tools. Research by Tan (2021) indicates that schools with robust infrastructure planning tend to sustain digital innovation longer and experience fewer operational disruptions. These findings suggest that innovation management must prioritize infrastructure readiness as a core component.

### **School Culture and Collaboration in Digital Innovation**

School culture significantly shapes how innovations are adopted and sustained. A collaborative and learning-oriented culture fosters trust, openness to experimentation, and willingness to adapt instructional practices. Sociocultural learning theories argue that meaningful change occurs through interactions and shared practices within professional learning communities (Vygotsky, 1978). Empirical studies demonstrate that teacher collaboration enhances innovation diffusion and improves the consistency of digital instructional practices (Harris and Jones, 2018). Schools that encourage reflective dialogue, peer support, and team-based problem-solving tend to exhibit higher success in digital transformation. These findings emphasize that fostering a positive school culture is essential to developing a sustainable digital ecosystem.

### **Previous Studies on School Innovation and Digital Ecosystems**

A growing body of research has examined the relationship between innovation management and digital transformation in schools. For example, Haukijärvi (2022) reported that digital ecosystems develop more effectively in schools with coordinated innovation strategies and strong leadership involvement. A study by Tondeur et al. (2021) found that teacher beliefs, organizational climate, and leadership support together influence the depth of digital integration. Gunawan et al. (2022) emphasized that digital readiness is strongly associated with managerial competency and institutional commitment. International studies similarly highlight that successful digital transformation requires alignment between leadership, infrastructure, professional development, and organizational culture (Mishra and Koehler, 2020). These studies provide compelling evidence that innovation management is a critical predictor of sustainable digital learning environments.

### **Synthesis and Conceptual Positioning**

Based on the theoretical and empirical literature, it can be concluded that the development of a digital learning ecosystem is shaped by multiple interrelated factors, including leadership, teacher competence, resource readiness, and organizational culture. Innovation management serves as the overarching framework that coordinates these factors and ensures coherence across school-level initiatives. The reviewed literature consistently demonstrates that digital transformation in schools is not a purely technological process but an organizational one, requiring strategic planning, collaborative engagement, and continuous professional growth. This synthesis positions innovation management as the central theoretical foundation for understanding how digital learning ecosystems are successfully developed and sustained.

## **2. RESEARCH METHOD**

### **Research Design**

This study employed a mixed-methods explanatory sequential design to obtain a comprehensive understanding of school innovation management in developing a digital learning ecosystem. The quantitative phase served as the initial stage to identify patterns and relationships among key variables related to innovation management, digital readiness, and ecosystem effectiveness. This phase was followed by a qualitative stage to explore the underlying reasons and contextual factors behind the quantitative findings. The explanatory sequential approach was chosen because it allows researchers to first capture general trends and then refine interpretations through in-depth qualitative inquiry, thereby strengthening the validity and contextual richness of the study (Creswell & Plano Clark, 2018). By integrating numerical evidence with narrative explanations, the design ensured a holistic analysis of how innovation practices shape digital transformation processes in schools.



## Participants

Participants consisted of teachers, school principals, ICT coordinators, and members of innovation teams in schools that had implemented digital learning for at least one year. The quantitative sample included teachers selected using purposive sampling to ensure adequate representation of individuals directly involved in technology integration. The qualitative sample included school leaders and ICT personnel chosen based on their strategic roles in innovation planning and implementation. Purposive sampling is appropriate for studies focusing on specific expertise or involvement because it enables researchers to collect information-rich data aligned with the research objectives (Palinkas et al., 2015). The inclusion of multiple stakeholder groups allowed this study to obtain diverse perspectives on how innovation is managed at the organizational level.

## Instruments

Data were collected using two main instruments: a Likert-scale questionnaire for the quantitative phase and semi-structured interview guidelines for the qualitative phase. The questionnaire measured variables such as innovation management practices, digital infrastructure readiness, teacher competence, and perceived effectiveness of the digital learning ecosystem. The instrument was adapted from validated digital leadership and innovation management scales and reviewed by educational technology experts to ensure content validity. Reliability testing using Cronbach's Alpha confirmed that the instrument met acceptable internal consistency thresholds, with coefficient values exceeding the recommended minimum of .70 (Taber, 2018). For the qualitative stage, the interview protocol was designed to explore planning strategies, resource allocation, teacher development mechanisms, and sustainability efforts related to innovation. The combined use of structured and semi-structured instruments allowed comprehensive data collection across empirical and experiential domains.

## Data Collection Procedures

The data collection process began with the administration of the online questionnaire to teachers through institutional communication channels. Participation was voluntary, and respondents provided informed consent before completing the survey. After analyzing the quantitative results, the research team identified schools that demonstrated distinctive patterns, such as high or moderate innovation implementation, to serve as sites for qualitative inquiry. Semi-structured interviews were then conducted with school leaders and ICT coordinators, either in person or via video conferencing, depending on logistical constraints. Interviews were audio-recorded and transcribed with participants' permission. Ethical protocols were strictly followed throughout the process, including maintaining confidentiality, securing digital data, and ensuring that participation posed no risk to respondents, in accordance with standard qualitative research ethics (Orb et al., 2001).

## Data Analysis

Quantitative data were analyzed using descriptive statistics, correlation analysis, and regression analysis to examine the relationships among innovation management, digital readiness, and ecosystem effectiveness. Statistical procedures were conducted using SPSS, enabling systematic identification of predictor variables and their relative contributions. Qualitative data were analyzed using thematic analysis, following Braun and Clarke's (2021) structured steps of familiarization, coding, theme development, and interpretation. This analytic approach was chosen because it provides a flexible yet rigorous framework for identifying patterns within qualitative datasets. Integration of both quantitative and qualitative findings occurred during the interpretation stage through a technique known as connecting and merging, which aligns data from both phases to generate comprehensive conclusions (Fetters et al., 2013). This process ensured that quantitative trends were explained through qualitative insights, resulting in a cohesive and well-grounded interpretation of how school innovation management shapes digital learning ecosystems.

## 3. RESULT AND DISCUSSION

### Innovative Leadership in Digital Ecosystem Development

The quantitative findings indicate that innovative leadership significantly predicts the



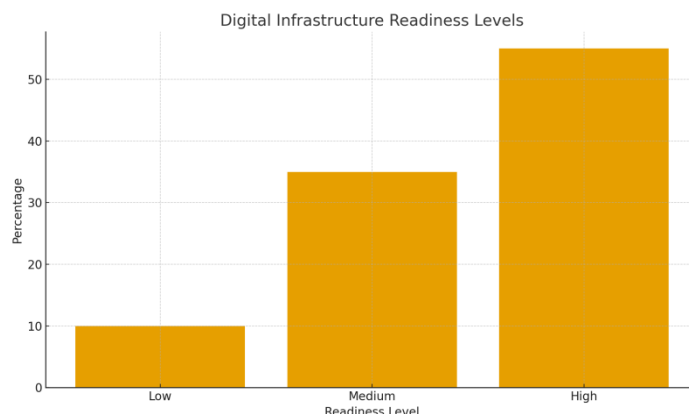
effectiveness of the digital learning ecosystem. Schools with principals who articulate a clear digital vision, communicate strategic goals, and encourage experimentation tend to demonstrate higher levels of technology adoption and instructional integration. Regression analysis shows that leadership variables accounted for a substantial proportion of variance in ecosystem outcomes. The qualitative findings support this pattern. Interviews revealed that school leaders who model digital practices, provide consistent guidance, and promote a culture of trust foster stronger engagement among teachers. These findings align with transformational leadership theory, which emphasizes inspiration, intellectual stimulation, and individualized support as central drivers of organizational change. Previous studies also confirm that leaders who promote shared decision-making and continuous learning create a conducive climate for innovation. Research consistently shows that leadership vision, paired with adequate digital literacy and infrastructure support, is the primary predictor of a school's ability to maintain an adaptive culture capable of evolving alongside technological advancements (Sutopo, 2024). This finding is consistent with research by Leithwood (2021), who emphasizes that transformational leadership significantly influences teacher engagement and digital adoption, as well as the work of Hallinger and Kovačević (2019), which identifies leadership vision and supportive school structures as predictors of successful technology integration. Principals with innovative leadership characteristics play a critical role in accelerating digital technology integration, which improves both learning planning and academic data transparency (Trimiltn et al., 2025). More recent empirical work on digital transformational leadership also shows that principals who strategically use digital communication and model technology-rich practices are more successful in building teacher commitment and integrating deeper learning approaches across classrooms (Schmitz et al., 2023; Wong and Ng, 2020).

**Table 1. Leadership Influence on Digital Ecosystem Indicators**

Indicator	Mean Score	Interpretation
Vision clarity	4.52	High
Teacher motivation	4.47	High
Innovation support	4.61	Very High
Modeling digital use	4.38	High

### Management of Digital Resources and Infrastructure

The results demonstrate that the availability and efficient management of digital resources play an essential role in the success of digital ecosystem implementation. Quantitative analysis shows a strong correlation between infrastructure readiness and reported ecosystem effectiveness. Schools with stable internet access, sufficient digital devices, and well-managed learning platforms scored significantly higher on digital ecosystem indicators. Qualitative insights further reveal that schools with structured resource planning, scheduled maintenance, and organized digital repositories experience fewer disruptions during instruction. These findings align with international studies showing that digital transformation strongly depends on infrastructure reliability, as highlighted by Tan (2021), who found that stable network access and device availability were key enablers of technology-driven learning, and by Tondeur et al. (2017), who demonstrated that planned digital resource management significantly improves technology use in schools. Recent studies on school readiness for digital transformation in the post-pandemic era similarly conclude that schools with higher levels of infrastructure readiness and access to timely technical support are substantially more likely to sustain digital learning innovations over time, especially in resource-constrained contexts (School's Readiness, Integration, and Technical Support to Digital Transformation, 2024).



**Figure 1. Digital Infrastructure Readiness Levels**

The figure illustrates that more than half of the schools demonstrate a high level of digital infrastructure readiness, with stable internet connectivity, adequate devices, and reliable platform access. Medium readiness accounts for over one-third of the sample, indicating partial but inconsistent availability of digital resources. Only a small proportion of schools fall under low readiness, highlighting infrastructure gaps that still require attention.

**Teacher Digital Competence and Professional Capacity Building**

Data analysis reveals that teacher digital competence is a major determinant of ecosystem quality. Schools with higher teacher competence scores reported greater consistency in the use of digital tools for instructional design, digital assessment, and interactive learning activities. The qualitative data reinforce these results. Teachers expressed that confidence in using digital tools emerged from continuous professional development, peer mentoring, and supportive coaching by ICT coordinators. These results corroborate earlier research by Tondeur et al. (2021) and Abadi et al (2023). who argue that sustained professional development is the strongest predictor of meaningful digital integration. Similarly, research by Koehler et al. (2013) emphasizes that teacher competence grows when training focuses on the pedagogical use of technology rather than technical mastery alone. Recent studies on teacher digital competence further highlight the importance of multidimensional competence models that include ethical, pedagogical, and assessment-related dimensions, and show that targeted professional development in these areas significantly improves teachers’ readiness for AI-enhanced and data-informed teaching (Manjarrez Yépez and Cordero, 2023; Teachers’ Digital Competence Model, 2023).

Table 2. Teacher Digital Competence Summary

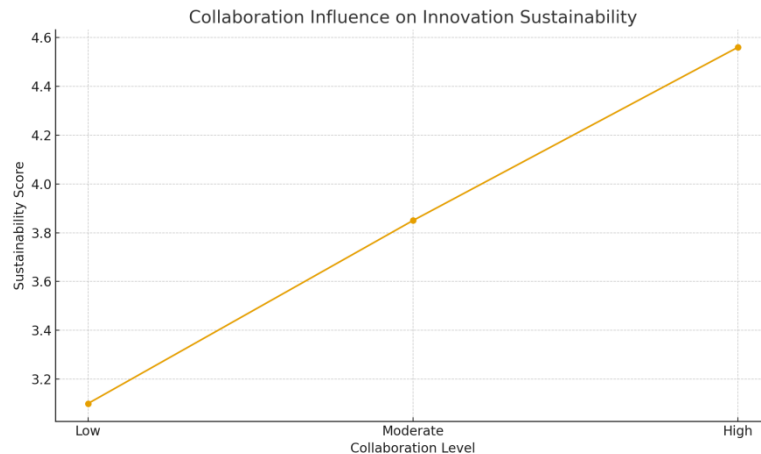
Competence Aspect	Score	Category
Technological Knowledge	4.33	High
Pedagogical Skills	4.41	High
Digital Assessment	4.22	High
Integration Confidence	4.48	High

**Collaborative School Culture and Innovation Sustainability**

The results show that schools with strong collaborative cultures tend to sustain digital innovations more effectively. Quantitative findings reveal that collaboration measures, including teamwork, peer support, and shared problem-solving, are significantly associated with ecosystem effectiveness. The qualitative data illustrate that schools with active professional learning communities promote open dialogue, peer observation, and feedback cycles that support digital pedagogical innovation. This finding echoes the work of Harris and Jones (2018), which highlights that professional learning communities strengthen innovation diffusion and teacher confidence. Additionally, Wenger’s (2010) communities of practice framework supports the idea that collaboration enhances collective problem solving and fosters long-term sustainability of innovation.



More recent empirical studies confirm that professional learning communities mediate the relationship between digital professional development and digital instructional integration, indicating that collaborative structures are central to sustaining technology-rich teaching practices and advancing sustainable digital transformation agendas in schools (Lee et al., 2024; Innovative Professional Learning Communities and Sustainable Education, 2023).



**Figure 2. Collaboration Influence on Innovation Sustainability**

This figure shows a clear positive relationship between collaboration and innovation sustainability. Schools with higher levels of teamwork, peer support, and shared problem-solving exhibit significantly stronger sustainability scores. The trend demonstrates that collaboration serves as a critical mechanism for embedding and maintaining digital innovation across school structures. Principals foster digital school culture through technology-based work habits, online collaboration, and digital literacy throughout the school community (Nugraha and Sari 2022).

This paper is frequently referenced in Indonesian educational studies because it provides a framework for evaluating how leadership styles—specifically those oriented toward innovation and adaptation—directly impact the quality of learning and institutional performance. It serves as a vital resource for understanding the human-centric aspects of digital transformation, emphasizing that culture and leadership are as critical as the hardware or software utilized in a digital school ecosystem

#### 4. CONCLUSION

The findings of this study demonstrate that the development of a robust digital learning ecosystem in schools is fundamentally shaped by the coherence and effectiveness of innovation management practices. Innovative leadership emerges as a central driver that not only influences teacher motivation and digital adoption but also establishes the strategic direction necessary for sustained transformation. The management of digital resources and infrastructure further strengthens the ecosystem by ensuring that technological tools and platforms are accessible, reliable, and aligned with instructional needs. Teacher digital competence, supported through continuous professional development and collaborative learning structures, reinforces the school's capacity to implement and refine digital pedagogies. Finally, a strong collaborative school culture acts as the binding mechanism that sustains innovation over time, enabling teachers and school leaders to collectively adapt, problem-solve, and improve digital learning practices. Collectively, these interconnected elements highlight that digital transformation is not merely a technical initiative but a complex organizational process requiring strategic leadership, systemic planning, and a culture of shared learning.

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