



Systematic Literature Review (SLR) on ICT-Based Literacy and Numeracy Learning Design in Elementary Schools

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ABSTRACT

This systematic literature review (SLR) examines the integration of Information and Communication Technology (ICT) in elementary school literacy and numeracy education, addressing its impact, challenges, and teacher roles. Analyzing 26 peer-reviewed articles (2018–2025) selected via PRISMA criteria, the study reveals that ICT enhances interactive learning, student engagement, and personalized instruction, outperforming traditional methods. Key tested variables included ICT tools (e.g., digital platforms, gamification), teacher competencies, and infrastructural barriers. Findings highlight infrastructure gaps and uneven teacher readiness as critical constraints. The study contributes to educational technology discourse by advocating for policy-supported teacher training and equitable resource allocation. Results underscore ICT's transformative potential in foundational education, urging systemic collaboration to bridge implementation gaps.

INTRODUCTION

The integration of Information and Communication Technology (ICT) in the design of literacy and numeracy learning in elementary schools has become an increasingly critical domain. ICT is expected to enrich educational strategies, provide support in developing essential student skills, and prepare them to face 21st-century challenges. Literacy and numeracy learning are foundational skills that students must master early on, given their crucial role in education and daily life. Through the use of digital tools, literacy and numeracy instruction is anticipated to become more interactive, engaging, and effective. This is reflected in research showing that ICT-based applications can enhance student engagement in the learning process and improve learning outcomes (Misnawati et al., 2023; Wulandari et al., 2023). Additionally, ICT enables more adaptive and personalized learning tailored to individual student needs, which is often unattainable in conventional teaching methods.

However, the application of ICT in literacy and numeracy learning at the elementary school level faces various challenges. One of the main obstacles is the limited technological skills possessed by many teachers. Research indicates that many educators still feel inadequately skilled in using technology, which can hinder the integration of ICT in their teaching (Mtani et al., 2024). Additionally, insufficient training and limited resources often act as barriers to maximizing the use of ICT in the classroom (Misnawati et al., 2023; Tizaka & Ismail, 2024). To address these challenges, continuous professional development for teachers and supportive infrastructure are needed to ensure effective integration of technology in literacy and numeracy instruction.

On the other hand, a transformational approach to learning is highly recommended in the context of ICT integration. Fitriana and Ridlwan (2021) demonstrated that implementing thematic learning strategies incorporating ICT can enhance student engagement and enrich their literacy and numeracy skills (Fitriana & Ridlwan, 2021). Approaches involving game-based applications and digital platforms have proven effective in improving students' numeracy skills, particularly when combined with project-based learning (Eldiana et al., 2025; Nityasanti et al., 2025). This approach not only makes learning more engaging but also allows students to apply their knowledge in real-world contexts, thereby improving their understanding and retention of the concepts being taught.

Furthermore, integrating digital literacy into numeracy education has become critically important in this digital era. The use of digital tools helps students navigate information resources more effectively, ultimately enhancing their overall literacy and numeracy skills (Bali et al., 2023). Programs that combine these elements, such as through games and interactive learning experiences, have demonstrated better outcomes for both students and teachers (Eldiana et al., 2025; Safitri, 2024). These findings underscore the importance of creating multidimensional learning environments that can adapt to 21st-century technological advancements, equipping students with the literacy and numeracy skills needed for academic success and active participation in society.

Despite the growing body of research on ICT integration in literacy and numeracy learning at the elementary level, several gaps remain unaddressed.

First, while studies highlight the benefits of ICT tools such as gamification and digital platforms, there is limited comparative analysis of their effectiveness across diverse socio-economic and geographic contexts, particularly in rural versus urban settings. Second, existing literature often focuses on student outcomes but overlooks the systemic challenges faced by teachers, such as inadequate training and resource disparities, which hinder optimal ICT implementation. Third, the role of parental and community involvement in supporting ICT-based learning is underexplored, despite its potential to bridge gaps in access and engagement. Lastly, there is a scarcity of longitudinal studies assessing the sustained impact of ICT on literacy and numeracy skills over time. Addressing these gaps is crucial for developing equitable, scalable, and context-sensitive ICT strategies in elementary education.

The importance of collaboration between educational institutions, families, and communities in this context cannot be overlooked. Programs like "Kampus Mengajar" emphasize the involvement of students, teachers, and parents in strengthening literacy and numeracy initiatives, thereby creating a crucial support network for sustainable learning outcomes (Sipayung et al., 2024; Situmorang, 2024). Community engagement can further provide the necessary adaptive resources for successful ICT implementation in elementary education (Hutauruk et al., 2023). This also demonstrates that strong social support can accelerate the ICT adoption process, enabling teachers and students to maximize technology's potential in learning.

Overall, the implementation of ICT in literacy and numeracy learning design for elementary schools requires a concerted effort from educators to update their skills, along with fostering collaboration among various stakeholders. Only through a meaningful commitment to technology integration can we hope to enhance primary students' educational experiences, ultimately preparing them to thrive in an increasingly digital world.

Moreover, the role of teachers in implementing Information and Communication Technology (ICT) for literacy and numeracy learning in elementary schools is crucial to the success of educational initiatives aimed at enhancing these fundamental skills. Teachers serve not merely as technology facilitators, but as leaders in integrating ICT into pedagogical practices aligned with literacy and numeracy objectives. A critical aspect of teachers' role in this context is their own ICT literacy. Research indicates that teachers with higher levels of ICT literacy are better prepared and more willing to incorporate these technologies into their classrooms, creating more engaging and effective learning environments for students (Baharuldin et al., 2020). The same study reveals that strong administrative support can enhance teachers' readiness to master essential digital competencies, thereby improving their ability to integrate ICT into instruction (Baharuldin et al., 2020). These findings align with research by Winarno et al. (2024), which demonstrates that effective strategies for promoting literacy and numeracy through ICT depend on supportive infrastructure, teacher collaboration, and real-world application relevance (Winarno et al., 2024).

Teachers' pedagogical knowledge is equally crucial for the effective use of ICT in literacy and numeracy education. Educators bear the responsibility of

selecting resources that cater to diverse student needs, as emphasized by Gunawan et al. (2023), who note that teachers can adapt curriculum content and leverage technological tools to enhance learning experiences through differentiation strategies (Gunawan et al., 2023). Furthermore, Kastorff & Stegmann (2024) argue that teachers' technological pedagogical knowledge serves as a significant predictor of students' ICT literacy, underscoring the necessity for ongoing professional development and support in this domain (Kastorff & Stegmann, 2024).

Moreover, the implementation of ICT in literacy and numeracy instruction is closely tied to teachers' technology self-efficacy. Pečiuliauskienė et al. (2022) assert that a lack of understanding of new ICT tools can diminish educators' confidence in utilizing these technologies for instructional purposes (Pečiuliauskienė et al., 2022). This finding underscores the need for targeted professional development programs designed to enhance teacher confidence and competence, as evidenced by the successful outcomes of initiatives aimed at improving literacy and numeracy skills (Suhardiman et al., 2024).

LITERATURE REVIEW

The impact of Information and Communication Technology (ICT) on literacy and numeracy learning in elementary schools has become a significant area of educational research. As technology becomes increasingly integrated into educational environments, understanding its effects on student learning outcomes particularly in literacy and numeracy has grown crucially important. The adoption of digital tools and learning platforms has been associated with improved student performance in these two fundamental areas (Handayani et al., 2022; Hidayanthi et al., 2024). ICT use in education not only offers potential for enhancing skill acquisition but also boosts student engagement and motivation, which are vital for effective learning (Handayani et al., 2022). As technology becomes embedded in daily life, its role in shaping the next generation of learners has spurred numerous studies examining its effectiveness, particularly within elementary education contexts.

One of the key findings from the literature is that ICT based tools make positive contributions to numeracy education. A study by Hidayanthi et al. (2024) highlights the role of digital platforms and e-books in promoting numeracy literacy among elementary school students. These platforms, when combined with project based learning and interactive media, have proven to significantly enhance students' mathematical understanding. The study emphasizes the importance of STEAM-based learning approaches that not only facilitate numeracy education but also foster students' critical thinking and problem-solving skills (Hidayanthi et al., 2024). Similarly, Siswandari (2023) found that integrating ICT into project-based learning activities can improve numeracy skills while simultaneously enhancing digital literacy skills, which are crucial in today's technology-driven world. These findings demonstrate a strong correlation between ICT integration and increased student engagement in

numeracy learning, suggesting that digital learning tools are effective in capturing student interest and improving their skills (Siswandari, 2023).

The benefits of ICT in literacy and numeracy instruction are further evident in its capacity to support personalized learning. Educational technology enables teachers to tailor learning experiences to accommodate diverse student needs. For instance, the implementation of gamification has been associated with higher student engagement levels, particularly in mathematics contexts. Duraiswamy and Mohammed (2024) demonstrate that gamification in numeracy instruction not only makes the subject more appealing but also encourages students to take ownership of their learning. This approach can significantly boost students' interest in mathematics while helping them develop deeper conceptual understanding of numeracy. Furthermore, gamified learning environments promote collaborative learning, which is essential for developing students' communication and teamwork skills crucial attributes for success in the modern world (Duraiswamy & Mohammed, 2024).

Students' socio-economic context plays a crucial role in determining the effectiveness of ICT in enhancing literacy and numeracy. Research reveals significant disparities in ICT access between urban and rural areas. According to Handayani et al. (2022), urban students generally demonstrate higher levels of ICT literacy compared to their rural counterparts, largely due to better access to technology and resources. This digital literacy gap raises concerns about educational equity, particularly as technology becomes increasingly integrated into teaching and learning practices (Handayani et al., 2022). However, research by Amaruddin et al. (2021) indicates that even in border regions facing infrastructure challenges, students maintain a strong desire to engage with ICT. This eagerness to adopt digital tools despite obstacles demonstrates robust motivation for technological adaptation across diverse demographics. Consequently, bridging the digital divide becomes essential to ensure all students, regardless of location, can benefit from the educational advantages offered by ICT (Amaruddin et al., 2021).

Teacher readiness represents another critical factor influencing the successful integration of ICT in literacy and numeracy instruction. Educators' ability to effectively utilize technology in the classroom largely depends on their pedagogical knowledge of ICT and their confidence in employing digital tools. Research indicates that teachers with higher levels of ICT knowledge and skills tend to be more successful in implementing technology in ways that enhance student learning (Kastorff & Stegmann, 2024; Nangimah & Dharin, 2023). Well-trained teachers who can integrate ICT into their instructional practices are better equipped to create engaging and effective learning environments that support students' literacy and numeracy development. Furthermore, teacher training programs focusing on ICT integration are essential to ensure educators can optimally leverage digital tools to address their students' diverse learning needs (Kastorff & Stegmann, 2024). Consequently, professional development programs must be continuously updated to incorporate the latest technological advancements and effective pedagogical strategies.

Furthermore, the adoption of ICT in classrooms enables more flexible and personalized learning experiences. Technology can be utilized to create diverse learning pathways tailored to students' varied learning styles and abilities. For instance, interactive learning platforms allow students to work at their own pace, ensuring they master key concepts before progressing to more complex material. This approach effectively addresses individual learning needs and guarantees all students receive the necessary support to succeed (Nur et al., 2023; Rosnelli & Ristiana, 2023). The capacity to deliver personalized learning experiences through technology proves particularly valuable in heterogeneous classrooms, where students may demonstrate varying proficiency levels in literacy and numeracy.

Despite the numerous benefits offered by ICT integration in literacy and numeracy learning, challenges in its implementation persist. One major obstacle is the inequality in access to digital resources and infrastructure. In many developing countries and rural areas, schools struggle with limited technological access, making it difficult to fully integrate ICT into the curriculum (Banawi et al., 2022; Fitriani et al., 2023). This lack of access not only hinders the effectiveness of ICT in education but also exacerbates existing educational disparities. To address these challenges, policy interventions are needed to ensure equitable access to technology for all students, particularly those in underserved regions.

In addition, varying levels of teacher readiness pose another significant challenge to successful ICT integration in classrooms. Educators who lack adequate training in using technology may struggle to incorporate digital tools into their teaching practices, thereby limiting the potential benefits of ICT for student learning (Hapudin & Mujazi, 2024). Therefore, providing teachers with ongoing professional development is crucial to ensure they possess the necessary knowledge and skills to effectively leverage ICT in their classrooms. Furthermore, schools must invest in essential infrastructure and resources to support ICT integration, including reliable internet access, digital devices, and technical support.

Parental involvement also serves as a key factor in the success of ICT-based learning initiatives. Research indicates that many parents underestimate the importance of numeracy development, focusing more on literacy skills during early education (Deda et al., 2023; Napoli et al., 2021). This imbalance in prioritizing foundational skills may hinder students' overall academic progress. Schools can address this issue by actively engaging parents in the learning process, educating them about the significance of numeracy and providing practical strategies to support their children's learning at home (Banawi et al., 2022; Napoli et al., 2021). By strengthening parental involvement, schools can foster a more supportive learning environment that enhances students' literacy and numeracy outcomes.

The integration of ICT in literacy and numeracy learning holds significant potential to enhance student learning outcomes. Through innovative digital tools and strategies such as gamification, project-based learning, and personalized instruction ICT can boost student engagement and skill development. However, successful ICT implementation requires addressing key challenges related to

teacher readiness, infrastructure, and parental involvement. By investing in teacher training, ensuring equitable access to technology, and promoting parental engagement, schools can fully harness ICT's potential to improve literacy and numeracy outcomes for all students.

METHODOLOGY

This study aims to identify and analyze Technology-Enhanced Learning (TEL) designs for literacy and numeracy instruction in elementary schools. The research employs a Systematic Literature Review (SLR) methodology to explore and synthesize relevant findings on ICT integration in literacy and numeracy education. The study hypothesizes that ICT implementation can make elementary education more interactive, engaging, and effective, while increasing student participation in learning processes (Misnawati et al., 2023; Wulandari et al., 2023). The review will identify key challenges in ICT integration, analyze proposed solutions, recommend evidence-based approaches to enhance ICT effectiveness in classrooms.

This study employs a *Systematic Literature Review* (SLR) method by analyzing 26 research articles that met the inclusion criteria after undergoing a systematic selection process. From an initial pool of 500 articles identified through searches in academic databases such as Google Scholar, Scopus, ERIC, and JSTOR, screening was conducted based on topic relevance, methodological quality, and alignment with the research focus. The selection process followed the PRISMA protocol with four main stages: identification, screening, eligibility assessment, and inclusion. Articles that did not meet the criteria – such as those not focusing on elementary education or not discussing ICT use in literacy and numeracy instruction – were excluded from the analysis.

This sampling technique ensures that the selected studies are representative and of high quality, enabling reliable synthesis of literature to address the research questions. Thus, the methodology explicitly states the final sample size (26 articles) and the rigorous criteria-based sampling technique, which includes systematic searching, abstract screening, and full-text eligibility assessment. This approach strengthens the validity of the research findings and provides a solid foundation for policy recommendations and practical applications.

This study centers on the following key research questions to investigate ICT's impact on literacy and numeracy learning in elementary education: 1) Implementation Analysis: How is Information and Communication Technology (ICT) integrated into literacy and numeracy instructional design at the elementary level? 2) Teacher Agency: What roles do educators play in implementing ICT for literacy and numeracy instruction? 3) Comparative Effectiveness: What efficacy differences exist between ICT-enhanced and traditional pedagogical approaches for elementary literacy/numeracy? 4) Integration Challenges: What are the primary barriers to successful ICT integration in elementary literacy and numeracy education?

Through these questions, it is hoped that a clearer picture can be obtained regarding how ICT can be integrated into basic education, as well as how existing challenges can be overcome to achieve better learning outcomes. With a deeper understanding of the influence of ICT on primary education, the findings of this

research can provide useful recommendations for educators, policymakers, and other stakeholders in improving the learning experience in elementary schools.

Literature data will be collected through a systematic search across various leading academic databases, including Google Scholar, Scopus, ERIC, and JSTOR. The keywords used in the search include 'ICT in literacy and numeracy learning,' 'technology integration in primary schools,' 'ICT-based learning,' 'game-based learning in numeracy,' and 'STEAM-based learning.' The article selection process will involve screening abstracts and assessing their alignment with the predetermined criteria. All relevant articles will be thoroughly reviewed, and the data within them will be extracted and analyzed. The research will be conducted from November 2024 to April 2025. Below is the table of inclusion and exclusion criteria for this study:

Tabel 1 Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Study Type	Studies focusing on ICT implementation in literacy and numeracy learning in primary schools.	Studies that do not discuss ICT use in literacy and numeracy learning.
Methodology	Qualitative, quantitative, or mixed-methods studies relevant to the research topic.	Studies focusing on topics other than literacy and numeracy or unrelated to ICT.
Population/Setting	Primary school students and teachers involved in ICT-based literacy and numeracy learning.	Studies not involving primary schools or irrelevant populations (e.g., secondary or higher education).
Publication Period	Articles published within the last 5 years (2018–2023).	Articles published more than 5 years ago (before 2018).
ICT Application Type	Use of game-based ICT apps, digital platforms, e-books, and project-based learning in literacy and numeracy.	Studies not involving ICT tools or using only traditional methods (e.g., blackboards).
Language	Articles published in Indonesian or English.	Articles not published in Indonesian or English.
Study Quality	Studies with clear methodology and valid, reliable data.	Studies with poor methodology or low-quality data (e.g., invalid or biased data).

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram outlines the systematic stages involved in the identification, screening, and inclusion of studies for this literature review. The process began with an initial identification of 500 articles from various databases, which then underwent preliminary screening to remove duplicates, irrelevant articles (filtered through automation tools), and other exclusions, leaving 245 articles for further review. From this pool, 96 articles were eliminated during the initial screening phase, and 149 reports proceeded to full-text retrieval. However, 53 of these could not be obtained. Subsequently, 96 reports were assessed for eligibility, but 56 were excluded for not meeting educational topic criteria, lacking discussion on literacy and numeracy instructional design, or being irrelevant to ICT. Ultimately, 26 studies met the inclusion criteria and were incorporated into this systematic review. This diagram illustrates the rigorous

and transparent selection process employed to ensure the quality and relevance of sources in the literature review.

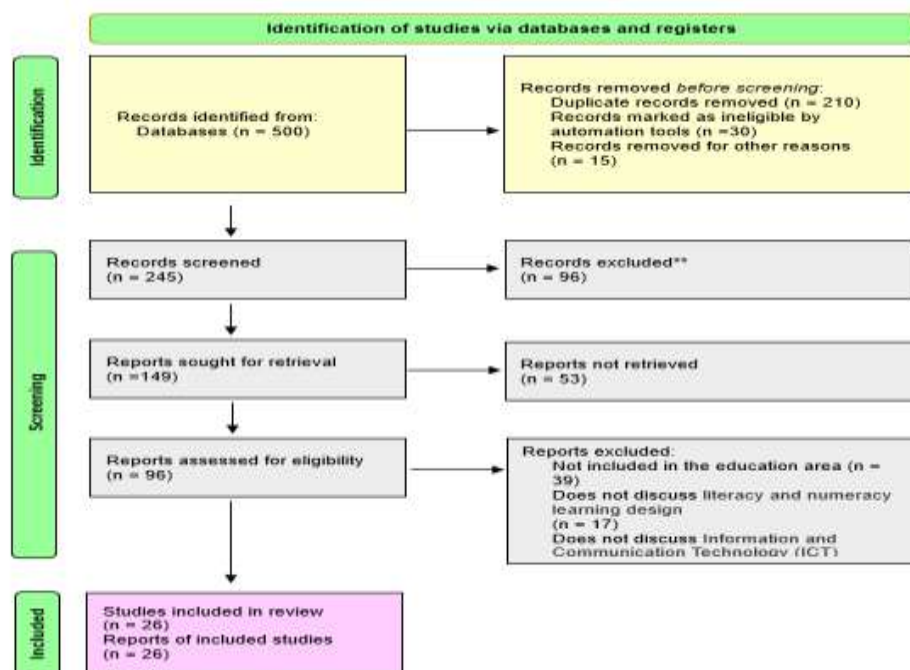


Figure 1. Prism groove

The presented PRISMA flow diagram underscores the thoroughness and transparency in the screening and selection process of articles for this systematic review. From an initial pool of 500 identified articles, only 26 studies met all inclusion criteria and were deemed suitable for further analysis. This process reflects the researchers' commitment to incorporating only highly relevant and quality literature, particularly those addressing ICT integration in literacy and numeracy instructional design for primary education. The final selection is expected to provide a robust foundation for developing educational policies and more effective, contextually appropriate technology-based teaching practices.

As part of a systematic literature review on ICT implementation in literacy and numeracy learning at primary schools, the following table summarizes 26 key research articles analyzed in this study. The table includes information on authors, publication year, research titles, and main findings from each study that met the inclusion criteria. All selected articles contribute to a deeper understanding of the effectiveness, challenges, and innovative approaches in using ICT to enhance students' fundamental skills at primary education level. By presenting the latest research findings in a comprehensive summary, this table is expected to serve as a strong foundation for developing more effective and inclusive technology-based learning strategies.

Table 2. Literature Summary

No	Author(s)	Year	Research Title	Key Findings
1	Handayani et al.	2022	The Impact of ICT on Elementary Students' Learning	ICT improves students' skill acquisition, engagement, and learning motivation.

			Outcomes in Literacy and Numeracy	
2	Hidayanthi et al.	2024	The Role of Digital Platforms and E-books in Numeracy Education	Digital platforms and e-books enhance mathematical understanding and critical thinking skills.
3	Siswandari	2023	ICT Integration in Project-Based Learning	Improves students' numeracy skills and ICT competencies.
4	Duraiswamy & Mohammed	2024	Gamification in Numeracy Learning	Gamification increases student interest, learning responsibility, and collaboration.
5	Amaruddin et al.	2021	ICT Use in Border Areas	Students show high motivation despite infrastructure limitations.
6	Kastorff & Stegmann	2024	Teachers' Technological Pedagogical Knowledge	Significant predictor of student ICT literacy; highlights importance of professional training.
7	Nangimah & Dharin	2023	Teachers' Knowledge and Skills	Teachers with strong ICT skills are more successful in enhancing student learning.
8	Nur et al.	2023	Technology-Based Personalized Learning	Interactive platforms support diverse learning styles and concept mastery.
9	Rosnelli & Ristiana	2023	Technology-Enabled Flexible Learning	Enhances learning effectiveness through differentiated learning paths.
10	Fitriani et al.	2023	ICT Access Limitations in Developing Countries	Limited ICT access exacerbates educational inequalities.
11	Banawi et al.	2022	ICT Infrastructure Challenges in Rural Schools	Technological barriers limit digital curriculum implementation.
12	Hapudin & Mujazi	2024	Teacher Readiness for ICT Integration	Low teacher readiness limits ICT effectiveness in learning.
13	Napoli et al.	2021	Parental Perceptions of Numeracy	Parents focus more on literacy; numeracy is often neglected.
14	Deda et al.	2023	Parental Involvement in Numeracy	Lack of parental understanding hinders numeracy support at home.
15	Wulandari et al.	2023	Technology-Enabled Flexible Learning	Improves learning effectiveness through differentiated pathways.
16	Mtani et al.	2024	ICT Implementation Challenges in Education	ICT integration requires clear and consistent policy support.
17	Situmorang	2024	ICT Integration in Project-Based Learning	Enhances student collaboration in project-based learning.
18	Sipayung et al.	2024	The Role of Gamification in Numeracy Learning	Gamification supports student engagement and motivates harder learning efforts.

19	Hutauruk et al.	2023	ICT Integration Challenges in Elementary Schools	Limited device access and infrastructure are major barriers.
20	Eldiana et al.	2025	ICT's Impact on Numeracy Learning in Elementary Schools	ICT implementation can boost student motivation in numeracy.
21	Suhardiman et al.	2024	Technological Readiness for Literacy and Numeracy Learning	Infrastructure readiness and teacher training are crucial for ICT integration.
22	Gunawan et al.	2023	ICT Implementation for Improving Literacy and Numeracy in Elementary Schools	ICT helps enhance students' conceptual understanding of numeracy and literacy.
23	Winarno et al.	2024	Utilizing ICT Platforms for Literacy and Numeracy	ICT enriches teaching methods in elementary schools.
24	Pečiuliauskienė et al.	2022	Technology's Role in Elementary Literacy Learning	Technology provides flexibility in how students learn literacy.
25	Baharuldin et al.	2020	ICT Integration in Education in Developing Regions	ICT implementation can help reduce educational disparities.
26	Kusuma et al.	2024	Technology's Impact on Numeracy Learning in Elementary Schools	Technology supports numeracy skill development through more interactive approaches.

This literature summary table not only illustrates the diversity of approaches and findings in ICT implementation for literacy and numeracy learning in primary education, but also highlights the contextual challenges faced by educators and students in effectively adopting technology. The findings from various studies emphasize the critical importance of teacher training, infrastructure support, and parental involvement as determining factors for successful ICT integration in elementary education settings. Therefore, this compiled literature serves as a vital foundation for formulating policy recommendations and developing adaptive, sustainable ICT-based learning implementation strategies to support the achievement of 21st-century educational goals.

RESEARCH RESULT

These research findings are compiled based on a synthesis of 26 selected articles reviewed in this systematic literature study on ICT-based literacy and numeracy learning design in primary education. The analysis was conducted to address four main research questions: (1) how ICT is implemented in literacy and numeracy learning design; (2) the teacher's role in ICT implementation; (3) a comparison of effectiveness between ICT-based learning and traditional

methods; and (4) key challenges in integrating ICT into literacy and numeracy instruction.

First, the analysis results indicate that ICT implementation in literacy and numeracy learning significantly contributes to improving the quality of primary education. The reviewed articles demonstrate that ICT use enriches instructional strategies by creating interactive, adaptive, and contextual learning environments. Digital platforms, e-books, game-based applications, and technology-supported project-based learning have proven effective in enhancing student engagement, deepening conceptual understanding, and developing more profound literacy and numeracy skills. For instance, ICT-supported STEAM approaches encourage students to develop critical thinking and problem-solving abilities (Hidayanthi et al., 2024; Siswandari, 2023). These findings support the conclusion that digital technology can serve not merely as a teaching aid, but as a transformative medium in education.

Second, the role of teachers becomes central in ensuring the successful implementation of ICT in learning. Teachers serve as the primary drivers in integrating technology into teaching practices. Research shows that teachers with high digital literacy levels tend to be more prepared and willing to explore technology-based learning approaches. Additionally, technological pedagogical knowledge is also a strong predictor of the effectiveness of ICT implementation. Teachers who can appropriately select and modify digital content are more successful in addressing the diverse learning needs of students (Gunawan et al., 2023; Kastorff & Stegmann, 2024). However, a common challenge is the lack of training and technical support, which affects teachers' self-efficacy in optimally utilizing ICT in the classroom.

Third, the effectiveness of ICT-based learning compared to traditional methods is elaborated in several studies, which demonstrate that digital approaches can yield better outcomes in terms of student engagement, information retention, and problem-solving abilities. Gamification, for example, has been proven to enhance students' learning accountability and foster meaningful collaboration among peers (Duraiswamy & Mohammed, 2024). Meanwhile, ICT-supported project-based learning provides broader opportunities for students to apply their knowledge in real-world contexts, making the learning process more meaningful and applicable (Siswandari, 2023). These studies indicate that ICT-based learning approaches are not only on par with but, in many cases, superior to conventional methods.

Fourth, the literature synthesis also reveals several key challenges in integrating ICT into literacy and numeracy education. Infrastructure limitations, such as access to digital devices and stable internet connections, pose significant barriers – particularly in rural and remote areas (Amaruddin et al., 2021; Banawi et al., 2022). Additionally, the digital divide among students from different socioeconomic backgrounds exacerbates inequalities in access to technology-based learning resources. Equally critical are teacher-related challenges, including a lack of relevant training, limited time to design ICT-based lessons, and resistance to pedagogical change. Further challenges arise from the home environment, where many parents still do not grasp the importance of numeracy

skill development, resulting in suboptimal support for their children’s learning at home (Deda et al., 2023; Napoli et al., 2021).

The PRISMA flow-based search results revealed that out of 500 initially identified articles, only 26 met the inclusion criteria for further analysis. This rigorous selection process underscores a commitment to data quality and relevance in producing reliable findings. The selected articles reflect diverse contexts, methods, and pedagogical approaches, yet all consistently demonstrate that ICT plays a pivotal role in enhancing the quality of literacy and numeracy instruction at the primary education level.

Overall, this study confirms that ICT integration in literacy and numeracy learning yields significant positive impacts. However, its successful implementation hinges on teacher readiness and competence, adequate infrastructure, and support from parents and communities. Thus, a comprehensive strategy is needed one that includes sustained teacher training, investment in digital facilities, and raising parental awareness about the importance of literacy and numeracy. By doing so, ICT adoption in education will not merely symbolize modernization but also serve as a tangible tool for fostering more inclusive, effective, and 21st-century-relevant learning.

The research results table was constructed to summarize the literature synthesis findings from various studies analyzed in this systematic review of ICT integration in literacy and numeracy instruction at the elementary school level. The table organizes key findings according to four main research questions: (1) ICT application in instructional design, (2) teachers' roles in ICT implementation, (3) comparison of ICT-based and traditional teaching effectiveness, and (4) major challenges in ICT integration. Each question category includes relevant authors with publication years, number of supporting studies, and summaries of key findings. This structured presentation aims to provide a clear, systematic mapping of each study's contribution to addressing the research focus, while highlighting consistent findings that underscore ICT's crucial role in enhancing the quality of elementary education.

Tabel 3. Research Findings

Research Question	Summary of Findings	Number of Articles	Authors
What is the effectiveness difference between ICT-based and traditional literacy and numeracy instruction in elementary schools?	ICT-based learning is more engaging and adaptive compared to traditional methods.	8	Deda et al. (2023); Duraiswamy & Mohammed (2024); Gunawan et al. (2023); Hidayanthi et al. (2024); Misnawati et al. (2023); Rosnelli & Ristiana (2023); Sipayung et al. (2024); Winarno et al. (2024)
What are the main challenges in integrating ICT into literacy and numeracy instruction in elementary schools?	Challenges include infrastructure limitations, teacher readiness, and parental involvement.	7	Amaruddin et al. (2021); Eldiana et al. (2025); Kastorff & Stegmann (2024); Nangimah & Dharin (2023); Napoli et al. (2021); Nur et al. (2023); Suhardiman et al. (2024)

How is ICT implemented in literacy and numeracy instructional design in elementary schools?	ICT enriches teaching strategies and enhances student engagement.	8	Baharuldin et al. (2020); Banawi et al. (2022); Handayani et al. (2022); Hutaaruk et al. (2023); Mtani et al. (2024); Pečiuliauskienė et al. (2022); Siswandari (2023); Situmorang (2024)
What is the teacher's role in implementing ICT for literacy and numeracy instruction in elementary schools?	Teachers play a crucial role and require ongoing ICT training.	3	Fitriani et al. (2023); Hapudin & Mujazi (2024); Wulandari et al. (2023)

The research findings table, organized according to the study's research questions, demonstrates consistent results across the analyzed studies while reinforcing the argument that ICT integration in primary school literacy and numeracy instruction represents not merely a pedagogical innovation, but a strategic necessity in addressing 21st-century educational challenges. The diversity of authors and number of supporting studies for each question indicates that academic attention to this issue is both extensive and substantive. Consequently, the utilization of this synthesis is expected to provide a robust foundation for policymaking, teacher training programs, and the development of curricula that are more responsive to technological advancements and diverse student learning needs.

DISCUSSION

This study integrates key findings from selected literature reviewed through the Systematic Literature Review (SLR) method to address four primary research questions regarding ICT integration in elementary-level literacy and numeracy instruction. The analysis not only consolidates synthesized results but also enriches interpretation through theoretical and practical reflections on the challenges, opportunities, and tangible contributions of ICT implementation within the dynamic and evolving context of primary education.

First, regarding the implementation of ICT in literacy and numeracy instructional design, consistent findings reveal that ICT serves not merely as a technical tool, but has fundamentally transformed how teachers deliver content and how students construct understanding. The use of e-books, educational game applications, interactive videos, and online learning platforms provides flexibility in learning time and methods. As demonstrated by Handayani et al. (2022) and Hidayanthi et al. (2024), the utilization of digital platforms not only enhances student motivation and participation but also directly impacts numeracy learning outcomes. Furthermore, technology-based STEAM approaches enrich the learning process by emphasizing exploration, collaboration, and critical thinking, which have been proven to improve students' literacy and numeracy mastery (Handayani et al., 2022; Hidayanthi et al., 2024).

Second, teachers' role as change agents and technology facilitators serves as the key determinant in effective ICT implementation. Teacher ICT literacy has been shown to positively correlate with students' digital literacy, as reported by Kastorff & Stegmann (2024). Teachers who possess adequate skills in selecting

and appropriately using technological tools can more easily adapt instruction to accommodate diverse student needs and learning styles. However, disparities in digital literacy among teachers persist. Research by Hapudin & Mujazi (2024) reveals that many teachers fail to optimize ICT utilization due to insufficient training, limited time for designing ICT-based lessons, and lack of technical support from schools. These challenges underscore the need for practical, context-specific continuous training programs, including peer mentoring and strong administrative support (Hapudin & Mujazi, 2024).

Third, compared to traditional teaching approaches, ICT-based approaches have proven to be more engaging, adaptive, and impactful on students' cognitive and affective skills. A study by Duraiswamy & Mohammed (2024) indicates that gamification in numeracy learning not only enhances motivation but also fosters active and collaborative student engagement (Duraiswamy & Mohammed, 2024). This finding is reinforced by Siswandari (2023), who demonstrates that project-based approaches integrated with ICT provide students with opportunities to solve real-world problems contextually, thereby strengthening critical thinking skills and conceptual transfer. In contrast to the one-directional nature of traditional methods, ICT-based approaches are interactive and more responsive to individual student needs (Siswandari, 2023).

Fourth, this discussion also emphasizes that the challenges of ICT implementation cannot be overlooked. The main obstacles include limited internet infrastructure, digital devices, and uneven electricity access, particularly in remote areas (Amaruddin et al., 2021; Banawi et al., 2022). The digital divide further exacerbates educational disparities among students from different socioeconomic backgrounds. Additionally, resistance from both teachers and parents toward digital approaches presents another barrier. Research by Napoli et al. (2021) indicates that parental attention tends to focus more on literacy aspects than numeracy, which ultimately affects their priorities in supporting home-based learning (Napoli et al., 2021).

To address these challenges, a collaborative approach involving schools, families, and communities emerges as a promising strategy. Programs such as the Teaching Campus initiative (Kampus Mengajar) and community engagement in technology provision and mentoring have proven effective in promoting more comprehensive ICT implementation. Research by Hutauruk et al. (2023) confirms that the success of technology-based learning is largely determined by strong social networks and cross-stakeholder support (Hutauruk et al., 2023).

Furthermore, comprehensive education policy support is crucial in bridging the gap between ICT's potential and field implementation challenges. Governments must ensure not only the provision of infrastructure and devices, but also continuous teacher training and implementation evaluation based on learning outcome indicators. This study demonstrates the necessity for adaptive and participatory policy approaches, including the development of digital curricula that systematically integrate ICT into core competencies for elementary school students.

The personalization dimension further enhances the value of ICT implementation in literacy and numeracy education. Supported by digital

platforms such as Learning Management Systems (LMS) and evaluative applications, teachers can monitor student progress in real-time, develop tailored interventions, and adapt learning materials to individual learning styles and paces. This approach proves particularly relevant for special needs students or those with diverse linguistic backgrounds (Nur et al., 2023; Rosnelli & Ristiana, 2023). Such flexibility fosters a more inclusive, equitable, and responsive learning environment that accommodates classroom dynamics.

Ultimately, ICT integration in education not only enhances academic competencies but also strengthens students' 21st-century skills, including collaboration, digital communication, and information literacy. Early development of digital literacy serves as a crucial foundation for young generations to grow into critical, adaptive, and responsible digital citizens. Therefore, strategies for implementing ICT in literacy and numeracy education should be viewed not merely as a response to contemporary changes, but as a long-term investment in creating resilient and competitive learners for the digital era.

The following figure presents the distribution of research findings based on the four main research questions in this systematic review. The chart illustrates the spread of supporting studies examining various aspects of Information and Communication Technology (ICT) implementation in literacy and numeracy instruction at the elementary school level. This visualization not only reveals dominant focuses in current literature but also helps identify research gaps requiring further attention.

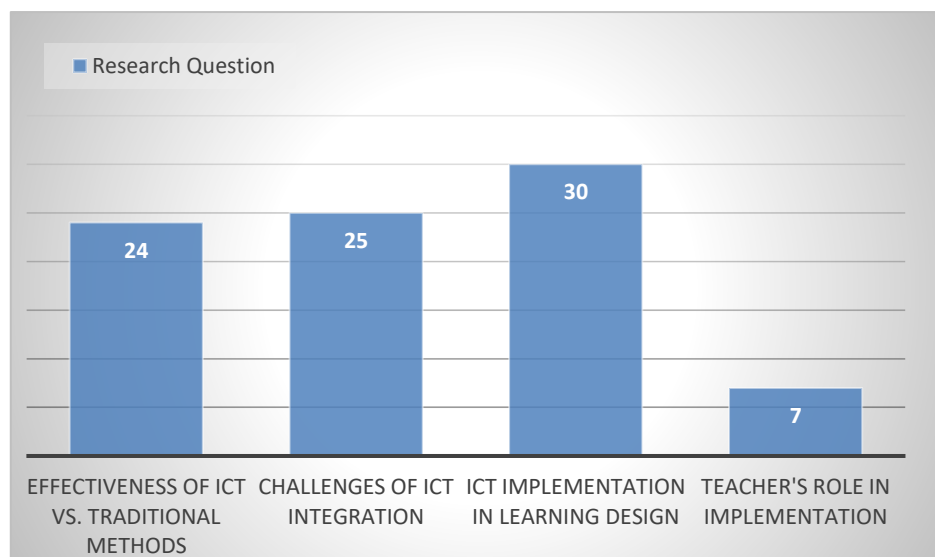


Figure 2. Distribution of Research Findings

The distribution of research findings reveals that ICT integration in instructional design has received the most substantial attention in the analyzed studies, followed by ICT implementation challenges and effectiveness comparisons with traditional methods. Meanwhile, teachers' role in ICT implementation, while critically important, remains relatively under-explored in the literature. This gap highlights the need for greater emphasis on teacher

empowerment and capacity building as key drivers of successful digital transformation in classrooms. Consequently, these findings underscore the urgency for education policies that not only provide technological tools but also equip educators with ongoing training, technical guidance, and sustained digital literacy development.

CONCLUSIONS AND RECOMMENDATIONS

This study confirms that the integration of Information and Communication Technology (ICT) in primary school literacy and numeracy instruction makes significant contributions to improving educational quality. ICT has been proven to enrich teaching strategies through more interactive, personalized, and contextual approaches. The utilization of digital media - including e-books, online learning platforms, educational applications, and project-based methods - enhances learning motivation, mastery of numeracy and literacy concepts, as well as students' critical thinking and collaborative skills.

On the other hand, the success of ICT implementation is significantly influenced by teachers' roles. Teachers' digital literacy and pedagogical knowledge serve as fundamental prerequisites for optimizing ICT utilization in classrooms. Educators with strong ICT skills tend to be more innovative in designing instruction and better able to adapt materials to individual student needs. However, challenges such as limited training opportunities, inadequate technical support, and resistance to technology adoption remain critical barriers that require immediate attention.

The effectiveness of ICT-based learning has been compared with traditional approaches, demonstrating superior outcomes in enhancing student engagement, information retention, and problem-solving abilities. This confirms that ICT-based methods represent not merely an alternative, but a more relevant potential solution aligned with 21st-century educational needs. However, persistent challenges including infrastructure disparities, the digital divide, and insufficient parental involvement remain critical issues in this transformation process.

Therefore, ICT integration in primary education is not merely a response to technological advancement, but a strategic imperative for building a more equitable, adaptive, and inclusive education system. Based on this study's findings, the recommendations include: (1) enhancing teacher competencies through practice-based training and pedagogical reflection; (2) investing in equitable digital infrastructure and resources; (3) developing curricula that incorporate digital literacy from early stages; and (4) actively engaging parents and communities in supporting technology-enhanced learning. Through this comprehensive and collaborative approach, sustainable and equitable literacy and numeracy learning goals can be achieved with full support from an educational ecosystem committed to children's digital future.

ADVANCED RESEARCH

This study has several limitations, including the focus on peer-reviewed articles published within the last five years, which may exclude valuable insights from earlier research or grey literature. Additionally, the analysis primarily

covers ICT integration in elementary schools, leaving gaps in understanding its application across other educational levels or specific demographic contexts. Future research could expand the scope to include longitudinal studies assessing the long-term impacts of ICT on literacy and numeracy outcomes, as well as qualitative investigations into teacher and student experiences with technology. Exploring the role of emerging technologies, such as artificial intelligence or virtual reality, in foundational education could also provide deeper insights into innovative pedagogical approaches. Addressing these areas would further enrich the discourse on ICT's transformative potential in education.

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