INNOVATION DIFFUSION PERSPECTIVE ON DIGITAL TRANSFORMATION IN EDUCATION: TOWARD A SMART SCHOOL SYSTEM

[1]Lulu Waliyatur Rosyida and [2]Nur Rahmi Sonia
[1,2] Pascasarjana UIN Kiai Ageng Muhammad Besari Ponorogo
Email: [1]lulu.rosyida@student.uinponorogo.ac.id and [2]nur.rahmi.sonia@uinponorogo.ac.id

Abstrak

Transformasi digital merupakan proses perubahan menyeluruh yang mencakup sistem, budaya organisasi, strategi, serta tata kelola pendidikan. Keberhasilan transformasi menuju smart school system selain ditentukan oleh ketersediaan teknologi, juga ditentukan oleh proses penerimaan dan adopsi inovasi oleh seluruh warga sekolah. Penelitian ini bertujuan untuk mengkaji transformasi digital pendidikan dalam perspektif teori difusi inovasi untuk mewujudkan smart school system. Penelitian menggunakan metode Systematic Literature Review (SLR) berbasis pendekatan PRISMA dengan menganalisis sepuluh artikel ilmiah dan sumber akademik relevan yang diterbitkan pada periode 2021–2026. Data diperoleh dari database Scopus, jurnal terindeks Sinta, dan Google Scholar. Analisis dilakukan menggunakan pendekatan analisis tematik untuk mengidentifikasi pola, faktor determinan adopsi inovasi, serta sintesis konseptual dalam pengembangan smart school system. Hasil kajian menunjukkan bahwa keberhasilan transformasi digital di sekolah tidak hanya dipengaruhi oleh ketersediaan teknologi, tetapi juga oleh karakteristik inovasi, kesiapan sumber daya manusia, kepemimpinan digital, serta dukungan organisasi. Penelitian ini memberikan implikasi bahwa model transformasi digital berbasis difusi inovasi dapat menjadi kerangka konseptual dalam membangun sistem pendidikan yang adaptif terhadap perkembangan teknologi. Penelitian selanjutnya disarankan mengembangkan studi empiris untuk menguji model transformasi digital berbasis difusi inovasi pada berbagai jenjang pendidikan serta mengeksplorasi integrasi teknologi baru seperti kecerdasan buatan dalam pengembangan smart school system.

Kata kunci: Transformasi Digital Pendidikan, Difusi Inovasi, Smart School System

Abstract

Digital transformation refers to a comprehensive process of change encompassing educational systems, organizational culture, strategies, and governance. The success of the transformation toward a smart school system depends not only on the availability of technology, but also on the acceptance and adoption of innovation by all members of the school community. This study aims to examine digital transformation in education from the perspective of innovation diffusion theory in realizing a smart school system. This research employs a Systematic Literature Review (SLR) method based on the PRISMA framework, analyzing ten scientific articles and relevant academic sources published between 2021 and 2026. Data were obtained from Scopus, Sinta-indexed journals, and Google Scholar databases. The data were analyzed using a thematic analysis approach to identify patterns, determinants of innovation adoption, and conceptual synthesis for developing a smart school system based on the innovation diffusion perspective. The findings indicate that the success of digital transformation in schools is influenced not only by technological availability but also by innovation characteristics, human resource readiness, digital leadership, and organizational support. This study implies that a digital transformation model based on innovation diffusion can serve as a conceptual framework for building an educational system that is adaptive to technological change. Future research is recommended to develop empirical studies testing the innovation diffusion based digital transformation model at various educational levels and institutional contexts, as well as exploring the integration of emerging technologies such as artificial intelligence in developing smart school systems.

Key words: Digital Transformation of Education, Diffusion of Innovation, Smart School System

INTRODUCTION

In the era of globalization, digital transformation has become one of the phenomena that has brought significant changes in various sectors of life, including education. The development of information and communication technology has encouraged educational institutions to adapt to an increasingly dynamic and digital-based environment. Education, as a means of shaping future generations, is required to be able to adapt to technological developments and utilize various digital innovations to improve the quality of learning and the effectiveness of educational institution management. Digital transformation in education is no longer understood as merely the use of technological devices as learning aids, but has evolved into a more comprehensive process of change that encompasses learning systems, organizational culture, institutional strategies, and educational governance. Thus, digital transformation is no longer an option for educational institutions, but a strategic necessity to ensure the sustainability and relevance of the education system in the digital age.

Digital transformation in education is the process of integrating digital technologies to enhance learning effectiveness, improve the efficiency of educational management, and elevate the quality of educational services. This is in line with Gregory Vial's conceptual framework, which states that digital transformation is an integrated organizational change process oriented towards technology-based innovation. Technology improves accessibility and flexibility in learning, enhances the effectiveness and efficiency of educational system management, and supports the implementation of collaborative learning. Until now, education has still focused on face-to-face interaction and conventional methods. However, over time, it has begun to shift towards a more flexible, adaptive model that is integrated with developing technology, such as the use of e-learning systems, Learning Management Systems (LMS), digital learning platforms, and other technological devices such as smart boards and other devices that support learning.

A number of studies show that the use of digital technologies such as LMS, online learning applications, and other digital devices can increase interaction between teachers and students, as well as provide flexibility in the teaching and learning process.[1] Other research also shows that successful digital transformation in schools is evident in the ability of institutions to strategically adopt technology, utilizing LMS, big data, and other digital tools through learning content and educational services.[2] In addition, digital transformation also encourages schools to develop more effective and efficient education management systems. This has led to the emergence of the smart school system concept, which is a school system that utilizes integrated digital technology to support the learning process, school management, and communication between teachers, students, parents, and other education stakeholders. Furthermore, schools are required to adapt and innovate in the learning process to produce graduates who are relevant in today's digital era.

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[1] Andi Muhammad Shaleh Alwi, "DIGITAL TRANSFORMATION IN EDUCATION: A STUDY OF TECHNOLOGY IMPLEMENTATION AT SMA NEGERI 5 MAKASSAR CITY" 7, no. 4 (2024): 277–281.

[2] Ahmad Fatoni, "MANAJEMEN TRANSFORMASI DIGITAL DALAM PENDIDIKAN ISLAM UNTUK MEWUJUDKAN SEKOLAH BERBASIS Pengadaan Perangkat Keras Atau Lunak , Tetapi Lebih Pada Perencanaan Strategis ," *Jurnal Manajemen Dan Pendidikan* 02, no. 9 (2023): 81–91.

The concept of the Smart School System emerged as a response to these demands. The smart school system refers to a school education system that applies digital technology to automate and modernize the learning process, school management, and interactions between teachers, students, parents, and the school as a whole. There are various ways that can be used to transform a school into a smart school. According to Ibrahim et al., developing an ICT culture as an important part of school culture and the support of school leadership and cooperation with individuals in the school system can build momentum in the process of change.[3] Meanwhile, other studies mention that the availability of adequate equipment, a decentralized education system, and the integration of technology in learning are factors that can describe the success of smart schools.[4] Thus, smart schools reflect interrelated components of digital transformation, rather than merely adopting limited technological devices for specific purposes.

However, the success of digital transformation in schools is determined not merely by the availability of technology, but also by the acceptance and adoption of innovation by all members of the school community. In this context, the theory of innovation diffusion developed by Everett M. Rogers provides a relevant conceptual framework for understanding how technological innovations are adopted in educational organizations. Rogers explains that the process of innovation adoption occurs through the stages of knowledge, persuasion, decision, implementation, and confirmation. In addition, the level of adoption is influenced by innovation characteristics such as relative advantage, compatibility, complexity, trialability, and observability.[5] The theory explains how innovations spread through various channels within a social system over time, and it can provide valuable insights for both educators and policymakers. By understanding the factors that influence the level of adoption, stakeholders can design more appropriate strategies to promote and support the successful integration of digital technologies in educational settings.[6]

Recent studies show that relative advantage and compatibility are key factors in the decision to adopt digital technology in schools, especially in the context of implementing learning management systems (LMS) and online learning platforms.[7] However, the digital transformation of education still faces various challenges, such as infrastructure

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[3] Mohammed Sani Ibrahim, Ahmad Zabidi Abdul Razak, and Husaina Banu Kenayathukka, "SMART PRINCIPALS AND SMART SCHOOLS," *PROCEDIA - SOCIAL AND BEHAVIORAL SCIENCES* 103 (2013): 826–836, HTTPS://DOI.ORG/10.1016/J.SBSPRO.2013.10.404.

[4] Mohammad Attaran, Norlidah Alias, and Saedah Siraj, "LEARNING CULTURE IN A SMART SCHOOL : A CASE STUDY," *Procedia - Social and Behavioral Sciences* 64 (2012): 417–423, https://doi.org/10.1016/j.sbspro.2012.11.049.

[5] Everett M. Rogers, *DIFFUSION OF INNOVATIONS, 5TH EDITION* (Free Press, 2003), https://www.perlego.com/book/780731/diffusion-of-innovations-5th-edition-pdf.

[6] Yilei Wang, Daocheng Hong, and Jun Huang, "A DIFFUSION OF INNOVATION PERSPECTIVE FOR DIGITAL TRANSFORMATION ON EDUCATION," *Procedia Computer Science* 225 (2023): 2439–48, https://doi.org/https://doi.org/10.1016/j.procs.2023.10.235.

[7] Mohammed Amin Almaiah, Ahmad Al-khasawneh, and Ahmad Althunibat, "EXPLORING THE CRITICAL CHALLENGES AND FACTORS INFLUENCING THE E-LEARNING SYSTEM USAGE DURING COVID-19 PANDEMIC," *Educationand Technologies* 25 (2020): 5261–80; Ronny Scherer, "THE TECHNOLOGY ACCEPTANCE MODEL (TAM): A META-ANALYTIC STRUCTURAL EQUATION MODELING APPROACH TO EXPLAINING TEACHERS' ADOPTION OF DIGITAL TECHNOLOGY IN EDUCATION RONNY," *Computers & Education*, 2018, 1–70, https://doi.org/10.1016/j.compedu.2018.09.009.

limitations, gaps in teachers' digital literacy, resistance to change, and a lack of data-driven strategic planning.[8] Therefore, the theory of innovation diffusion is important for understanding how technology is accepted and systematically integrated into the school environment to support sustainable digital transformation. It is not just a matter of installing technology, but also a process of organizational change.

Although numerous studies have examined digital transformation in education, most of them primarily focus on the implementation of technology such as the use of Learning Management Systems (LMS), e-learning platforms, or other digital tools without thoroughly exploring the process of innovation adoption within educational organizations. Meanwhile, research on smart school systems tends to emphasize infrastructure and technological integration, yet has not sufficiently linked these aspects to user behavior dynamics and the process of innovation diffusion within school environments. Furthermore, studies employing Diffusion of Innovation theory are generally partial in nature and have not specifically integrated this perspective into a systemic and sustainable framework for digital transformation in education. Based on these research gaps, there remains a lack of comprehensive studies that integrate the perspectives of digital transformation, Diffusion of Innovation theory, and the development of smart school systems into a unified conceptual framework. Therefore, this article aims to analyze digital transformation in education from the perspective of Diffusion of Innovation theory in order to understand how the adoption of digital technologies occurs within school environments. Through a systematic literature review approach, this study seeks to identify the characteristics of innovations that influence the adoption of digital transformation, examine the stages of the innovation diffusion process in the implementation of smart school systems, and analyze the key factors that determine success as well as the main risks in digital transformation in education. In addition, this study proposes a conceptual model of digital transformation based on Diffusion of Innovation theory that can serve as a strategic framework to accelerate the realization of sustainable smart school systems. Thus, this research is expected to contribute theoretically to the development of digital transformation studies in education while also providing practical implications for educational institutions in designing more adaptive, systematic, and sustainable digital technology implementation strategies.

METHOD

This study uses a qualitative approach with the Systematic Literature Review (SLR) method, which is compiled based on the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) guidelines. This method is used to identify, select, and synthesize various previous studies relevant to the topic of digital transformation in education from the perspective of innovation diffusion in order to comprehensively understand the process of developing a smart school system. Through this approach, the study aims to provide a conceptual overview of the factors that influence the adoption of digital transformation in schools.

This study aims to answer four research questions, namely: (1) characteristics that influence the adoption of digital transformation in schools, (2) stages of the innovation

[8] Sahrul Syawal, "TRANSFORMASI DIGITAL DALAMADMINISTRASI PENDIDIKAN: MODEL TATA KELOLA SEKOLAH DI ERA KECERDASAN BUATAN," *Jurnal Pendais* 7, no. 1 (2025): 99–115.

diffusion process that occur in the implementation of the smart school system, (3) factors that determine the success and main risks of digital transformation in education, and (4) a digital transformation model based on innovation diffusion theory that can be used to accelerate the realization of a sustainable smart school system.

The literature search process was conducted through several reputable academic databases, namely Scopus, Web of Science, ScienceDirect, and Google Scholar, with publications ranging from 2021 to 2026. The selection of this time range was intended to obtain relevant and up-to-date literature related to the development of digital transformation in the field of education. The keywords used in the literature search process were a combination of several main terms, namely digital transformation in education, diffusion of innovation theory, and smart school system.

Next, the article selection process was carried out using inclusion and exclusion criteria. The inclusion criteria included journal articles that had undergone peer review, discussed the topics of digital transformation in education, diffusion of innovation theory, or the development of smart school systems, and were available in full text. Meanwhile, articles that are not relevant to the research topic, duplicate articles, and articles that have not undergone peer review are eliminated from the analysis process. The literature selection process is carried out in several stages in accordance with the PRISMA flow, namely the identification stage, title and abstract screening, feasibility assessment based on full text, and the final inclusion stage for articles that meet the research criteria. The selected articles were then extracted to identify important information such as the research objectives, methods used, main findings, and the research's contribution to the study of digital transformation in education.

The data obtained was then analyzed using a thematic analysis approach to identify patterns of research findings, determining factors in the adoption of digital innovation, and the conceptual relationship between digital transformation, the innovation diffusion process, and the development of a smart school system. The results of this analysis were then used to develop a conceptual synthesis of a theory-based model of digital transformation in education that could support the realization of a sustainable smart school system.

RESULT AND DISCUSSION

Result

To provide a more comprehensive picture of how the digital transformation of education in the perspective of innovation diffusion contributes to the realization of a smart school system, researchers conducted a literature review of a number of relevant previous studies, both in the national and international contexts. This review aims to identify the characteristics that influence the adoption of digital transformation in schools, the stages of the innovation diffusion process that occur in the implementation of the smart school system, the factors that determine the success and main risks of digital transformation in education, and digital transformation models based on innovation diffusion theory that can be used to accelerate the realization of a sustainable smart school system, as well as research gaps. Through this literature synthesis, the research is directed at formulating a more systematic conceptual framework for understanding the mechanisms of innovation diffusion as a perspective for accelerating the sustainable digital transformation of schools.

Table 1. Literature Review

No	Researcher & Year	Title/ Source	Key Findings	Limitations/ Notes
1	Hidayanti & Safuan, 2025	Smart School as a Solution for Digital Transformation in Education	Implementation of Smart School at Mulya School successfully integrated learning and school management efficiently, transparently, and adaptively through connected digital modules.	Does not link to innovation diffusion theory; no critical analysis of long-term digital transformation success factors.
2	Faiza et al., 2025	Strengthening Teachers' Digital Literacy Through Edunav	Edunav strengthens 4 dimensions of teachers' digital literacy, improving planning and evaluation quality; effectiveness depends on technology-pedagogy integration (TPACK).	Focuses on Edunav implementation; does not link to innovation diffusion theory or digital transformation models based on the theory.
3	Fauzi, 2025	Digital Leadership in Education (SLR)	HR readiness for digital leadership remains limited; technical and soft skills training plus digital culture effectively drive innovation and institutional efficiency.	Does not link to innovation diffusion theory or smart school systems.
4	Susilowati et al., 2024	Diffusion of Innovation in Educational Technology	Technology adoption during and post-pandemic shows innovation diffusion process supporting sustainable open learning.	Does not link findings to smart school systems; explanation of innovation diffusion remains general.
5	Damayanti et al., 2025	Smart School Management Through Digital Transformation	Nasima Elementary successfully integrated digital technology in curriculum and administration; success supported by systematic planning, but teacher competency challenges remain.	Does not link to innovation diffusion theory; focuses on smart school management and digital transformation.
6	Jarkawi et al., 2025	The Role of Digital Transformation in Educational Management	Digitalization drives innovation (big data, analytics), improves transparency and school quality; main challenges: digital divide and cultural resistance.	Does not link to innovation diffusion theory or smart school; focuses on benefits and barriers of digital transformation.
7	Ilyas et al., 2025	Digital Transformation in Educational Management for School Quality	Digital transformation improves managerial efficiency and education quality through big data and analytics; success depends on adaptive leadership and organizational culture.	Does not link to innovation diffusion theory or smart school; general focus on digital transformation.
8	Wei et al., 2025	Digital Teaching Innovation: A Systematic Review	Digital teaching innovation requires technology-teaching method integration; 5 pathways for teacher innovation identified, though most remain at augmentation stage (SAMR).	Does not link to innovation diffusion theory or smart school; focuses on factors supporting educational technology transformation.
9	Novriyanto & Hardhienata, 2025	Diffusion of Disruptive Innovation: Smart Teacher AI	Smart Teacher AI implementation aligns with Rogers' innovation diffusion framework; platform effectively improves teachers' digital competence in planning and evaluation.	Does not link to smart school systems; focuses on innovation diffusion theory and digital competence development.

10	Putri & Sary, 2025	Digital Leadership & Competence in Smart School Settings	Digital leadership and teachers' digital competence have positive significant effects on teacher performance in smart school environments.	Focuses on smart school; does not integrate innovation diffusion theory and digital transformation simultaneously.

Source: Data researcher

Discussion

Characteristics of Innovation that Influence the Adoption of Digital Transformation in Schools

Digital transformation adopted in school environments is influenced not only by the availability of technology, but also by innovation characteristics, individual factors, and organizational support that determine the success of technology implementation in education. Everett M. Rogers' theory of innovation diffusion explains that the level of adoption of an innovation is influenced by five main characteristics, namely relative advantage, compatibility, complexity, trialability, and observability.[9] These five characteristics play a role in shaping the perceptions of education stakeholders such as teachers, principals, educational staff, and students regarding the benefits and ease of using digital technology in the learning process and school management.

The first characteristic is relative advantage, which is the extent to which innovation is considered better than previous methods. In the context of digital transformation in education, digital technology offers various advantages such as increased learning effectiveness, efficiency in school administration, and flexibility in accessing learning resources. The use of digital learning platforms, Learning Management Systems (LMS), and various online learning applications enables more dynamic interaction between teachers and students. A number of studies show that the use of digital technology in learning can increase student engagement in cognitive, affective, and behavioral aspects, while also encouraging the improvement of educators' digital competencies in developing more innovative learning strategies. [10]

The second characteristic is compatibility, which is the degree to which an innovation aligns with the values, needs, and practices that exist within an organization. In the context of education, digital transformation will be more easily accepted if the technology applied is in line with learning needs, school organizational culture, and the readiness of the human resources involved. The implementation of digital technology that is not in line with school needs or is not supported by an organizational culture that is open to change can cause resistance to innovation. Therefore, the compatibility between digital technology and the pedagogical and managerial needs of schools is an important factor in the success of digital transformation in education.

The third characteristic is complexity, which is the degree of difficulty of an innovation to be understood and used by its users. The higher the level of complexity of

[9] Rogers, *DIFFUSION OF INNOVATIONS, 5TH EDITION*.

[10] Melissa Bond et al., "MAPPING RESEARCH IN STUDENT ENGAGEMENT AND EDUCATIONAL TECHNOLOGY IN HIGHER EDUCATION : A SYSTEMATIC EVIDENCE MAP," *International Journal of Educational Technology in Higher Education* 17, no. 2 (2020): 1–30; Julio Cabero-almenara et al., "DIGITAL TEACHING COMPETENCE ACCORDING TO THE DIGCOMPEDU FRAMEWORK . COMPARATIVE STUDY IN DIFFERENT LATIN AMERICAN UNIVERSITIES," *JOURNAL OF NEW APPROACHES IN EDUCATIONAL RESEARCH* 12, no. 2 (2023): 276–91, https://doi.org/10.7821/naer.2023.7.1452.

a technology, the lower the likelihood that it will be widely adopted. In the context of digital transformation in education, complexity is often related to the level of digital literacy of teachers, the availability of technology training, and the ease of use of digital systems implemented in schools. A study shows that the availability of digital devices as learning tools that can be accessed anytime and anywhere, as well as their ability to respond to the various interests and needs of educators, can encourage the creation of new learning experiences and the professional development of educators in the digital age.[11] In addition, providing training and guidance for teachers in using digital technology can help reduce barriers to the adoption of innovation.

The fourth characteristic is triability, which is the extent to which an innovation can be tested before being fully adopted. In the context of education, opportunities for teachers to try out digital technology through training programs, workshops, or limited implementation can increase their confidence in using the technology in the learning process. The experience of trying out technology firsthand allows educators to understand the benefits and potential of using technology to support learning. This is especially important in the digital transformation process, which requires gradual changes in learning practices. A study conducted during the pandemic that measured teachers' readiness for digital learning shows the need for support from educational institutions to facilitate the transition to online learning in order to ensure the success of digital learning.[12]

The final characteristic is observability, which refers to the extent to which the results of an innovation can be seen or observed by others. In a school environment, when the benefits of digital transformation are clearly visible, such as improved student learning outcomes, administrative efficiency, or enhanced learning collaboration, teachers and other educational institutions tend to be more motivated to adopt these innovations. The successful implementation of digital technology in a school often serves as an example that encourages other educational institutions to adopt the same innovation. Key elements that contribute to successful digital transformation in education include professional engagement, the effective use of digital resources, the integration of technology in teaching and learning processes, appropriate assessment practices, empowering learners, and supporting the development of students' digital competencies. In addition, these factors can support the process of innovation diffusion in the school environment.[13]

In addition to these five characteristics of innovation, the success of digital transformation in education is also influenced by other supporting factors such as professional engagement, availability of digital resources, development of teaching and learning strategies, digital-based assessment systems, and the ability to empower learners

[11]Torrey Trust, Jeffrey Paul Carpenter, and Daniel G. Krutja, "MOVING BEYOND SILOS : PROFESSIONAL LEARNING NETWORKS IN HIGHER EDUCATION," *The Internet and Higher Education* 35, no. June (2017): 1–11, https://doi.org/10.1016/j.iheduc.2017.06.001.

[12]Sarah K. Howard et al., "READY, SET, GO! PROFILING TEACHERS' READINESS FOR ONLINE TEACHING IN SECONDARY EDUCATION," *Technology, Pedagogy and Education* 30, no. 1 (2021): 141–58, https://doi.org/https://doi.org/10.1080/1475939X.2020.1839543.

[13]Christine Redeceker and Yves Punie, *EUROPEAN FRAMEWORK FOR THE DIGITAL COMPETENCE OF EDUCATORS*, 2017.

and facilitate their digital competence. These factors play a role in creating a digital learning ecosystem that supports the diffusion of innovation in schools.

Based on various literature reviews, the characteristics of relative advantage and observability are often the most significant factors in driving the adoption of digital technology in educational institutions. Technologies that are able to demonstrate tangible benefits in improving the quality of learning, teacher work efficiency, and interactions between teachers and students tend to be more quickly accepted by users. In addition, the suitability of technology to learning needs and school organizational culture is also an important factor in determining the success of digital transformation implementation in realizing a sustainable smart school system.

Stages of the Innovation Diffusion Process that Occur in the Implementation of the Smart School System

The process of adopting digital transformation in the development of a smart school system can be explained through the theory of innovation diffusion proposed by Everett M. Rogers. This theory explains how an innovation is introduced, disseminated, and ultimately adopted by individuals or organizations in a social system through certain stages. Rogers explains that the process of innovation diffusion occurs through five main stages, namely knowledge, persuasion, decision, implementation, and confirmation.[14] In the context of digital transformation in education, these five stages describe the process by which educational institutions recognize, evaluate, and integrate digital technology into their learning systems and school management.

Figure 1. Stages of the Innovation Diffusion Process

The knowledge stage is the initial stage in the innovation diffusion process when individuals or organizations begin to obtain information about an innovation. At this stage, schools begin to learn about various digital innovations through information about educational technologies such as Learning Management Systems (LMS), online learning platforms, digital-based school administration systems, and various other educational technology applications. Access to this information can be obtained through teacher training, educational seminars, government policies related to the digitization of education, or through professional networks between educators. At this stage, an initial understanding of the benefits and functions of digital technology is an important factor that drives interest in these innovations.

The persuasion stage is the process when individuals or organizations begin to form attitudes toward the introduced innovation. In the context of education, schools begin to assess the potential benefits of digital technology based on ease of use, suitability for learning needs, and the potential for improving the quality of education. At this stage, teachers and education stakeholders consider whether digital technology can help improve learning effectiveness, expand access to learning resources, and support a more interactive and collaborative learning process. Research shows that positive perceptions

[14]Rogers, *DIFFUSION OF INNOVATIONS, 5TH EDITION*.

of the benefits of technology and organizational support are important factors in shaping positive attitudes toward the adoption of digital innovations.

The decision stage is when an organization decides to accept or reject the introduced innovation. In the context of digital transformation in education, the decision to adopt technology is usually influenced by several factors, such as school leadership, institutional policy support, availability of technological infrastructure, and the readiness of human resources to utilize digital technology. Visionary digital leadership often plays an important role in encouraging technology adoption in schools, as leaders have a strategic role in determining the direction of policy and implementation strategies for digital transformation in educational institutions.

The implementation stage is when innovations begin to be applied in practice within the organization. In the context of developing a smart school system, this stage is marked by the integration of digital technology in various aspects of education, such as the use of Learning Management Systems (LMS) in learning, the implementation of digital-based school administration systems, the use of educational data analytics for decision making, and the use of technological devices such as smart boards, interactive learning devices, and online learning management systems. At this stage, schools begin to build a digital learning ecosystem that enables a more flexible, collaborative, and technology-based learning process.

The confirmation stage is the final stage in the innovation diffusion process when organizations evaluate decisions that have been made in adopting innovations. At this stage, schools assess the extent to which the use of digital technology has had a positive impact on the quality of learning, the efficiency of school management, and student engagement in the learning process. This evaluation can be carried out through learning data analysis, feedback from teachers and students, and measurement of educational institution performance. If the evaluation results show significant benefits, the adoption of digital technology will be further strengthened and more widely integrated into the education system.

Of the five stages, the formation of a smart school system ecosystem began to take shape during the implementation stage, when digital technology began to be systematically integrated into the learning process, school management, and data-driven decision making. This is in line with the concept of smart education, which emphasizes the integration of technology, data, and learning processes to create a more adaptive and innovative education system.[15] Thus, the process of innovation diffusion becomes an important framework in understanding how digital transformation can be implemented gradually and sustainably in the development of a smart school system.

Determinants of Success and Key Risks of Digital Transformation in Education

Digital transformation extends beyond the implementation of technology, it involves a comprehensive shift in the educational management paradigm that promotes data-driven decision-making and responsiveness to learners' needs in the digital era.[16] Its

[15] Zhi-ting Zhu, Ming-hua Yu, and Peter Riezebos, "A RESEARCH FRAMEWORK OF SMART EDUCATION," *Smart Learning Environments* 3, no. 4 (2016), https://doi.org/10.1186/s40561-016-0026-2.

[16] Jarkawi et al., "THE ROLE OF DIGITAL TRANSFORMATION IN EDUCATIONAL MANAGEMENT: INNOVATION, CHALLENGES, AND ITS IMPACT ON SCHOOL QUALITY," *Journal of Human University* 52, no. 10 (2025).

success in education depends not only on the application of technology, but also on leadership factors, particularly digital leadership. Digital leadership refers to a leader's ability to leverage digital technologies to direct, manage, and ensure organizational success in responding to change. In this context, leaders act as key drivers who promote the effective adoption and integration of technology, while ensuring that transformation is carried out in a strategic and sustainable manner. In addition, leaders must also be able to provide encouragement, inspiration, and empowerment to their teams so that they are ready to face the dynamics of rapid change.[17] This situation requires leaders to have a deep understanding of digital innovation, agility in responding to the latest technological developments, and the ability to lead teams operating in a connected work ecosystem that is highly dependent on the use of technology.[18]

A leader does not merely ensure the utilization of digital tools, but also encourages the team to work together harmoniously in a virtual space, make data-driven decisions, and build an organizational climate that is open to experimentation without fear of failure. Therefore, the essence of digital leadership is more about providing support for the organization to move flexibly, rather than limiting it with rigid rules.[19] This leadership combines vision, digital literacy, and managerial skills to address the educational needs of the modern age.[20] The application of digital leadership is evident in the use of technology to support school management. From planning and program implementation to evaluation, everything can be strengthened with digital systems. Thus, digital leadership is an important factor in promoting the realization of a smart school system, which is an education system that utilizes integrated digital technology in the learning process, school management, and data-based decision making.

Although digital transformation offers various opportunities for improving the quality of education, its implementation process also faces various challenges and risks. In the context of digital transformation, digital risk management is an important aspect that educational institutions need to pay attention to. Digital risk management involves efforts to identify, analyze, and manage various potential threats arising from the use of digital technology, whether technical, operational, or strategic in nature. [21] In the educational environment, digital risks can arise in various forms, such as data security breaches, technological access gaps, low digital literacy among educators, and inadequate

[17] Nini Daniah and Priyono, "DIGITAL LEADERSHIP DALAM PENDIDIKAN : TINJAUAN LITERATUR TENTANG INOVASI DAN PENGELOLAAN SEKOLAH," *JIIC: Jurnal Intelek Insan Cendikia* 2, no. 9 (2025): 16161–70.

[18] Ahmad Gunawan, *DIGITAL LEADERSHIP FOR INDUSTRY 5.0 : INTEGRASI MANUSIA, TEKNOLOGI DAN INDUSTRI*, ed. Marwan Effendi (Takaza Innovatix Labs, 2025), https://bookstore.takaza.id/product/digital-leadership/.

[19] Daniah and Priyono, "DIGITAL LEADERSHIP DALAM PENDIDIKAN : TINJAUAN LITERATUR TENTANG INOVASI DAN PENGELOLAAN SEKOLAH."

[20] Fauzan Isma, "TRANSFORMASI KEPEMIMPINAN PENDIDIKAN ISLAM DALAM ERA DIGITAL: TANTANGAN DAN PELUANG BAGI KEPALA SEKOLAH," *Jurnal Generasi Tarbiyah: Jurnal Pendidikan Islam* 4, no. 1 (2025): 70–79, https://doi.org/10.59342/jgt.v4i1.

[21] Nasyanda Indah Joelia, Irsyad, and Tia Ayu Ningrum, "DIGITAL RISK MANAJEMENT : TANTANGAN DAN SOLUSI DI ERA TRANSFORMASI DIGITAL ORGANISASI PENDIDIKAN," *Jurnal Ilmu Manajemen Dan Pendidikan* 02, no. 03 (2025): 1079–82.

technological infrastructure.[22] Here are some of the main risks that arise in the digital transformation process, including:

Technological and security risks relate to threats to the educational information systems used by educational institutions. These threats can take the form of system hacking, leaks of personal data belonging to students and teaching staff, malware attacks, and disruptions to network systems. Weaknesses in information technology security systems can cause disruptions to digital education services and pose risks of data privacy violations. Therefore, educational institutions need to implement robust digital security systems and data protection policies to safeguard educational information. [23]

Human resource risks are associated with the limited digital competencies of both teaching and administrative staff. Low levels of digital literacy can hinder the effective use of technology in learning processes and increase the likelihood of errors in the use of digital systems. In addition, resistance to change often becomes a barrier in the process of digital transformation within educational institutions. To address these challenges, capacity building of human resources must be carried out systematically. Therefore, the development of teachers' digital competencies through training and professional development programs is a critical step in supporting the success of digital transformation in education. Empirical studies also indicate that the use of the ICT-CFT framework can gradually enhance teachers' digital competencies across the levels of knowledge acquisition, knowledge deepening, and knowledge creation, thereby encouraging more innovative use of technology in teaching and learning.[24]

The availability of adequate technological infrastructure is an important factor in the implementation of digital transformation in education. However, in practice, there is still a gap in access to technology between urban and rural areas, especially in terms of the availability of stable internet networks and adequate technological devices. This digital infrastructure gap can hinder the implementation of technology-based learning, especially in online and hybrid learning models.

Strategic and policy risks are associated with a lack of strategic planning and adequate policy support in the process of digital transformation in education. Without clear policies and focused planning, the implementation of digital technology in schools can be ineffective and out of step with educational needs. In addition, a lack of coordination between education stakeholders can also slow down the process of adopting digital technology in schools.[25]

Thus, the success of digital transformation in education does not only depend on the application of technology, but also on organizational readiness, digital leadership,

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[22] Harris Pinagaran Nasution et al., "DEVELOPING THE SMART - RISK SYSTEM TO ENHANCE INTERNAL OVERSIGHT GOVERNANCE IN HIGHER EDUCATION INTERNATIONAL JOURNAL OF," *International Journal of Multidisciplinary Sciences and Arts* 5, no. 1 (2026): 198–204.

[23] Joelia, Irsyad, and Ningrum, "DIGITAL RISK MANAJEMENT : TANTANGAN DAN SOLUSI DI ERA TRANSFORMASI DIGITAL ORGANISASI PENDIDIKAN."

[24] Anthony Aapia Korku Dzidzornu and Xukan Xu, "Assessing Digital Literacy Competency among Student Teachers in Ghana : Perceptions , Challenges , and Pathways for Improvement Using the UNESCO ICT-CFT," *Discover Education* 4, no. 481 (2025).

[25] Ailsa Aurellia, Charisa Najma Athifa, and Yusuf Amrozi, "TRANSFORMASI DIGITAL YANG ADIL: PERAN MANAJEMEN RISIKO DALAM MENGURANGI KETIMPANGAN DIGITAL," *Nusantara Computer and Design Review* 3, no. 1 (2025): 54–63, https://doi.org/https://doi.org/10.55732/ncdr.v3i1.1654.

human resource competencies, and adequate infrastructure and policy support. The integration of these factors is key to realizing a technology-based education system that can support the creation of an adaptive and sustainable smart school system.

Digital Transformation Model Based on Innovation Diffusion Theory to Accelerate the Realization of a Sustainable Smart School System

Digital transformation is a fundamental change process that utilizes digital technology to improve organizational performance, create new value, and change operational models and work culture. In the context of education, digital transformation is not limited to the use of technology such as computers or the internet, but also includes changes in learning systems, institutional management, governance, and patterns of interaction between parties in the environment. Digital transformation and new technologies create a complex environment that demands the development of advanced digital skills, as technological advances open up opportunities to improve learning processes.[26] In the context of modern education, digital transformation is an important foundation in building a smart school system, which is a school system that utilizes digital technology to create adaptive, collaborative, and sustainable learning.[27]

Based on the results of literature synthesis and conceptual analysis, this study proposes a digital transformation model for education based on innovation diffusion theory to accelerate the realization of a sustainable smart school system. This model illustrates that the process of digital transformation in schools occurs through five stages of innovation diffusion, namely knowledge, persuasion, decision, implementation, and confirmation, as proposed by Everett M. Rogers. Based on the results of the literature analysis, this study proposes a conceptual model of digital transformation in education based on the theory of innovation diffusion, as shown in Figure 2 below.

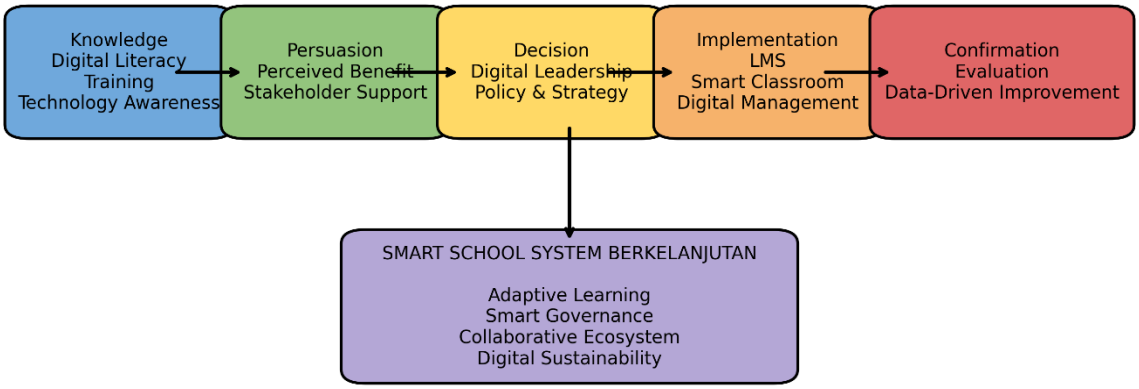

Figure 2. Innovation Diffusion-Based Digital Transformation Model to Realize a Sustainable Smart School System

Based on the model in the figure, digital transformation in schools takes place through a gradual process that follows Everett M. Rogers' theory of innovation diffusion,

[26]Silvia Farias-gaytan, Ignacio Aguaded, and Maria-Soledad Ramirez-Montoya, "INSTITUTIONS : A SYSTEMATIC LITERATURE REVIEW," *Humanities and Sociaal Sciences Communications*, 2023, 1–11, https://doi.org/10.1057/s41599-023-01875-9.

[27]Le Thi Hong Lien, Pham Thanh Thui, and Vi Hong Quang, "DIGITAL TRANSFORMATION IN SCHOOL MANAGEMENT TOWARD SMART LEARNING ENVIRONMENTS," *Tennessee Research International of Social Sciences* 7, no. August (2025): 196–211.

namely through five main stages: knowledge, persuasion, decision, implementation, and confirmation. This model shows that the success of digital transformation in education does not happen instantly, but through a systematic innovation adoption process that involves various organizational factors, human resources, and technological support. The innovation diffusion-based digital transformation model can begin with strengthening the knowledge stage by improving the digital literacy of teachers and educational staff.

Next are the persuasion and decision stages, where school stakeholders begin to assess the benefits of digital technology in improving learning effectiveness and school management. At this stage, the role of digital leadership is also very important in building a vision for digital transformation and encouraging a culture of innovation in the school environment. This is an important factor in accelerating the adoption of digital innovation in schools.[28] Next, in the implementation stage, schools began to systematically integrate digital technology into various aspects of education management. The application of digital technology in school management has proven to improve operational efficiency, transparency, and flexibility in the learning process.[29] The final stage in innovation diffusion is confirmation, whereby schools need to conduct data-based evaluations of the effectiveness of technology use and its impact on learning quality and school organizational performance.

Thus, the digital transformation model based on innovation diffusion theory provides a systematic conceptual framework for implementing digital technology in schools. This model emphasizes the importance of integrating human resource readiness, digital leadership, technological infrastructure, and school innovation culture. Through the gradual and sustainable application of this model, schools can accelerate the realization of a smart school system that can improve learning quality, educational management efficiency, and student readiness in facing the challenges of the digital era.

This model also shows that the process of innovation diffusion ultimately results in a Sustainable Smart School System. This system is characterized by several key features, namely adaptive learning, which is learning that can be tailored to the needs and characteristics of students; smart governance, which is technology and data-based school management; collaborative ecosystem, which is an educational ecosystem that supports collaboration between teachers, students, and other stakeholders; and digital sustainability, which is the sustainable use of digital technology to support future educational development.

Based on the research findings, it is clear that the digital transformation of education does not only depend on the availability of technology, but also on the integration of human resource digital literacy, digital leadership, technological infrastructure, organizational innovation culture, policy support, and data-based evaluation. The integration of these factors is key to accelerating the adoption of digital technology in schools and supporting the formation of a technology-based educational ecosystem. Through the gradual and sustainable implementation of this model, schools can realize a

[28] Erviany Dwiana Putri and Fetty Poerwita Sary, "EXPLORING THE ROLE OF DIGITAL LEADERSHIP AND DIGITAL COMPETENCE IN ENHANCING TEACHER PERFORMANCE IN SMART SCHOOL SETTINGS," *IRJEMS : International Research of Economics and Management Studies* 4, no. 11 (2025): 180–89, https://doi.org/10.56472/25835238/IRJEMS-V4I11P124.

[29] Alwi, "DIGITAL TRANSFORMATION IN EDUCATION: A STUDY OF TECHNOLOGY IMPLEMENTATION AT SMA NEGERI 5 MAKASSAR CITY."

smart school system that is capable of improving the quality of learning, the efficiency of education management, and the readiness of students to face the challenges of the digital era.

CONCLUSION

From the explanation above, it can be concluded that the characteristics of innovation influencing the adoption of digital transformation in schools can be explained through the Diffusion of Innovation theory, which consists of relative advantage, compatibility, complexity, trialability, and observability.The stages of the diffusion process that occur in the implementation of a smart school system can be described through five main phases: knowledge, persuasion, decision, implementation, and confirmation. Furthermore, the effectiveness of digital transformation in education depends not only on technological implementation, but also on a range of influencing factors, including digital leadership. Digital leadership can be understood as the capacity of a leader to optimize digital technology in order to guide, manage, and lead the organization toward success amid the dynamics of digital transformation. Furthermore, there are several major risks in educational digital transformation, including technology and security risks, human resource risks, infrastructure risks, and strategic and policy risks. A digital transformation model based on the diffusion of innovation can begin by implementing all stages of the diffusion process while integrating technology within them. Through the gradual and continuous implementation of this model, schools can accelerate the realization of a smart school system that enhances the quality of learning, improves the efficiency of educational management, and strengthens students' readiness to face the challenges of the digital era.

This study confirms that digital transformation in education is a systemic change process that does not solely depend on technology, but also on the adoption of innovation through the stages of knowledge, persuasion, decision, implementation, and confirmation. The results suggest that successful digital transformation in schools depends not only on access to technology, but also on how innovations are adopted, which is shaped by the nature of the innovation, the readiness of human resources, and the level of organizational support. The proposed model demonstrates that a diffusion of innovation–based approach can accelerate the realization of a sustainable smart school system. Therefore, it is recommended that educational institutions continuously strengthen digital literacy, optimize the role of digital leadership, and conduct data-driven evaluations at each stage of the innovation adoption process. Furthermore, future researchers are encouraged to develop empirical studies that test the diffusion of innovation–based digital transformation model across different levels of education and institutional contexts. Further research may also explore the integration of emerging technologies, particularly artificial intelligence, in the development of smart school systems to enrich the study of educational innovation in the digital era.

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