



Information and Communication Technology (ICT) Integration: A Narrative Review of Learning Outcomes, Opportunities and Implementation Challenges in Tanzanian Pre-Primary Education

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Abstract : The study conducted a systematic review of empirical and policy literature to examine the role of Information and Communication Technology (ICT) in improving early literacy and numeracy in pre-primary education in Tanzania. The purpose of the review was to collect evidence on the impact of ICT use on the learning outcomes of young children, learner engagement, teacher preparedness, and equitable access to ICTs. The information was collected using a systematic narrative review methodology using peer-reviewed journal articles, policy documents and empirical studies. Literature was collected from Scopus, ERIC, Google Scholar and publications by national and internationally recognised organisations. A structured matrix of data was used to extract data, and thematic analysis was used to synthesise data. Four themes were identified that are interlinked: ICT and early literacy and numeracy; learner engagement and social interaction; teacher preparedness and professional development; infrastructure and equity considerations. The results revealed that the use of ICT in developmentally appropriate play-based pedagogies has significant impact on children's phonological awareness, vocabulary, counting skills, and number sense. Interactive digital tools can also encourage student engagement and creativity, and facilitate collaborative learning. However, teachers' pedagogical skills, teachers' constant professional growth, school leadership and infrastructure are critical factors to the effectiveness of the use of ICT. The factors that were revealed as constituting limitations were teacher readiness, access to digital resources, reliability of connectivity, and gaps between urban and rural schools. The review also shows that there is a disconnect between the national aspirations for the use of ICTs and their use in classrooms, especially in resource-limited settings. The study therefore concluded that effective ICT integration requires a balanced approach combining appropriate processes, and conducting empirical studies at the classroom level to provide evidence of effective ICT-based learning in pre-primary education in Tanzania. Based on the findings, the study recommended that investments in teachers' capacity, equity of infrastructure, strengthening monitoring and evaluation.

Keyword : ICT integration; Pre-primary education; Early literacy and numeracy; Digital learning; Teacher preparedness

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INTRODUCTION

The rapid digital transformation associated with the Fourth Industrial Revolution has fundamentally reshaped educational systems worldwide, compelling education systems to reconsider how digital technologies can support equitable and quality learning across all levels of education. Various governments are struggling to think about how to impart young people with the knowledge, skills and digital competencies that they need to engage in a society that has become dependent on technology. Internationally, organisations such as UNESCO, UNICEF, OECD and the World Bank have called for embedding digital technologies meaningfully in education in order to foster equality of access, enhance the quality of learning, and equip learners for the digital age. However, these groups also warn that technology is not a tool that is effective for improving learning outcomes, but it is dependent on the use of pedagogies that suit the technology, teachers' competence, alignment of curriculum and conducive learning environments. These frameworks share the common goals, all dealing with promoting meaningful use of ICTs, but have varying emphases. UNESCO highlights teacher expertise, OECD is on child development and pedagogical quality, while the European Commission has a focus on digital ecosystems and infrastructure. These models collectively indicate that the successful use of ICTs is dependent on

technology investment and pedagogical preparedness.

Information and Communication Technology (ICT) is considered one of the most important drivers of educational innovation in the world, which has the potential to change the paradigms of teaching and learning at all levels of education. Digital technologies have rapidly developed which has engendered expectation that ICT will improve the quality of education in the future, by creating more interactive, flexible and learner-centred learning environments. However, divergent views from the international evidence on the educational value of ICT. Despite the dissimilarities in opinions, evidence concerning positive outcomes for children's motivation, engagement, literacy development, and problem-solving skills have been reported (Zuo et al., 2025a), there is also some research suggesting that the benefits are limited rather than generalizable. OECD (2021) and UNESCO (2023) warn that poorly-designed digital interventions, excessive screen time, and insufficient pedagogical support can have negative impact on children's cognitive and socio-emotional growth. The conflicting results indicate that effective use of technology is not just a function of the technology itself, but its usage within the context of a pedagogical approach that is developmentally appropriate.

There are several international frameworks guiding the countries to

integrate ICT into education. UNESCO's ICT Competency Framework for Teachers (2018) has emphasized the need for teachers to acquire competencies in curriculum design, pedagogy, assessment, professional learning and digital citizenship, for the effective integration of ICT in the teaching and learning process. Similarly, the OECD Starting Strong VII framework encourages a balanced approach to digital technologies in early childhood settings, highlighting the importance of play-based learning, child welfare, and active teacher mediation (OECD, 2021). The European Commission's Digital Education Action Plan (2021-2027) emphasise building digital ecosystems and competencies across education system. These frameworks vary in focus, but have a shared understanding that technology should augment and not supplant quality pedagogy. While all these international agreements have the same goal of meaningful integration of ICTs, their priorities differ. The focus areas of UNESCO are teacher competencies and institutional capacity; those of OECD are child development and pedagogical quality; and those of the European Commission are digital transformation and building digital infrastructure. The differences indicate that the successful integration of ICT should be an intersection between technology investment, teacher preparedness, teacher development and effective pedagogy. This holistic view is especially

important in low-resource settings, where technology is not a direct means of ensuring better learning outcomes.

The experiences outlined in Sub-Saharan Africa highlight the opportunities and challenges in the implementation of ICT in Early Childhood Education (ECE). Some nations such as Rwanda, Kenya, South Africa and Ghana have scaled up their digital learning programmes to boost Literacy and Numeracy. However, the adoption is hampered by limited teacher digital competence, a lack of adequate infrastructure, inconsistent policy implementation and inequalities between rural and urban schools continue to exist (UNESCO, 2023). This makes ICT a continental policy priority, but the experiences of implementation of educational technology reforms reveal that they are still very context specific.

To promote the use of ICT in education in Tanzania, national policies have been advocating the use of ICT to enhance digital literacy and learning outcomes in basic education (including pre-primary) have been gaining momentum. The initiatives connect to the global and national initiatives focusing on the use of technology to improve access, quality and equity in education (Ministry of Education, Science and Technology-MoEST, 2022a; Mwalongo, 2025a). However, studies indicate that ICTs use in Tanzanian pre-primary schools is still ad hoc and restricted (Komba, 2023a; Tandika & Ndjijye, 2024). The challenges for

effective integration of ICTs include persistent problems like poor infrastructure, lack of adequate teachers' training and urban-rural disparity (Komba, 2023a; Tandika & Ndiujye, 2024). Tanzania has shown a strong policy commitment in educational digitalisation through the policy on Education and Training Policy (MoEST, 2014, 2023), the ICT in Education Strategy (MoEST, 2022b) and the National ICT Policy (MoEST, 2014, 2023), among others, which also emphasises the importance of digital literacy starting from early childhood education. The initiatives fall in line with SDG 4 and the African Union's Continental Education Strategy for Africa (CESA 2016-2025) which calls for equitable access to quality education with digital innovation. The current Tanzanian research shows conflicting results on the implementation of ICTs. For the reasons of limited classroom integration, Komba (2023b) found that infrastructure and resource limitations are the main problems, while Tandika and Ndiujye (2024) determined that the main problems are the teacher's lack of readiness and pedagogical competence. However, at urban private schools, Mwalongo (2025b) notes that parents' demand for learning through ICTs is also growing, indicating positive societal acceptance despite the challenges of the institutions. These studies together point to a need to consider the interaction of the ITC infrastructure, teacher competence, institutional leadership and policy

implementation, rather than any single element, for successful integration of ICT.

Although there's a growing literature on interculturalism and international literature on national minorities, there are a number of gaps. First, the current evidence has mainly been looked at from an angle of integrating ICTs into the primary and secondary education setting and not in the pre-primary setting, and therefore misses the unique characteristics of young children. Second, previous research mainly focuses on the individual parts of the integration of ICTs, including infrastructure, teachers' preparedness, or the learning outcomes without integrating these aspects into a holistic policy and pedagogical approach. Third, few reviews critically compare international ICT frameworks and their applicability in low-resource contexts, such as Tanzania. In Tanzania, there is therefore a lack of comprehensive evidence about how ICTs can be used in developmental, pedagogically sound, and contextually appropriate ways in pre-primary education.

In this context, the present systematic narrative review critically synthesises the recent empirical studies, policy documents, and international ICT frameworks in an attempt to assess the impact of the integration of ICTs on learning outcomes in the pre-primary education sector of Tanzania. In particular, the review examines evidence on early

literacy and numeracy development, learner engagement, teacher readiness, infrastructure and policy implementation, and examines lessons learned to draw out implications for equitable and sustainable incorporation of ICTs in Tanzanian pre-primary education.

LITERATURE REVIEW

ICT and Early Learning Outcomes

Recent meta-analyses and systematic reviews indicate that ICT has a positive effect on learning outcomes in early childhood, specifically language acquisition, emergent literacy, and foundational numeracy. The use of technology-based learning environments has proven to support vocabulary acquisition and phonological awareness, as well as letter recognition and early mathematical reasoning in developmentally appropriate and pedagogically appropriate ways (Zuo et al., 2025b; Herodotou, 2020). Interactive applications, digital storybooks and educational games allow for repeated practice, immediate feedback and individualized learning experiences, allowing young children to learn at their own speed and be motivated and engaged (Li et al. (2023). In addition to literacy and numeracy, there is recent evidence that ICT may also support other aspects of cognitive and socio-emotional development. Interactive digital environments promote problem-solving, critical thinking, memory, and executive

functioning skills by inviting children to explore, experiment, and make decisions. Further, good quality teaching programs help children develop creativity, imagination and collaborative learning through storytelling, simulations, puzzles and digital play activities that involve children working in groups and cooperatively with each other (Kucirkova & Flewitt, 2020a). These experiences are consistent with the contemporary pedagogies that view children's active learning, inquiry, and play as key to their whole child development. Although Zuo et al. (2025a) both report positive effects of ICT, Zuo et al. emphasise structured instructional programmes whereas Neumann highlights interactive digital applications. This suggests that pedagogical design rather than technology alone determines learning outcomes.

ICT has also shown great potential to support inclusive education in dealing with varied learning needs of young children. Children with learning difficulties or disabilities can access education through alternative means, such as assistive technologies and educational materials, including text-to-speech, interactive visuals, and adaptive learning platforms. These technologies can improve participation, communication and independence and minimise learning barriers. According to UNESCO (2023), there is a growing need for inclusive digital technologies

to ensure equitable access to quality early childhood education, especially in low- and middle-income countries where access to quality learning materials for early childhood development is limited. Moreover, the use of ICT can be used to enhance children's motivation and engagement in meaningful activities. In line with the findings of numerous studies, children are more likely to be involved, curious, and persistent learners when digital technologies are used alongside play-based learning (OECD, 2021; Darling-Hammond et al., 2020). Multimedia elements like quizzes, games, feedback with sound, and animation engage children and help the concept to become more familiar in multiple ways to their minds. This is especially important in the pre-primary years, where children are best engaged in learning through experience and the use of all their senses (Son, 2024).

Although these benefits have been documented in the literature, the value of ICT in education is always qualified by the use of the technology. Simple provision of digital devices does not guarantee better learning. Rather, positive impacts are shaped by teachers' pedagogical skills, quality of digital content, children's developmental readiness, adult support and the balance between digital and non-digital learning experiences (Herodotou, 2020; OECD, 2021). Other research indicates that too much or unsupervised use of screens, with a high level of passive screen use,

can have a negative impact on attention, social interaction, sleep quality and physical activity (World Health Organisation, 2019; Radesky, et al 2020). Therefore, researchers call for the developmentally appropriate integration of technology, mediated by teachers, and planned for effective learning outcomes, with a focus on hands-on, play-based learning. The effectiveness of the use of ICT is heavily reliant on the competency of the teacher and quality of instruction. When teachers have sufficient knowledge of digital pedagogical practices, they can more effectively pick the right educational applications, support children's collaborative learning, guide children's use of digital tools, and be more effective in using digital resources for larger learning objectives. On the other hand, underprepared teachers, limited teachers' professional development and weak technological infrastructure decrease the opportunity for ICT to have a positive impact on learning outcomes (UNESCO, 2023; Tandika & Ndijuye, 2024). Thus, teacher capacity development is a critical factor in the impartation of digital knowledge among children. In general, literature shows that ICT can have a powerful impact on the quality of early learning outcomes in cognitive, language, numeracy, social and creative fields as long as it is embedded in developmentally appropriate pedagogical practices. However, these benefits are dependent on effective instructional design, teacher

competence, and appropriate digital resources, as well as supportive learning environments. It is important to note that ICT must not be seen as a replacement for early childhood pedagogical approaches but as an additional resource to enhance children's learning experiences and develop the skills that support lifelong learning.

Theoretical Perspectives on ICT in Early Childhood Education

Understand the role of Information and Communication Technology (ICT) in the early childhood sector, a theoretical framework that explains the learning processes of young children and the impact of digital technologies on their learning should be employed. Constructivist, socio-cultural and ecological perspectives can be combined to offer a comprehensive approach to the study of ICT integration as they all view learning as an active process that is socially constructed and context-dependent, not a process of information acquisition. These theories are convergent on the active construction of knowledge by children, but however differ on how active learning takes place. Thus, they provide complementary explanations for both the learning values and limitations associated with ICT.

Piaget's constructivist theory provides one of the earliest foundations for understanding children's

interactions with digital technologies. Piaget (1952) proposed that children learn cognitively by constructing knowledge through their exploration, manipulation, experimentation and interaction with their environments. In this view, ICT is seen as having an educational value only if the use of ICT creates an active engagement with information, rather than a passive consumption. Children have the opportunity to test out ideas, solve problems, and get feedback on their work through interactive simulations, educational games, digital puzzles, and inquiry-based applications, which all promote the development of their cognitive skills. Constructivist theory has been criticised, however, for focusing on cognitive processes as the main focus of learning and neglecting the impact of social and cultural influences on children's learning experiences. Therefore, the view of ICT-supported learning can only be explained from Piaget's perspective, which is limited, specifically in a classroom situation in which teachers are the guide and the interaction among peers is very important.

The socio-cultural theory of Vygotsky (1978) is used to overcome this limitation by focusing on the importance of social interaction, the use of language, and culturally mediated experiences in shaping children's cognitive development. At the heart of this view is the notion of a Zone of Proximal Development (ZPD), where children learn new knowledge and

skills with the help of more knowledgeable adults or peers. In the context of technology-integrated learning, digital technologies become cultural tools that are used for sharing information, communication, collaboration, scaffolding and problem solving. The study shows that teacher-mediated digital storytelling, educational games and collaborative learning activities with children through the use of multimedia tools stimulate children's dialogue, reflection and knowledge construction in a cooperative way, which helps to develop children's language skills, creativity and higher-order thinking skills. Therefore, socio-cultural theory provides a wider explanation for the integration of ICTs than constructivism, as it emphasises that technology is not the source of learning but learning is realised through purposeful pedagogical mediations and meaningful social interactions.

Constructivist and socio-cultural theories are not contradictory theories; the contrast between individual and social learning processes is not intended to contradict each other. Rather, recent research in early childhood education indicates that they are complementary. Constructivism describes how children interact with digital environments to build their knowledge, while socio-cultural theory describes how digital learning is influenced by teachers, peers and culture. These perspectives come together to suggest that the use of

ICT in education needs to be embedded within pedagogies that are conducive to exploration and also promote interaction, dialogue and collaboration. This holistic theoretical view is supported by emerging research showing that digital technologies can be more educationally meaningful when integrated into guided, play-based and exploratory learning experiences rather than being treated merely as isolated instructional tools. For example, Samuelsson (2024) found that guided play with programmable robots promoted sustained engagement among young children, while teacher scaffolding and opportunities for free exploration provided complementary learning opportunities. Similarly, Hollenstein and Vogt (2024) demonstrated that teacher-guided pretend play supported children's agency and learning about digitalisation through modelling, scaffolding and sustained shared play. Digital play has been increasingly recognised as an influential pedagogical method in ECE and has been the focus of research since the theories were first introduced and the research has increasingly focused on digital play as an important pedagogical tool in Early Childhood Education. While previous studies tend to see technology as a possible threat to play, recent studies suggest a different view, suggesting that play that is supported by technology can augment opportunities for creativity and imagination, symbolic thinking and

problem solving when integrated with hands-on play. Interactive storytelling apps, role-playing games, coding and multimedia-making activities allow children to seamlessly navigate both the physical and the virtual world, building meaning by engaging with the world and each other. However, there is a lack of empirical evidence. Several studies show positive outcomes of digital play on cognitive engagement and language learning; however, there are also studies that suggest that there may be fewer opportunities for physical activity, face-to-face interaction and open-ended play if the digital play is poorly designed and/or the time spent is excessive. The conflicting results indicate that how digital play can be used for educational purposes is not as much about the technology itself, but rather about the quality of the pedagogical design, adult mediation, and developmental appropriateness (Kucirkova, 2021).

Other more recent theoretical perspectives have built on constructivist and socio-cultural approaches with the ecological and socio-material perspectives that claim the interaction with ICT is not separable from the context in which children get to learn. These philosophies take a different perspective on technology as a neutral instructional tool and consider learning as co-constructed with children, teachers, families, digital technologies, institutional practices and material resources (Kucirkova, 2021).

Additionally, teacher competence, parental support, school leadership, infrastructure, cultural expectations, policy environments and cognitive ability all play a role in the effectiveness of the use of ICT. This larger picture is especially important in Lower Middle-Income Countries (LMIC) where disparities in electricity, internet access, digital resources, and teacher professionalisation have a great impact on the possibilities of meaningful ICT use. Therefore, the success of implementing it relies on the availability of technology and also the development of supportive educational ecosystems to facilitate teacher and student use of digital materials.

Together, these theoretical lenses offer a comprehensive theoretical framework of ICT integration in early childhood education. They do, however, show some significant differences in their beliefs about the processes of learning. Constructivism is focused mostly of all on children's independent exploration, socio-cultural theory focuses on guided participation and collaboration, while the perspectives of the ecological and the socio-material theories expand the analysis to include institutional, cultural, and material environments that shape the practice of education. All these theories point in the same direction: the use of ICT should not preclude play-based and socially mediated learning, but, on the contrary, enhance them by providing well-designed pedagogical encounters that

reflect children's learning contexts and developmental needs. This integrated theoretical approach is especially relevant for countries like Tanzania where differences in technological infrastructure and teachers' preparedness are still considerable, giving a better perspective of opportunities and challenges encountered in integrating ICTs in pre-primary education. It highlights that investment in digital technologies is not enough; there is a need to build the capacity of teachers, support institutions and enact policies to ensure that ICTs are engagingly contributing to the holistic development of children.

ICT Use in Tanzanian Pre-Primary Contexts

Research on the integration of Information and Communication Technology (ICT) in pre-primary education in Tanzania remains relatively limited when compared to that of primary, secondary and tertiary educational levels. This imbalance is not new, as historically, ICT investments have been more at the upper levels of education, where digital literacy was considered more relevant to academic outcomes and workforce readiness (UNESCO, 2023). The current research, which focus on the potential of ICT in supporting child development in the early years of education has, however, led to growing recognition of the importance of early childhood education and raised the interest of scholars and policymakers

on how digital literacy through ICT can be used in pre-primary environments. Even with this increasing focus, empirical findings in Tanzania remain disjointed, with the majority of studies measuring teacher preparedness or infrastructure and comparatively little attention given to how these two could possibly influence children's learning experiences.

ICT has been gaining increasing attention within the policy context in Tanzania as an enabler for quality education and equitable learning opportunities. The Education Sector Development Plan (2021/22-2025/26) and the National ICT Policy (2025) recommend the use of digital technologies in all education levels to enhance the teaching and learning process and management of education (MoEST, 2022a). However, how these policy goals are enacted in classrooms has not been uniform. National policies have been more effective than implementation capacities, resulting in a constant policy-implementation gap, in line with results found in many LMICs (UNESCO, 2023; World Bank, 2020). The results are inconsistent, indicating that just commitment to policy is not enough for meaningful integration of ICT without investing in teacher capacity, infrastructure, and institutional support.

A key determinant that has been consistently reported to be crucial for the successful integration of the use of ICTs in Tanzanian pre-primary education is teacher competence.

Tandika and Ndijuye (2024) identified that, for many pre-primary teachers, the digital skills they possess are merely basic and opportunities for longer, practice-based professional development are limited. Teachers often feel inadequate when choosing developmentally appropriate digital resources, using technology in play-based instruction, and directing children's technology use while engaged in classroom activities. The results are similar to previous research by Lubuva et al (2022), which also revealed that teacher educators lack ICT competencies in general; hence, the weakness is not only from the schools but also from the ICT pre-service teacher education institutions. While both studies highlight the lack of digital competence as a significant factor, they stress it in different ways. While Lubuva et al (2022) identified a lack of institutional support in teacher education as the major problem, Tandika and Ndijuye (2024) identified the lack of continuous professional development after teacher induction. If taken together, these studies suggest that enhancing teachers' ICT competence must be done not only by means of initial teacher education but also by means of continuous professional development, rather than through a single training programme.

The evidence from other Sub-Saharan African countries is similar to this, but there are differences in the type and extent of the challenges to implementation. Successful integration

of ICTs in Africa is not only dependent on the technology, but also on the pedagogical skills of teachers, their leadership support, and their ongoing professional development. Likewise, Mulindwa and Ankwatse, (2025) revealed that technology investments often experience substandard educational results when the focus is on purchasing technology rather than changing the way instruction is delivered. Conversely, studies in Rwanda show that the adoption of ICTs is more sustainable and pedagogically significant when infrastructure is supported by systematic teacher training and a supportive national framework for implementation. This comparison does not suggest that Tanzania has technological deficits, but rather that there are systemic issues that need to be coordinated, including teacher development, school leadership, the alignment of the curriculum, and technical support.

In addition to teacher competence, infrastructural inequalities are still hampering the integration of ICTs in pre-primary schools in Tanzania. The World Bank (2020) and Komba (2023a) have all noted the lack of digital devices, unreliable electricity, weak internet connectivity, and lack of technical maintenance, especially at public and rural schools. The findings concur that there are infrastructure deficits, but they disagree on the consequences of the deficit. The World Bank (2020) mainly addresses these challenges as a

resource allocation problem stemming from a wider set of development constraints at the national level, while Komba (2023a) focuses on variations in the implementation capacity and institutional management of development projects at the local level. The complementary views indicate that if the provision of hardware is to be increased, equitable integration of ICTs is unlikely to be achieved without sustainable funding, technical support systems, and school-level management capacity. If ICTs are not implemented in a coordinated fashion, there is a possible risk of exacerbating inequalities between urban and rural schools, instead of assisting in the reduction of these inequalities.

Interestingly, despite these structural limitations, there is a growing demand for learning with ICTs from parents, teachers and stakeholders in learning. Mwalongo (2025b) indicates that parents, especially in urban areas and private schools, have become more aware of the importance of ICT competence as a key factor in quality early childhood education and future educational achievement. EdTech Hub (2022) also found that relatively low-cost digital infrastructure investments, coupled with teacher mentoring and pedagogical support, can significantly enhance children's engagement, participation, and collaboration in learning. These results seem to contradict research highlighting the broad-based implementation obstacles.

The results, however, do not give contradictory evidence; rather, they indicate that it is possible to integrate ICTs within a context that is systematically dealt with. Localised pilot programmes have then provided a good illustration of the potential effectiveness of targeted interventions, but also of the challenges of scaling up such interventions for a variety of educational contexts with unequal resource availability.

The literature available in Tanzania also has some methodological shortcomings. The evidence that is available comes largely from qualitative case studies or small-scale institutional surveys, or from implementation projects based in a local context, which offer good contextual detail but limited opportunities for national generalisations. Also, a significant number of studies are based on the self-reported perceptions of teachers about ICT competence and practices; few studies have focused on actual classroom use, children's learning outcomes or on examining changes in ICT integration over time. Consequently, there is a lack of consistency and overall picture of the situation, and it is uncertain if the problems reported are local or national. The methodological weaknesses of the study highlight the importance of more in-depth research and/or mixed approaches that are able to capture the multi-faceted nature of the relationship between the competence of teachers,

infrastructure, leadership, policy implementation and children's learning experience.

METHODOLOGY

The study employed systematic narrative review to synthesize and critically evaluate the literature on the use of Information and Communication Technology (ICT) in the early childhood and pre-primary education in Tanzania. The review was systematic to identify, screen, and synthesize relevant evidence and to provide context for interpreting findings from Tanzania and similar low-resource settings. Peer-reviewed journal articles, policy documents and empirical studies published were identified from Scopus, ERIC, Google Scholar and publications of recognised national and international organisations. The studies included those that focused on either early childhood or pre-primary education and included empirical or policy evidence from Tanzania or similar Sub-Saharan African context. Studies that were either not empirical or did not have policy evidence were not included as were studies that addressed other education levels.

A structured data extraction matrix was developed to extract data on study characteristics, ICT interventions, learning outcomes, teaching practices, teacher preparedness, infrastructure, and key findings. Extracted data was synthesized using thematic analysis in

which the evidence was coded and grouped into themes to establish pattern, similarities and differences, and gaps in the research between the included studies. In order to maintain methodological rigor, strict and predetermined inclusion and exclusion criteria were consistently adopted and evidence was sourced from trusted peer-reviewed publications as well as official policy documents. Ethical approval was not required as it was only secondary data, but academic integrity was achieved by representing the findings accurately and citing all sources properly.

FINDINGS AND DISCUSSION

This section consolidates findings from the reviewed literature on integrating Information and Communication Technology (ICT) in pre-primary education. The reviewed studies clearly converged on four interrelated themes: (i) ICT and early literacy and numeracy, (ii) learner engagement, creativity and social interaction, (iii) teacher preparedness and professional development, and (iv) infrastructure and equity considerations.

ICT and Early Literacy and Numeracy

The literature reviewed found that there is a positive relationship between the effective use of ICTs in early childhood education and the improvement of early childhood literacy and numeracy that occurs when the ICTs are used appropriately,

based on early childhood teaching principles. Studies in various settings have found that interactive digital resources with multimodal elements (sounds, animation, visual cues, and direct feedback) can be utilised to develop letter-sound awareness, vocabulary, counting, and number sense (Goldstein et al., 2024; Zuo et al., 2025a). The findings showed that there was congruence between the constructivist and sociocultural learning approaches, which focus on the involvement of children and sense-making. Zuo et al. (2025b) found that interactive applications have significant effects on literacy development, but that ICTs are best integrated into well-designed instructional programs.

These complementary results suggest that technology is not enough, and the pedagogical issues need to be addressed and resolved. The majority of the studies are consistent in stating that the use of ICT enhances learners' engagement, while there are some differences regarding the type of technologies that are more effective. The collaborative digital play is motivating but meaningful engagement is facilitated through teacher mediation (Vanbecelaere et al., 2023). This divergent perspective indicates that, though access to technology may enable children's engagement, it is also contingent on the design of the digital experiences within learning activities in the classroom. The results reported across the reviewed

studies suggest that ICT can positively contribute to early literacy and numeracy development, although the magnitude and consistency of the effects vary across interventions. Digital and tablet-based interventions have demonstrated improvements in skills such as phonological awareness and other foundational literacy competencies. However, recent evidence indicates that learning outcomes depend not merely on access to digital technology but on how it is pedagogically designed, scaffolded and integrated into structured learning experiences (Goldstein et al., 2024; Vanbecelaere et al., 2023). Thus, differences in learning outcomes may be attributed more to the quality of pedagogical integration than to the technology itself. Pedagogy: research indicates that the use of ICT to support and enhance play as opposed to replacing it is more successful. Research evidence indicates that using a combination of digital and storytelling, songs, manipulatives and guided play provides children with opportunities to learn and practise concepts in different ways and multiple times (OECD, 2021). This will be supported with teaching, which plays a significant role as it will relate a digital representation to experience, supporting early numeracy and literacy learning. This result supports constructivist points of view, which state that technology must not be used instead of children's active exploration and play (Piaget, 1952; Vygotsky, 1978).

Therefore, ICT can play its best role in pedagogies of play in which it is not used in isolation but as an instrument to replace the teacher-child interaction. Despite these benefits, some research has highlighted the potential for restricted opportunities for children's imaginative play when they have too much screen time unless there is a careful balance between screen time and hands-on experiences (OECD, 2021; UNESCO, 2023). This means that, when ICT is used to supplement, rather than drive early childhood learning, there is more creativity. Policies support discussion on the use of ICT in Tanzania's pre-primary education system, pointing out the inconsistency in the use of ICT in the educational system at the pre-primary level. Analysis of available evidence reveals that increased literacy and numeracy outcomes are mainly in urban and private schools where teachers can access more devices and digital resources and training (Mwalongo, 2025a). However, in other rural public schools, a few schools have low progress, and some schools haven't progressed at all because of inadequate infrastructure and teacher support. This variant has shown that teachers' competence is as important as the tools, coverage, and availability of the curriculum in learning outcomes by using ICTs.

However, there is little empirical data that have been analysed to examine outcomes of pre-primary learning in Tanzania. The literature

reviewed is more on the intent and implementation of the policy, with little evidence from classrooms, which means there is a need for more intervention studies to be conducted in the country of Tanzania. The literature examined indicates that the use of ICT is most likely to support students' involvement in learning, to encourage students' creativity and to promote social interaction when they are used in collaborative, developmentally appropriate learning that is led by the teacher.

Learner Engagement, Creativity, and Social Interaction

Results in the literature clearly demonstrate the positive impact of integrating ICT in pre-primary education, particularly by incorporating digital tools in play and inquiry-based pedagogies. Research shows that interactive apps, digital storytelling platforms, and multimedia content can engage children's attention, foster curiosity and interest, and encourage them to actively learn, rather than passively absorb information (Samuelsson, 2024). The findings have implications for early childhood education policies that focus on all aspects of childhood development through exploration and play. Most studies find that the use of ICT results in greater student engagement, but some studies have identified various types of technology that can have the most impact. These conflicting viewpoints suggest that children's

involvement with technology is not only a matter of access, but one of the organisation of digital experiences in classroom activities.

The literature goes beyond engagement, and highlights the role of ICT in fostering creativity and symbolic thinking, particularly when children are creating digital content. Engaging in activities like creating stories, drawings and simple multimedia projects has been shown to enrich imaginative play and enhance meaning-making, especially when digital, physical and social play are combined (Kucirkova & Flewitt, 2020). However, the creative outcomes of these activities are more or less dependent on the design of pedagogy and the way these activities are introduced and carried out by teachers. Although there are advantages, there are concerns that having too many screen-based activities may reduce opportunities for imaginative play, a concern echoed by several studies, which recommend a balance of such activities with hands-on learning experiences (OECD, 2021; UNESCO, 2023). This indicates that when ICT is used but not overused, it enhances creativity in learning activities for the early childhood sector. Research indicates that collaborative use of ICTs helps to promote social interaction, communication and cooperative learning, from a sociocultural standpoint. When children join in with others (partner or group) and teachers in digital activities, they are exposed to

turn-taking, conversation, and cooperative problem-solving. These social interactions are especially crucial in pre-primary education because social and cognitive development go hand-in-hand. However, there are concerns in the literature that individualised or unsupervised use of ICTs with drill-and-practice-type apps or too much screen time will limit opportunities for interaction and creativity (OECD 2021). This is a particular challenge in low-resource settings such as Tanzania where small teachers' training programs and large class sizes affect the utilisation of ICTs. The literature reviewed suggests that the use of ICT in the classroom, when integrated into a collaborative learning model with a teacher as facilitator, and within a developmentally appropriate setting, fosters learner engagement, creativity, and social interaction best.

Teacher Preparedness and Professional Development

One of the factors that influences the effectiveness of the application of ICT in pre-primary education is teacher preparedness. The findings from Tanzania indicate that preschool teachers are not confident in their ability to use ICTs in their teaching, because they are not adequately trained and experienced in the use of developmentally appropriate ICT teaching strategies (Tandika & Ndijuye, 2024). Therefore, the use of ICTs is limited or occasional, and they are mostly used for administrative and

demonstration purposes and not fully integrated in daily teaching and learning processes.

The study findings reveal that pedagogical ICT competence of pre-primary teachers is low mainly due to lack of ICT professional development and the limited institutional support (Komba, 2023b). Studies highlight the need for teacher competence as a major challenge, though they focus on different aspects of competence: one on pedagogical competence and the other on organisational barriers. These studies collectively indicate that both teacher preparation and supportive school environments are needed to improve teacher preparedness. Also, there is a gap between policy expectations and teacher training practice, as noted in the literature. While national and international policies encourage pedagogical use of the ICTs, the training programmes of pre-service and in-service teachers generally emphasise technical skills more than pedagogical applications (UNESCO, 2023). This disparity inhibits teachers' ability to align digital tools and activities with curriculum objectives, students' needs, and principles of early childhood development. The results show the continued gap between the educational use of national ICT policies and the classroom. While policy documents celebrate the potential of technology-enhanced learning (MoEST, 2022a; UNESCO, 2018), sustained professional learning is not adequately funded, and

this hampers teachers' capacity to turn policy expectations into effective learning with technology.

Research across multiple settings has shown that there is a better response to continuous, hands-on, professional learning than to one-off training sessions. Practical training, mentoring, peer collaboration, and reflection activities boost teachers' confidence and teaching skills, particularly when supported by strong leadership and clear policies (OECD, 2021). Therefore, improving the readiness of teachers through ongoing professional development is essential in Tanzania to optimise the use of investments in ICTs to achieve impact on early education outcomes.

Infrastructure and Equity Considerations

Infrastructure limitations are frequently cited in the literature as key obstacles to successful ICT integration in Tanzanian pre-primary education. Studies highlight issues like insufficient digital devices, unreliable electricity, poor internet connectivity, and inadequate technical support, all of which hinder consistent and meaningful use of ICT in teaching (Komba, 2023a; World Bank, 2020). These challenges often lead to superficial or sporadic ICT activities, thereby diminishing their potential benefits for learning. The reviewed literature consistently demonstrates that infrastructure challenges disproportionately affect rural schools.

Unlike urban schools, rural institutions often experience unreliable electricity, weak internet connectivity, and limited access to digital devices (World Bank, 2020; UNESCO, 2023). Consequently, geographical location remains an important determinant of ICT implementation.

Equity issues are central to the discussion, highlighting clear disparities between urban and rural schools and between public and private institutions. Children in under-resourced environments have considerably fewer opportunities to access ICT-supported learning, raising fears that poorly implemented ICT initiatives could worsen existing educational inequalities rather than address them (MoEST, 2022a). This directly challenges policy aims for inclusive and equitable quality education. Although, Tanzania's ICT policy seeks to promote equitable access, implementation has progressed unevenly because resource allocation often favours urban areas. Similar disparities have been documented across Sub-Saharan Africa, suggesting that infrastructure investment alone is insufficient without complementary teacher support and sustainable financing mechanisms.

The literature emphasizes promising context-sensitive strategies for low- and middle-income countries, such as affordable devices, offline digital content, shared-use models, and community-supported infrastructure. When paired with teacher training and

inclusive policies, these can lead to more equitable learning outcomes (OECD, 2021; EdTech Hub, 2022). In Tanzania, it is essential to address infrastructure and equity together to ensure ICT integration fosters inclusive, high-quality pre-primary education, rather than widening existing gaps. Therefore, improving ICT integration requires coordinated investment in infrastructure, teacher capacity, curriculum alignment, and institutional support rather than isolated technology provision.

Policy and Practice Implications

This study underscores key policy and practice considerations for effectively integrating ICT into Tanzanian pre-primary education. Based on the evidence reviewed, the implications centre on three interconnected areas: enhancing teacher training and professional development, upgrading ICT infrastructure and ensuring equitable access, and aligning ICT use with play-based learning methods. Tackling these aspects together is crucial to ensuring that ICT effectively supports early literacy, numeracy, and overall child development, while avoiding the reinforcement of existing inequalities. The results highlight the importance of policies that go beyond mere technology provision, focusing instead on pedagogical quality, teacher capacity, and relevance to the local context in early childhood education (UNESCO, 2023; OECD, 2021).

Strengthening Teacher Training

The review highlights teacher readiness as essential for successful ICT integration in early childhood education. It shows that many pre-primary teachers in Tanzania lack the confidence and skills necessary to use ICT effectively, mainly because their training focuses more on basic technical skills than on instructional use (Tandika & Ndijuye, 2024a). To bridge this gap, future policies should emphasize ongoing, pedagogy-focused professional development that helps teachers incorporate ICT into play-based, child-centered learning settings.

Both pre-service and in-service teacher training programs should integrate ICT pedagogy as a fundamental part of early childhood education. This involves enhancing teachers' ability to choose suitable digital tools, create blended learning experiences, and support children's learning through guided technological interactions (UNESCO, 2018; OECD, 2021). Training must clearly connect ICT use with curriculum objectives for early literacy, numeracy, and socio-emotional skills, ensuring consistency between policy expectations and classroom implementation.

At the policy level, there should be a greater focus on practice-based professional development models that integrate hands-on training, mentoring, classroom coaching, and peer collaboration. Evidence from low- and middle-income settings indicates that

such ongoing approaches are more successful than single workshops in enhancing teacher confidence and instructional quality. Building stronger partnerships among government ministries, teacher training institutions, and development partners is crucial for expanding these initiatives and ensuring they align with national education and ICT policies, including Tanzania's Education and Training Policy and ICT in Education frameworks (MoEST, 2014, 2023; MoEST, 2022b).

Improving Infrastructure and Access

The study emphasizes that infrastructure and access remain major obstacles to equitable ICT integration in Tanzanian pre-primary education. Policy initiatives should focus on ongoing investments in infrastructure tailored for early childhood settings. This involves supplying age-appropriate digital devices, ensuring a stable electricity supply, and implementing appropriate connectivity solutions, especially in rural and underserved regions where access is still limited (Komba, 2023b; World Bank, 2020).

To promote sustainability and cost efficiency, policymakers should adopt flexible, context-aware technology solutions like shared devices, offline digital content, and low-bandwidth apps. Evidence from comparable low-resource environments indicates these strategies can greatly improve access while

lowering costs and complexity (EdTech Hub, 2022). Additionally, long-term infrastructure planning must include maintenance, technical support, and replacement plans, as neglecting these aspects often leads to rapid deterioration of ICT resources.

Enhancing infrastructure demands coordinated efforts among government agencies, local authorities, school communities, and development partners. Improving accountability systems and increasing community participation can boost ownership and ensure the sustainability of ICT initiatives. Additionally, national ICT and education strategies must explicitly prioritize pre-primary education, supported by well-defined monitoring and evaluation frameworks to avoid increasing digital inequalities across regions and between public and private schools (MoEST, 2022a; UNESCO, 2023).

Aligning ICT with Play-Based Learning

The findings highlight that ICT initiatives in early childhood education should be based on play-based pedagogical principles. Digital tools are meant to enhance and support play, exploration, and inquiry, not replace hands-on learning. This aligns with Tanzania's early childhood curriculum and global early learning frameworks, both of which emphasize holistic, child-focused development (MoEST, 2016, 2023; OECD, 2021).

Curriculum guidelines should clearly specify how to incorporate ICT into play-based activities like storytelling, role-play, music, creative arts, and teamwork. Research shows that when digital tools are used in open-ended and interactive ways, they enhance creativity, language skills, and social interactions among young children (Kucirkova & Flewitt, 2020). Therefore, teachers need clear guidance and practical examples of blended learning approaches that effectively combine digital and traditional resources in ways suitable for children's developmental stages.

Professional development programmes need to cover key issues such as managing screen time, choosing culturally relevant and age-appropriate digital content, and balancing structured and unstructured play. At the policy level, clear pedagogical guidance is essential to ensure ICT integration supports, rather than hinders, holistic child development and culturally responsive learning in Tanzanian pre-primary education (OECD, 2021; UNESCO, 2018).

CONCLUSION

This systematic review findings concludes that ICT has great potential in promoting early literacy and numeracy in Tanzania pre-primary education when applied through the developmentally appropriate and play-based pedagogical approaches. The review shows interactive digital tools

can be used to improve children's literacy and numeracy skills, engagement and participation. However, pedagogical competence of teachers, sufficient professional development, conducive learning environments, and equitable access to ICT infrastructure are crucial to the effectiveness of ICT. This review also conclude that certain problems such as under-qualified teachers, substandard infrastructure and urban/rural disparities remain to be a major obstacle in the effective use of ICTs. It is therefore important to develop meaningful and effective ICT-supported learning through a coordinated effort to support the capacity building of teachers, access to infrastructure and the contextual relevance and inclusion of the use of ICT.

Recommendations

There is need to bolster the use of the ICTs in pre-primary education through: Providing guidelines for the implementation of the use of the ICTs; allocating resources for the provision of equitable infrastructure for the use of ICTs, especially in the rural areas; and creating ICT monitoring and evaluation mechanisms. Teacher education institutions and education authorities need to improve pre-service and in-service training with emphasis on pedagogical integration of ICTs in play-based learning and mentoring and continuous professional development. School should encourage more blended

learning models that integrate digital technologies into the play-based learning, with directions for digital content and screen time management. Further investigations and research are needed on the effects on early literacy and numeracy of using ICT interventions and teachers' experiences and challenges in implementing ICT, especially in rural and resource-constrained contexts.

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