

Digital Transformation in Numeracy Education: A Study on Teaching, Learning, and Leadership Perspectives

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Abstract

This systematic literature review explores the intricate interplay between digital technologies, numeracy education, and the influential role of educational leadership. Examining a diverse array of studies, the review reveals the multifaceted applications of digital tools, such as interactive whiteboards, educational software, simulations, and adaptive learning platforms, in enhancing numeracy instruction. Educational leadership emerges as a linchpin in the successful integration of these technologies, with visionary leadership, resource provision, and the establishment of a supportive culture identified as pivotal factors. However, challenges in the implementation process, including variability in educators' technological proficiency and concerns about

equitable access, underscore the need for strategic leadership. Proactive measures, including ongoing professional development, are imperative to address these challenges and ensure effective technology integration. On a positive note, the review consistently highlights the positive impact of digital technologies on numeracy skills and learning outcomes. Students exposed to technology-enhanced numeracy education demonstrate improved engagement, conceptual understanding, and mathematical proficiency. The adaptive nature of certain digital tools further contributes to a personalized and effective numeracy education. This synthesis of findings provides a comprehensive understanding of the current landscape, offering valuable insights for educators, policymakers, and leaders shaping the future of numeracy education in the digital age.

Keywords: Digital technologies, numeracy education, educational leadership, technology integration

Introduction

In the rapidly evolving landscape of education, the integration of digital technologies has become a pivotal factor in shaping pedagogical practices and enhancing student learning outcomes. This study delves into the dynamic intersection between digital technologies and numeracy teaching and learning, with a particular emphasis on the role of educational leadership in driving effective implementation. As educators strive to equip students with the essential skills for the 21st century, the incorporation of digital tools in numeracy education stands as a critical dimension that demands careful investigation.

The proliferation of digital technologies in recent decades has revolutionized various facets of society, and education is no exception. The advent of interactive whiteboards, educational apps, and online platforms has opened new avenues for engaging and personalized learning experiences (Ertmer, 2005). In the context of numeracy education, digital technologies offer the potential to transcend traditional teaching methods and provide students with interactive and immersive learning environments (Abendan, et al., 2023).

Numeracy, encompassing mathematical proficiency and quantitative reasoning, is a cornerstone of modern education, essential for navigating the complexities of an increasingly data-driven world (National Research Council, 2001). Recognizing the importance of numeracy skills, educators are exploring innovative strategies to enhance teaching and learning in this domain, and digital technologies present promising avenues to achieve this objective (Puteh et al., 2020).

The successful integration of digital technologies into numeracy education is contingent upon effective leadership within educational institutions. Educational leaders play a pivotal role in setting the vision, creating a supportive culture, and providing resources necessary for the seamless adoption of digital tools (Anderson & Dexter, 2005). Understanding how leadership influences the implementation of digital technologies in numeracy teaching is crucial for fostering a positive and transformative learning environment.

As digital technologies continue to shape the educational landscape, understanding their impact on numeracy teaching and learning is imperative. This study adopts a comprehensive approach

by scrutinizing the role of educational leadership in harnessing the potential of digital technologies to elevate numeracy education. Through this exploration, educators, policymakers, and educational leaders can glean valuable insights into fostering an environment where students not only acquire essential numeracy skills but also develop the digital literacy required for success in the 21st century.

Literature Review

A comprehensive examination of the literature surrounding the integration of digital technologies in numeracy education reveals a rich tapestry of research that underscores the multifaceted nature of this dynamic intersection. The literature review is organized into several key themes, each shedding light on distinct aspects of the role of digital technologies in numeracy teaching and learning, with a specific focus on the influence of educational leadership.

The integration of digital technologies in numeracy education has gained significant attention in recent years. The literature suggests that the use of interactive whiteboards, educational software, simulations, and online resources has the potential to enhance student engagement and conceptual understanding in mathematics (Ertmer, 2018; Geiger, 2018). For instance, digital tools can provide interactive and dynamic representations of mathematical concepts, allowing students to explore, manipulate, and visualize abstract ideas (Attard, 2014). These technologies not only cater to diverse learning styles but also create opportunities for collaborative learning and problem-solving (Diano Jr, et al., 2023).

Digital technologies also offer adaptive learning platforms that can tailor instruction to individual student needs, providing targeted support and challenges based on their proficiency levels (Puteh et al., 2020). The adaptive nature of these tools holds the potential to address the diverse learning needs of students, promoting a more personalized and differentiated approach to numeracy education (Attewell & Battle, 1999).

The evolving demands of the 21st-century workforce underscore the importance of numeracy skills in education. The ability to comprehend, analyze, and apply mathematical concepts in real-world contexts is essential for students to become critical thinkers and problem solvers (National Research Council, 2001). Numeracy extends beyond rote memorization of formulas; it involves mathematical reasoning, quantitative literacy, and the capacity to interpret and use data effectively (Ginsburg et al., 2006). As such, the integration of digital technologies aligns with the contemporary need for students to develop not only mathematical proficiency but also digital literacy skills that are increasingly vital in various professions (Erwin & Mohammed, 2022).

Educational Leadership and Digital Technology Integration:

Educational leadership emerges as a critical factor influencing the successful integration of digital technologies in numeracy education. Leaders at various levels, including school administrators, department heads, and teacher leaders, play a crucial role in shaping the vision, policies, and practices related to technology use in schools (Anderson & Dexter, 2005). Research indicates that effective leadership is characterized by a deep understanding of pedagogical practices, a commitment to ongoing professional development, and the creation of a supportive culture that encourages experimentation and innovation (Groenewald, et al., 2023).

Leadership practices that foster a positive digital culture within educational institutions are essential for the successful implementation of technology-enhanced numeracy education. This involves providing resources, infrastructure, and professional development opportunities for educators to effectively integrate digital tools into their teaching practices (Ertmer, 2005). Additionally, educational leaders must navigate policy decisions related to the use of digital technologies, addressing issues such as equitable access, ethical considerations, and data privacy (Blunt, et al., 2021).

While the integration of digital technologies in numeracy education offers numerous opportunities, it is not without challenges. One significant challenge is the variability in educators' technological proficiency and comfort levels, which can impact the successful implementation of digital tools (Manire, et al., 2023). Professional development initiatives that address this variability and provide ongoing support are crucial for building educators' confidence and competence in utilizing digital technologies effectively (Mouza, 2008).

Furthermore, issues related to equity and access must be considered. Disparities in access to technology among students and schools can exacerbate existing educational inequalities (Warschauer, 2006). Educational leaders play a pivotal role in advocating for policies that ensure equitable access to digital resources and bridge the digital divide (Zhao & Frank, 2003).

While the existing literature provides valuable insights into the integration of digital technologies in numeracy education, there are notable research gaps. Few studies specifically focus on the role of educational leadership in driving successful implementation. Future research should explore the leadership practices, policies, and professional development strategies that contribute to effective technology integration in numeracy education (Ondog, et al., 2023).

Moreover, there is a need for longitudinal studies that examine the sustained impact of digital technologies on students' numeracy skills and their subsequent success in higher education and the workforce. Understanding the long-term outcomes of technology-enhanced numeracy education can inform educators and leaders about the enduring benefits and potential challenges associated with this pedagogical approach (Tiu, et al., 2023).

The literature review highlights the intricate relationship between digital technologies, numeracy education, and educational leadership. The integration of digital tools in numeracy education holds great promise for enhancing student learning outcomes, but its success is contingent upon effective leadership practices. As we navigate the complexities of the 21st century, it is imperative to continue investigating and refining the role of digital technologies in numeracy education, ensuring that educational leaders are equipped to guide their institutions toward a future where students are not only mathematically literate but also digitally fluent.

Methodology

The research methodology employed for this study involved conducting a systematic literature review to comprehensively examine existing scholarly works related to the integration of digital technologies in numeracy education, with a specific focus on the role of educational leadership.

The systematic review followed a structured and transparent process to ensure rigor and reliability in the identification, selection, and synthesis of relevant literature.

The first step in the systematic literature review process was the formulation of clear and focused research questions. These questions guided the entire review process, addressing key aspects of the integration of digital technologies in numeracy education and the influence of educational leadership on this integration.

A systematic and comprehensive search strategy was devised to identify relevant studies. Electronic databases, including but not limited to ERIC, PubMed, Education Source, and IEEE Xplore, were systematically searched for articles published up to the date of the literature review. Keywords such as "digital technologies," "numeracy education," "educational leadership," and related terms were used in various combinations to ensure the retrieval of pertinent literature.

Inclusion and exclusion criteria were established to narrow down the pool of potential studies. The criteria were based on relevance to the research questions, publication in peer-reviewed journals or conference proceedings, and a focus on the integration of digital technologies in numeracy education with consideration of educational leadership aspects.

A two-stage screening process was implemented. In the initial stage, titles and abstracts of retrieved articles were screened against the inclusion and exclusion criteria. Subsequently, full-text articles were examined to determine their suitability for inclusion in the systematic review. The screening process was conducted independently by two researchers to enhance reliability. Data extraction involved systematically extracting relevant information from the selected studies. This information included details on study design, participant characteristics, digital technologies utilized, numeracy education outcomes, and the role of educational leadership. A standardized data extraction form was developed and utilized for consistency.

The quality of the selected studies was assessed using established criteria relevant to the research questions. This involved evaluating the methodological rigor, research design, and the clarity of reporting in each study. Studies were not excluded based on quality but were considered in the overall synthesis of findings. The synthesized data from the selected studies were subjected to thematic analysis. Patterns, trends, and recurring themes related to the integration of digital technologies in numeracy education and the role of educational leadership were identified. The synthesis aimed to provide a comprehensive understanding of the existing literature and highlight key insights and gaps.

Findings and Discussion

Diverse Applications of Digital Technologies in Numeracy Education:

The systematic literature review uncovered a rich array of digital technologies utilized in numeracy education, showcasing the versatility of tools that have been integrated into instructional practices. Interactive whiteboards, identified in the reviewed studies (Ertmer, 2018), emerged as a dynamic platform fostering collaborative learning. Educational software played a significant role, providing interactive exercises and real-world applications to reinforce numeracy skills (Puteh et al., 2020). Additionally, online simulations were recognized for their

capacity to immerse students in virtual mathematical scenarios, offering a unique and practical dimension to their learning experiences (Ertmer, 2018). Furthermore, the integration of adaptive learning platforms, as highlighted by Puteh et al. (2020), emerged as a transformative approach, tailoring instruction to individual learning needs and ensuring a personalized learning journey.

These technologies collectively served to create interactive and personalized learning environments, resonating with diverse learning styles and preferences. The engagement fostered through interactive whiteboards and educational software, coupled with the immersive nature of online simulations, provided students with opportunities to explore abstract mathematical concepts in ways that traditional methods may not afford (Valle, et al., 2023; Puteh et al., 2020). The adaptive nature of certain platforms ensured that students received targeted support and challenges based on their proficiency levels, addressing the varying learning needs within a classroom setting (Puteh et al., 2020).

The diverse applications of digital technologies in numeracy education underscored their potential to transcend traditional teaching methods, offering a multifaceted approach that caters to the intricacies of mathematical learning. As educators continue to explore innovative strategies to enhance numeracy skills, the integration of these technologies proves to be a promising avenue for fostering interactive, personalized, and effective learning experiences.

Educational Leadership as a Catalyst for Successful Integration:

Within the landscape of numeracy education, the systematic literature review underscored the indispensable role of educational leadership as a catalyst for the triumphant integration of digital technologies. A synthesis of multiple studies revealed a consistent narrative emphasizing the pivotal influence of leaders in steering the course of technology adoption within educational settings.

Effective leadership practices emerged as a cornerstone in facilitating the seamless assimilation of digital technologies into numeracy education. Visionary leadership, as highlighted by Anderson and Dexter (2005), played a central role in setting the direction for technological initiatives. Educational leaders who articulated a clear vision for the role of digital technologies in numeracy education provided a guiding framework that informed decision-making and motivated stakeholders towards a common goal.

Moreover, the provision of resources emerged as a critical aspect of leadership influence. Leaders who strategically allocated resources—both financial and technological—fostered an environment conducive to technological integration (Harris & Leithwood, 2009). These resources encompassed not only the acquisition of digital tools but also professional development opportunities for educators, ensuring that they were well-equipped to harness the potential of these technologies in enhancing numeracy instruction.

Beyond tangible resources, the establishment of a supportive culture was identified as another hallmark of effective leadership. Harris and Leithwood (2009) accentuated the role of leaders in cultivating a positive and innovative digital environment within educational institutions. Leaders who championed a culture of experimentation, collaboration, and ongoing professional

development created an atmosphere where educators felt empowered to explore and integrate digital technologies into their numeracy teaching practices (Kilag et al., 2023).

Educational leaders, therefore, played a pivotal role not only in the initiation but also in the sustainability of technology integration initiatives. The direction set by leaders, coupled with the provision of essential resources and the establishment of a supportive culture, collectively shaped the effectiveness of digital technologies in enhancing numeracy education. Their influence extended beyond mere oversight; leaders became architects of a digital ecosystem that thrived on innovation and adaptability.

The findings underscored the symbiotic relationship between educational leadership and the successful integration of digital technologies in numeracy education. As educational institutions navigate the complexities of the digital age, effective leadership practices stand out as a decisive factor in leveraging technology to enhance numeracy instruction. The implications of these findings extend to policymakers, administrators, and educators, emphasizing the need for strategic leadership to maximize the transformative potential of digital technologies in the realm of numeracy education.

Challenges in the Implementation Process:

The systematic literature review illuminated a spectrum of challenges intertwined with the implementation of digital technologies in numeracy education, emphasizing critical areas that demand attention for effective integration. Key challenges surfaced consistently across multiple studies, shedding light on the complex landscape that educational leaders must navigate.

One primary challenge highlighted in the literature was the variability in educators' technological proficiency (Basar, et al., 2021). The review emphasized that not all educators possess the same level of comfort or expertise in utilizing digital tools for numeracy instruction. This variability creates a potential barrier to the seamless integration of technology, necessitating targeted professional development initiatives to enhance educators' digital literacy skills. The findings underscored the imperative for educational leaders to acknowledge and address this variability through strategic planning and tailored support mechanisms.

Equitable access to technology emerged as another significant challenge in the implementation process (Mouza, 2008). Disparities in access among students and schools can exacerbate existing educational inequalities. The systematic review pointed to the critical role of educational leaders in advocating for policies and initiatives that bridge the digital divide. Strategic leadership was identified as essential in ensuring that all students, regardless of socio-economic factors, have equal access to the digital resources integral to numeracy education.

Moreover, the literature highlighted the ongoing need for professional development as a recurring challenge (Mouza, 2008). Continuous advancements in digital technologies necessitate educators to stay abreast of emerging trends and refine their pedagogical practices accordingly. The review underscored that educational leaders must prioritize and invest in sustained professional development initiatives to cultivate a cadre of educators who are not only proficient in using digital technologies but also adept at integrating them meaningfully into numeracy instruction (Kilag, et al., 2023).

The challenges identified in the implementation of digital technologies in numeracy education underscore the intricate nature of this transformative process. Educational leaders play a central role in navigating these challenges, from addressing variability in educators' technological proficiency to ensuring equitable access and fostering continuous professional development. By strategically addressing these challenges, leaders can create an environment conducive to the effective integration of digital technologies, ultimately enhancing the numeracy learning experiences of students across diverse educational settings.

Positive Impact on Numeracy Skills and Learning Outcomes:

The amalgamation of research findings unequivocally underscores the affirmative influence of digital technologies on numeracy skills and learning outcomes within educational settings. The studies reviewed consistently reported favorable outcomes associated with the integration of digital tools into numeracy education, shedding light on the transformative potential of technology in enhancing the overall learning experience.

Attard's (2017) and Geiger's (2018) studies provided compelling evidence that students exposed to technology-enhanced numeracy education exhibited marked improvement across various dimensions. One noteworthy area of enhancement was increased engagement. The interactive and dynamic nature of digital tools captivated students' interest, fostering a learning environment that transcended traditional instructional methods.

Moreover, the positive impact extended to conceptual understanding and mathematical proficiency. Geiger (2018) specifically highlighted improvements in students' comprehension of abstract mathematical concepts, indicating that digital technologies facilitated a deeper and more nuanced understanding. Attard (2017) supported this, emphasizing the role of technology in making complex mathematical ideas more accessible through interactive visualizations and simulations.

The adaptive nature of certain digital tools emerged as a key factor contributing to personalized and effective numeracy education (Puteh et al., 2020). Puteh et al.'s study highlighted how adaptive learning platforms tailored instruction to individual learning needs, ensuring that students received content and challenges aligned with their proficiency levels. This adaptability not only addressed the diverse learning needs within a classroom but also contributed to a more personalized and differentiated approach to numeracy education (Kilag, et al., 2023).

The synthesized findings underscore that the positive impact of digital technologies on numeracy education extends beyond superficial improvements. From heightened engagement to enhanced conceptual understanding and mathematical proficiency, the integration of digital tools has the potential to reshape the landscape of numeracy learning. As educational institutions continue to navigate the evolving demands of the 21st century, these findings provide valuable insights into the transformative role that technology can play in fostering a more dynamic and effective numeracy education for students.

Conclusion

This systematic literature review delved into the multifaceted intersection of digital technologies, numeracy education, and the pivotal role of educational leadership. The findings illuminated key insights that collectively contribute to a nuanced understanding of the dynamics at play in this evolving landscape.

The diverse applications of digital technologies in numeracy education, as revealed in the literature, underscore their potential to transcend conventional teaching methods. Interactive whiteboards, educational software, simulations, and adaptive learning platforms offer educators a spectrum of tools to create interactive, engaging, and personalized learning environments. These technologies cater to diverse learning styles, fostering a more dynamic and inclusive approach to numeracy education.

Educational leadership emerged as a linchpin in the successful integration of digital technologies. Visionary leadership, resource provision, and the establishment of a supportive culture were identified as critical factors influencing the direction and effectiveness of technology integration initiatives. The role of educational leaders as architects of a positive digital environment underscores the need for strategic leadership to navigate the complexities of technology adoption in numeracy education.

However, challenges in the implementation process surfaced prominently. Variability in educators' technological proficiency, concerns about equitable access to technology, and the ongoing need for professional development underscore the importance of proactive and strategic leadership. Addressing these challenges is crucial to ensuring that the benefits of digital technologies are accessible to all students and that educators are well-equipped to integrate these tools effectively into their teaching practices.

On a positive note, the review consistently highlighted the positive impact of digital technologies on numeracy skills and learning outcomes. Students exposed to technology-enhanced numeracy education demonstrated improved engagement, conceptual understanding, and mathematical proficiency. The adaptive nature of certain digital tools emerged as a key contributor to personalized and effective numeracy education, catering to individual learning needs.

As educational institutions navigate the dynamic landscape of 21st-century education, the synthesis of these findings offers valuable insights for educators, policymakers, and educational leaders. By understanding the diverse applications of digital technologies, recognizing the pivotal role of leadership, addressing implementation challenges, and leveraging the positive impact on learning outcomes, stakeholders can collaboratively shape a future where numeracy education is not only technologically enriched but also strategically led for the benefit of all students. This study provides a foundation for informed decision-making, policy development, and future research endeavors in the realm of digital numeracy education.

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