Education transformation: strategies and challenges in implementing educational technology

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ABSTRACT

The integration of innovation and technology into educational settings has emerged as a promising avenue for reshaping learning and teaching methodologies. However, this transformative process is not devoid of challenges, necessitating a comprehensive understanding to fully exploit its potential. This article aims to delineate best practices for implementing innovation and technology in elementary education environments. Employing a qualitative descriptive methodology, the research conducts semi-structured interviews with Information Technology (IT) learning support teachers in elementary schools. Through reflective thematic analysis, two primary perspectives emerge from the participants' experiences. Firstly, participants underscore the potential of IT-based learning innovation in elementary schools. They emphasize that leveraging innovative educational technology can foster a more engaging and adaptive learning environment, aligning with the evolving demands of the digital era. Secondly, the study identifies various challenges and corresponding opportunities associated with IT-based learning innovation. These complexities underscore the need for tailored adaptation efforts to effectively implement innovative teaching approaches aligned with student needs. The findings suggest that addressing these challenges can enable schools to capitalize on the full potential of innovation and technology, thereby creating dynamic, inclusive learning environments responsive to future demands. This research contributes to the literature by providing insights into the practical implications of integrating innovation and technology in elementary education, offering guidance for educators and policymakers seeking to navigate and maximize the benefits of educational innovation.

1. Introduction

In an era where technology has become an integral part of daily life, the application of innovative educational technology is crucial for enhancing the quality of education. Changes and developments in digital-based information systems fundamentally impact various aspects, including transaction methods between institutions and individuals [1]–[3]. A shift in perception is also necessary as an initial step in the field of education to cope with the rapid development of information technology. The use of technology is not merely about keeping up with the times but is also key to optimizing learning experiences, motivating students, and creating an adaptive and progressive educational environment. The importance of implementing innovative educational technology extends beyond the advancement of technology itself to the impact it can have on improving the quality of education [4], [5]. Considering that children and teenagers today grow up in a highly connected and technology-based environment, education must evolve to remain relevant and create a motivating learning

environment that hones the skills needed for the future [6]. Technological development is a necessity in modern life [7]–[10], and it progresses alongside innovation and scientific advancement. Every innovation is sought to have a beneficial impact on human life [10], [11].

Learning innovation offers many conveniences, as well as a new approach to conducting human activities [12]–[14]. Educational technology serves as an innovation to facilitate learning and enhance performance by creating, utilizing, and managing appropriate technological processes and resources [13], [15], [16]. The application of educational technology presents new alternatives for achieving higher quality education [17]–[19]. The learning process must be innovative and capable of bringing learning material closer to students' lifeworlds. The quality of education encompasses the quality of facilities and infrastructure, the quality of teachers, and the quality of students [18], [20], [21]. Educational technology has transformed the learning process, shifting from rigid and monotonous approaches to becoming more flexible and engaging. It promotes innovation in the planning, development, utilization, management, and evaluation of learning resources to facilitate and streamline the learning process [16], [17], [22], [23]. This research aims to offer new insights for teachers navigating the complex dynamics of the educational landscape by deeply understanding the needs and potential of innovative educational technology. Focused on enhancing the quality of education, the strategic implementation of innovative educational technology ensures that every student has access to quality, relevant education supporting their full potential development [2], [4]. In confronting the challenges and dynamics of global societal development, education must continue to adapt and innovate [24]. Elevating the quality of education is a primary agenda, with the application of innovative technology identified as a solution that can expedite the achievement of these goals [25].

Through augmented reality [26], virtual reality [27], Artificial Intelligence [28], and online learning platforms [29], teachers can create more interactive and personalized learning experiences for each student [30]. Innovative educational technology also offers an opportunity to mitigate educational access disparities by providing broader and more equitable resources [31]. According to Zhang, without neglecting traditional values, educational technology can enrich learning experiences and help students prepare for rapid changes [32]. The general definition of technology encompasses tools, machines, methods, processes, activities, or ideas designed to facilitate human activities in daily life [33]. The benefit of technology lies in enhancing human life and making it more convenient [34]. As Timotheou *et al* stated, the development of information technology has spurred a new way of life, known as e-life, indicating life is influenced by various electronic needs [35]. Innovation is understood as an idea, concept, practice, or object recognized and accepted as new by an individual or group for adoption [36]. Essentially, innovation results from brilliant thinking characterized by novelty, whether in specific practices or as products of intellectual and technological efforts applied through certain means [37]. This aims to address emerging problems and enhance specific conditions or processes in society.

Implementing innovative educational technology in schools presents various challenges and obstacles [38]. Numerous challenges and ethical considerations emerge during the planning and implementation phases [39]. Questions arise: How can we ensure equitable access to technology for all students? How can technology be seamlessly integrated into the existing curriculum? How can we anticipate and mitigate the adverse effects of technology use? How can we innovate with technology in learning while preserving traditional values? This research aims to address these questions and present findings that can positively contribute to the enhancement of educational quality in the digital era. This study is driven by the necessity for educators to gain a deeper understanding of the impact of implementing educational technology innovations on enhancing the quality of basic education. Aligned with technological advancements, this study endeavors to explore how these innovations can be optimized within the context of teaching and learning activities in basic education. Consequently, this study is poised to offer valuable insights for educators, policymakers, and other stakeholders in primary education to augment the effectiveness of the education system.

2. Method

This research aims to provide a comprehensive exploration of the implementation of educational technology in elementary schools, with a specific focus on the strategies employed and challenges encountered by educators. The study utilizes a qualitative descriptive methodology, incorporating semi-structured interviews with Information Technology (IT) support teachers from elementary and middle schools in Blora, Central Java, Indonesia. In the subsequent results section, I adhere to

recommendations regarding reflective thematic analysis, endeavoring to strike a balance between participant quotes that encapsulate the main themes and analytical commentary elucidating the underlying concepts [40]. Participant quotes are meticulously selected for their clarity and are chosen with the aim of ensuring a diverse representation of viewpoints. To accomplish this, we adopt a qualitative approach centered on reflective thematic analysis as the primary methodological framework.

2.1. Participant Selection and Data Collection

The participants comprise IT teaching staff selected deliberately for their comprehensive knowledge and extensive experience pertaining to the phenomenon under investigation [41]. Specifically, this study involves educational technology support teachers in primary education, deliberately chosen based on their minimum of five years of experience in teaching or supporting IT-related subjects. Data collection occurred through semi-structured interviews tailored to facilitate a thorough exploration of their experiences. Each interview session, lasting 40-60 minutes, was conducted in person to enhance comprehension of their context and practices.

2.2. Thematic Analysis Process

Following data collection, the interview transcripts underwent analysis employing a reflective thematic approach. The initial stage encompassed precise transcription of each interview, succeeded by multiple readings aimed at comprehensively understanding each participant's narrative. Subsequently, emerging patterns and themes from the data were identified and organized into distinct categories representing crucial aspects of the teachers' experiences. This iterative process involved continuous reflection to guarantee the accuracy and comprehensiveness of our interpretations.

2.3. Reflectivity in Analysis

As researchers, we acknowledge that our perspectives can influence data interpretation. Consequently, we engaged in critical reflection on our assumptions and biases throughout the analysis process. This was undertaken to ensure that our findings constituted an authentic and impartial representation of the participants' perspectives.

2.4. Analysis

The results of this reflective thematic analysis will be presented in the next section of this article, emphasizing the key strategies utilized by teachers in implementing educational technology and elucidating the primary challenges they encounter. Additionally, we will investigate how these findings can offer valuable insights for policymakers and educational practitioners in formulating and executing effective educational technology programs in primary education.

3. Results and Discussion

This research aims to acquire a more comprehensive understanding of teachers' experiences in supporting information technology learning in elementary education. It is anticipated that the insights gained from teachers' experiences in information technology-assisted learning will offer a comprehensive overview of successful practices in this domain. This practical knowledge will furnish class teachers and other subject instructors with clearer guidance for integrating information technology into their classes. General findings indicate that the integration of information technology in learning has effectively enhanced students' enthusiasm for learning and has the potential to improve their technological proficiency. However, the implementation of information technology in learning presents various challenges and obstacles that must be addressed. Efforts to confront these challenges involve contextual alternative strategies, ensuring the effective and efficient execution of information technology-based learning.

The findings of this study are categorized into two primary themes: (1) innovations in learning facilitated by the advancement of information technology in elementary schools, and (2) challenges and corresponding solutions in implementing learning innovations driven by information technology advancement in elementary schools. These themes are presented at both a descriptive-analytical level, incorporating accompanying quotes, and at a more interpretative analytical level, wherein individual quotes are elaborated upon in detail to underscore analytical points. The thematic map in this research is represented in Fig. 1.
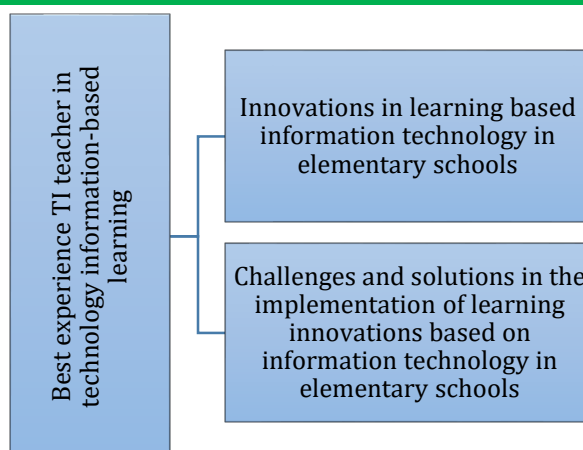
Fig. 1. Thematic map

3.1. Innovation in learning based on the development of information technology in elementary schools

Utilizing innovative educational technology has the potential to enrich students' learning experiences and enhance the quality of teaching [42]. Through the strategic integration of technology, schools can enhance teaching effectiveness, offer dynamic learning experiences, and equip students with the necessary skills for navigating the ever-evolving digital landscape. The majority of participants emphasized that the implementation of innovative educational technology enables schools to cultivate a more engaging, responsive, and relevant learning environment tailored to the demands of the contemporary digital era. These practices not only enhance the student experience but also foster students' adeptness in utilizing technology efficiently. Y*** highlighted the remarkable enthusiasm exhibited by learners in IT education when technology is incorporated.

> "*I doubt I could make my teaching as engaging and capture the students' enthusiasm to this extent without the innovation and use of contemporary technology.*"

Numerous technology-based learning innovations applicable to elementary education emerged from the analysis of most participants' interview responses: (1) Implementing online platforms to deliver interactive learning materials accessible from anywhere. This involves utilizing online learning platforms enabling students to access lessons and online assignments remotely; (2) Incorporating Augmented Reality (AR) and Virtual Reality (VR) in classrooms to provide immersive learning experiences. For instance, exploring historical and scientific concepts through AR or VR applications during science and social studies classes; (3) Employing Adaptive Learning by integrating Artificial Intelligence (AI) to offer personalized learning experiences for each student. This includes AI-based systems that identify students' strengths and weaknesses and adjust learning materials accordingly; (4) Utilizing Mobile Applications for easy access to learning resources. This encompasses students utilizing mobile apps to read e-books, watch learning videos, and participate in online discussions; (5) Encouraging collaborative projects among students using online collaborative tools and platforms. For example, students collaborate on research projects and presentations using tools like Google Docs or Microsoft Teams; (6) Integrating robotics and coding programs into the curriculum to foster problem-solving and logical skills. This entails students learning to create simple programs and control robots as part of science or technology lessons; (7) Employing integrated learning management systems to efficiently manage materials, assessments, and student engagement. This involves schools adopting Learning Management Systems integrated with evaluation systems; (8) Utilizing sensor technology and smart devices to facilitate interactive science experiments. For instance, students use sensors to measure temperature, pressure, or humidity in science experiments; (9) Employing big data analysis to analyze student data and gain insights into their learning progress and needs. This includes using big data analysis to identify student learning patterns and tailor teaching strategies accordingly; (10) Developing interactive educational content, such as learning videos and simulations, to enhance student engagement and comprehension. This involves utilizing interactive animated videos to elucidate complex concepts in specific subjects.

3.2. Challenges and Solutions in Implementing Information Technology-Based Learning Innovations in Schools

Implementing innovative educational technology in elementary schools presents challenges and barriers [6], particularly during the planning and execution stages. Every educational institution, including elementary schools, must strive to foster and uphold a culture of quality that promotes optimal growth and learning. Educational leaders are tasked with creating an environment conducive to supporting students, teachers, and staff in maximizing their achievements and motivating teachers to adopt innovative and relevant teaching approaches [43]. School leaders should make decisions with careful consideration of their impact on students' learning experiences. The education paradigm of the Fourth Industrial Revolution (Industry 4.0) exemplifies various methods of integrating cyber technology into learning, both physically and virtually. This educational approach responds to the demands of the Industrial Revolution by necessitating a curriculum that aligns with the contemporary landscape. Such a curriculum can serve as a gateway to the world, leveraging technologies like the Internet of Things (IoT). Nonetheless, its implementation poses challenges for educators, particularly in fostering critical thinking and problem-solving skills, enhancing communication and collaboration abilities, nurturing creative and innovative thinking, and developing technology and information literacy. In the industrial development sector, information technology and telecommunications play a dominant role, especially in education. Technological advancements have eradicated geographical barriers, enabling swift and seamless international communication. Moreover, information dissemination has become easily accessible globally through technologies such as the Internet. Industry 4.0, as a phase of the technological revolution, profoundly influences human activities, necessitating rapid adaptation and the ability to anticipate future changes.

One of the challenges posed by Industry 4.0 in education is the need for Human Resources, particularly teachers, to innovate learning using rapidly evolving information technology tools to enhance the quality of education. The current generation of students is well-acquainted with the digital world and is accustomed to the technology prevalent in Industry 4.0. Consequently, teachers, as frontline educators, must upgrade their competencies to effectively navigate the Education 4.0 era [44]. Progressive educational leaders are those who facilitate the exchange of ideas and innovations. School principals play a pivotal role in fostering such exchanges among staff and teachers [45]. Open and transparent communication within schools is a fundamental cornerstone for establishing a supportive environment conducive to student growth and school advancement. Continuous openness and transparency foster trust among all stakeholders, including teachers, students, parents, and school staff. By adopting a Learning-Oriented Leadership approach, schools can evolve into dynamic and innovative institutions focused on meeting the diverse learning needs of students. This approach extends beyond mere instruction to guiding the future through meaningful education. The following section presents the results of the participant interview analysis concerning the challenges associated with implementing information technology-based learning innovations and provides strategies for overcoming them. This analysis encompasses an examination of the challenges and barriers encountered, alongside some successful practices for resolution. A****** expressed that:

> "*The main difficulty in technology-based learning innovation is the support in fulfilling the needs for technology infrastructure and facilities. Creative teachers are pointless if they lack the necessary resources.*"

The first challenge is the limitation of infrastructure and access that can hinder the implementation of technology. Advanced technology often requires regular maintenance and updates. This challenge can become an additional burden for schools with limited resources. Some schools might have unstable internet connections or limited devices. The digital divide creates a gap between students who have access to technology and those who do not. This challenge requires a fair and inclusive approach to ensure all students can keep up with technological advancements. School library programs that lend devices and provide internet access to needy students will help reduce this gap. Subsidy programs for devices for students from low economic backgrounds by local governments are one solution to improve student access. Collaborating with technology service providers for maintenance and regular updates will reduce the cost burden of innovation. Adding to the challenges, Y*** mentioned:

> "*Even if the infrastructure is in place, but if teachers are technologically inept, unwilling, or reluctant to put in the effort to use technology in teaching, it's also pointless. Not to mention the limited ability of teachers to integrate technology into their teaching.*"

The next challenge is that the application of technology sometimes does not align with the existing curriculum. Effective integration requires good coordination between technology and learning materials. Inadequate training for teachers is a serious barrier. Teachers need to acquire sufficient skills and understanding to integrate technology into their teaching methods. The development of a curriculum integrated with technology as a support and regular training programs for teachers focusing on the use of new tools and applications should be pursued more seriously. Another challenge is the difficulty in measuring the actual impact of technology use on learning outcomes. Accurate evaluation is needed to understand whether the investment in technology is yielding the expected benefits. The importance of data security becomes a hindrance when involving technology in education. Schools need to ensure that student data and personal information are well-protected. The use of technology in education raises ethical and privacy issues. Monitoring and data collection can raise concerns about the privacy of students and teachers. Implementing strict data security policies and using secure platforms is essential to create a healthy internet culture. Establishing strict and transparent privacy policies and using data analysis and technology-based learning tests to measure student progress are critical. This is in line with E**'s statement:

> "*Most teachers are afraid of using technology, especially online-based technology, not without reason but due to many cases of fraud, data theft, privacy, and security. Therefore, there is a need for security assurance and strengthening digital literacy for teachers.*"

The use of technology can sometimes present challenges in maintaining creativity and human interaction in the learning process. Resistance to change is a psychological challenge that can hinder the acceptance of innovations. Discomfort with change may be experienced by teachers, students, or parents, impeding the successful implementation of technology. Socialization programs and campaigns aimed at educating stakeholders about the benefits of educational innovation need enhancement. Technology integration should prioritize enriching traditional learning experiences rather than replacing them. The aspect of cyberbullying necessitates teachers' understanding of its potentially damaging impact [46]. Cyberbullying violates ethical principles such as personal integrity, compassion, and responsible behavior, disrupting students' psychological and personal development [47]. The issue of sexting also demands teachers' understanding of the negative consequences of using phones to take and send sexual images of themselves or others [48]. The benefits of technological advancement are numerous, as outlined above, but the challenges faced are equally complex. Technological advancement indeed provides convenience and can accelerate project completion, but some challenges require thoughtful address. Various challenges have been described with the advent of information technology-based learning innovations. Students' attention, focused on the excitement of the digital world, diverts them from real life, increasingly eroding social life and alienating them from their surrounding environment. The freedom to surf the digital world, if not accompanied by a sense of responsibility, can lead students to inappropriate places, preventing optimal achievement of learning objectives. Even more concerning, it could lead to moral degradation.

4. Conclusion

The findings of this small-scale qualitative research conducted in the realm of information technology-based learning development underscore the need for cautious interpretation. While the study does not purport to generalize teacher practitioner experiences beyond their immediate contexts, it highlights the specificity inherent in efforts to develop learning using information technology. The identified results suggest potential transferability to various learning environments, such as those of class teachers or subject teachers, which are intertwined with the ongoing evolution of information technology. However, it is crucial to acknowledge certain limitations within the research. Firstly, the small-scale nature of the study may restrict the generalizability of findings to broader educational contexts. Additionally, the qualitative methodology employed, while rich in capturing nuanced experiences, may not fully capture quantitative data that could provide deeper insights into the effectiveness of information technology-based learning development. Nevertheless, the contributions of this research are significant. It sheds light on the intricate relationship between information technology and learning development, emphasizing the pivotal role of context specificity. Furthermore, it underscores the importance of innovative educational technology in deepening our understanding of educational contexts and enhancing life skills within the contemporary era of massive information technology. Moving forward, future research endeavors should aim to address these weaknesses by employing larger sample sizes and integrating quantitative measures alongside

qualitative approaches. Moreover, efforts should be made to explore the long-term effects of information technology-based learning development on student outcomes and educational practices. By doing so, we can continue to advance our understanding of how technology can be strategically integrated into educational settings to cultivate a more inclusive, adaptive, and sustainable learning environment. This research has the potential to inform policy decisions and educational practices, ultimately contributing to the creation of a dynamic and relevant educational landscape that meets the demands of future generations.

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