Integrating Robotics in Early Childhood Development Classrooms: Exploring Pedagogical Opportunities and Challenges in Zimbabwean Contexts

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ABSTRACT

This study critically investigates the integration of robotics within Early Childhood Development (ECD) classrooms in Zimbabwe, with the primary aim of exploring both the pedagogical opportunities and the practical challenges associated with its implementation. Employing a qualitative research design, the study collected data through semi-structured interviews with ECD educators and direct classroom observations, allowing for an in-depth understanding of teacher experiences, instructional practices, and learner interactions with robotic tools. The findings reveal that the incorporation of robotics in early learning environments significantly enhances learner engagement by capturing attention and sustaining motivation, while simultaneously promoting the development of critical thinking, problem-solving, and collaborative skills among young children. Educators observed that robotics activities provide a dynamic, hands-on platform for experimentation and exploration, aligning with constructivist and sociocultural approaches to learning. Despite these benefits, the study identifies considerable barriers to effective integration, including insufficient teacher training in robotics pedagogy, limited availability of appropriate technological resources, infrastructural challenges such as inconsistent electricity supply, and inadequate institutional support. The study underscores the necessity of comprehensive professional development programs that equip educators with the skills and confidence to effectively implement robotics-based learning, coupled with targeted policy interventions and investment in educational technology infrastructure to ensure equitable access and sustainable integration. These findings provide critical insights for policymakers, school administrators, and educators seeking to leverage robotics to enrich early childhood education in Zimbabwe and similar resource-constrained contexts.

Key Terms: Robotics, Early Childhood Development (ECD), Pedagogy, Technology Integration, Zimbabwe

INTRODUCTION

Early Childhood Development (ECD) is widely recognised as a foundational stage for lifelong learning and cognitive development (UNICEF, 2019). In recent years, educational technologies such as robotics have emerged as tools capable of enriching teaching and learning experiences by promoting active participation, collaboration, and computational thinking (Benitti, 2012). While developed countries have progressively adopted robotics in early learning environments, resource-limited settings like Zimbabwe are only beginning to explore its potential. There is a pressing need to understand how robotics can be effectively integrated into ECD classrooms to enhance pedagogical practices while addressing contextual challenges.Despite global enthusiasm for robotics in education, there remains a significant gap in literature focused on its implementation at the early childhood level within Zimbabwean contexts. This study investigates the pedagogical opportunities and challenges associated with robotics integration in ECD environments, offering insights that may inform policy, professional development, and practice.

Background of the Study

Educational robotics has gained increasing attention worldwide as a means of enhancing early childhood learning experiences by fostering cognitive, social, and STEM-related competencies. Research in diverse international contexts has shown that robotics and coding activities in early childhood settings can support

problem-solving, computational thinking, and executive functions such as planning and cognitive flexibility in preschool children, particularly when activities are designed to be developmentally appropriate and interactive. For instance, studies involving programmable educational robots like Bee-Bot have found significant improvements in spatial reasoning and collaborative skills among young learners exposed to structured robotics activities compared to traditional instructional approaches, highlighting the pedagogical potential of robotics for early learners (Metin, 2022; Arfé et al., 2019; Di Lieto et al., 2020; as reviewed in Metin, 2022). These global findings situate robotics not merely as a technology tool, but as a means to support active, play-based learning that aligns with constructivist pedagogies and 21st century skill development frameworks increasingly adopted in contemporary early childhood education research.

At the continental level, African countries are also experimenting with robotics in educational settings, although adoption remains uneven due to contextual constraints. In Nigeria, private EduTech initiatives have introduced robotics kits in preschools to enhance cognitive and social development, demonstrating tangible gains in spatial reasoning and teamwork among young learners, yet scalability is limited by high costs and insufficient teacher training in many regions (ConnectNigeria, 2025). In East Africa, despite the presence of NGO-led initiatives such as Africa Code Week and mobile coding workshops in Kenya and Rwanda, these efforts often struggle to achieve systemic impact due to limited infrastructure, inconsistent electricity supply, and inadequate professional development for educators, reflecting broader digital divide challenges within the continent (Muriithi et al., 2019; Chigona, 2019; as summarised in Madyembwa et al., 2025). This continental evidence suggests that while African education systems recognise the potential benefits of robotics for early learners, structural barriers and resource inequalities significantly shape the feasibility of sustained and meaningful integration.

Within Southern Africa, evidence further emphasizes both the opportunities and ongoing challenges associated with integrating technology into early years education. Research from South Africa, for example, highlights that robotics and play-based technologies can enhance early mathematics and computational learning, yet successful implementation is contingent on extensive, sustained teacher training and professional support. Studies in foundation phase classrooms found that limited practical training, insufficient follow-up support after initial workshops, and time constraints reduce teachers' capacity to effectively use play-based robotics strategies in learning activities (Journal of Education, 2025). These findings mirror broader regional concerns that without structured professional development and supportive policy frameworks, educators may be unable to translate robotics initiatives into improved pedagogical practices, reinforcing the need for context-specific capacity building across Southern African education systems.

In the Zimbabwean context, the integration of robotics and related ICTs into Early Childhood Development (ECD) education is emerging alongside national policy shifts and grassroots initiatives, yet remains under-researched and uneven in practice. National reforms, including the Education 5.0 vision and revised curriculum frameworks, advocate for digital literacy and future-ready skills such as coding and robotics even at the ECD level, reflecting a governmental commitment to equipping learners for a technology-driven future (Business Daily News Zimbabwe, 2025; Madyembwa et al., 2025). Initiatives such as the *Robotics for Every Child (REACH)* STEM outreach program demonstrate efforts to engage thousands of Zimbabwean children with hands-on robotics learning and teacher "train-the-trainer" models to build educator capacity (Institute of Entrepreneurs Zimbabwe, 2025). Nevertheless, research on ICT integration in Zimbabwean ECD settings consistently highlights persistent challenges

Research Objectives and Questions

This study aims to:

i. Explore the pedagogical opportunities presented by the integration of robotics in ECD classrooms in Zimbabwe.

ii. Identify the challenges faced by ECD educators when implementing robotics in their teaching.

iii. Provide recommendations for supporting effective use of robotics in early childhood education.

The research was guided by the following questions:

i. To examine the pedagogical opportunities and benefits associated with the integration of robotics in Early Childhood Development (ECD) classrooms in Zimbabwe, focusing on learner engagement, critical thinking, and collaborative skills.

ii. To identify and analyse the challenges and barriers faced by ECD educators in implementing robotics-based teaching, including issues related to teacher preparedness, resource availability, and infrastructural constraints.

iii. To propose evidence-based recommendations for enhancing the effective integration of robotics in ECD settings, encompassing professional development, policy interventions, and investment in educational technology infrastructure.

REVIEW OF LITERATURE

Pedagogical Opportunities of Integrating Robotics in Early Childhood Development Classrooms

At the global level, the integration of robotics in Early Childhood Development (ECD) education has increasingly been recognised as a transformative pedagogical approach capable of enhancing holistic child development. Educational robotics has been widely adopted in early learning systems across Europe, Asia, and North America as a means of fostering cognitive growth, creativity, and social interaction through play-based and experiential learning. Research from technologically advanced education systems demonstrates that robotics enables young learners to engage actively with abstract concepts through tangible manipulation, supporting deeper understanding and sustained engagement (Bers, 2018; Eguchi, 2019). Robotics activities are often embedded within inquiry-driven curricula that encourage exploration, experimentation, and reflection, aligning closely with contemporary early childhood pedagogical principles that prioritise learner agency and meaningful engagement. These global practices position robotics as more than a technological innovation, framing it instead as a pedagogical tool that supports early learning through developmentally appropriate, hands-on experiences.

Extensive international research further highlights the role of robotics in supporting foundational cognitive skills among young children, particularly in relation to problem-solving, logical reasoning, and early computational thinking. Studies conducted in preschool and kindergarten settings have shown that age-appropriate robotics tools help children develop sequencing skills, cause-and-effect reasoning, and planning abilities through structured yet playful activities (Kazakoff & Bers, 2014; Sullivan & Bers, 2016). These skills are increasingly regarded as essential competencies for participation in digitally mediated societies. Moreover, robotics-based learning environments promote perseverance and resilience, as children are encouraged to test ideas, make mistakes, and refine solutions iteratively. Such learning processes align with constructivist approaches to early education, reinforcing the view that robotics supports cognitive development while respecting the developmental needs and learning styles of young children.

Beyond cognitive outcomes, global literature emphasises the social and emotional benefits associated with robotics integration in early childhood classrooms. Robotics activities often require collaboration, turn-taking, communication, and shared decision-making, thereby fostering social interaction and cooperative learning among young learners (Bers & Tu, 2021). Research indicates that when children work in small groups to complete robotics tasks, they develop social competencies such as empathy, negotiation, and peer support. These interactions are particularly valuable in ECD settings, where socialisation and emotional development are central educational goals. By encouraging collaborative engagement, robotics creates inclusive learning environments where children learn with and from one another, reinforcing the social dimension of learning that is fundamental to early childhood education.

Within the broader African context, the literature reflects growing interest in the use of educational technologies, including robotics, to improve teaching and learning outcomes, although implementation remains uneven. Studies from various African countries suggest that robotics has the potential to enhance learner engagement and promote STEM-related skills from an early age, particularly when integrated through play-based approaches

(Chigona, 2019; Muriithi et al., 2019). However, these studies also highlight persistent challenges, including limited access to technological resources, inadequate infrastructure, and insufficient teacher training. In many African ECD settings, the successful adoption of robotics is constrained by systemic inequalities and resource limitations, which influence how technology is accessed and utilised in early learning environments. As a result, while the pedagogical potential of robotics is widely acknowledged, its practical implementation remains context-dependent.

Evidence from Southern Africa, particularly South Africa, provides further insights into both the opportunities and constraints associated with robotics integration in early childhood education. Research conducted in foundation phase classrooms indicates that robotics can support learner-centred and constructivist pedagogies, enabling children to learn through exploration and collaboration (Mtebe & Raisamo, 2014). However, these studies also reveal that the effectiveness of robotics integration is closely linked to teacher preparedness, ongoing professional development, and institutional support. Educators often express positive attitudes towards technology but report limited confidence in using robotics pedagogically due to insufficient training and lack of clear curricular guidance. These findings suggest that without sustained support structures, the pedagogical benefits of robotics may not be fully realised in early childhood contexts.

In the Zimbabwean context, literature on robotics integration in Early Childhood Development classrooms remains limited, despite national education policies that advocate for the incorporation of ICTs to enhance learning outcomes (Ministry of Primary and Secondary Education, 2017). Existing studies on ICT use in Zimbabwean ECD settings tend to focus broadly on digital literacy rather than on robotics as a specific pedagogical tool, leaving a significant gap in empirical research. While curriculum reforms encourage innovation and learner-centred approaches, many ECD classrooms continue to face challenges related to resource availability, infrastructural constraints, and limited teacher training in educational technologies. Consequently, there is a critical need for contextually grounded research that examines how robotics can be integrated into Zimbabwean ECD classrooms in ways that are pedagogically meaningful, culturally responsive, and practically sustainable. Addressing this gap is essential for informing policy, practice, and professional development aimed at strengthening early childhood education in Zimbabwe.

Challenges Affecting the Implementation of Robotics in ECD Teaching and Learning

Despite the growing recognition of robotics as an innovative pedagogical tool in Early Childhood Development (ECD) education, literature across global and regional contexts consistently reports significant challenges that hinder its effective implementation. At the global level, studies from both developed and developing countries highlight that inadequate teacher preparedness remains a primary barrier to the meaningful integration of robotics in early learning environments. In countries such as the United States and the United Kingdom, research indicates that while schools may have access to robotics kits, many early childhood educators lack the pedagogical knowledge required to integrate these tools into developmentally appropriate learning activities (Bers, 2018; Sullivan & Bers, 2016). This challenge is further compounded by limited pre-service and in-service training programmes that focus specifically on robotics pedagogy for early learners, resulting in superficial or inconsistent classroom use.

In Asian contexts, including Singapore and China, where strong investments in educational technology exist, challenges have been linked to curriculum pressure and instructional time constraints. Studies report that ECD teachers often struggle to balance robotics activities with mandated curriculum requirements, leading to robotics being treated as an extracurricular activity rather than an integral pedagogical tool (Lim & Smith, 2020). Additionally, concerns have been raised about the cognitive appropriateness of robotics activities when insufficient attention is given to age-appropriate design and scaffolding. These findings suggest that even in technologically advanced systems, the successful implementation of robotics in ECD settings requires careful alignment with curriculum goals and child development principles.

Within the African context, the challenges affecting robotics integration in ECD classrooms are more pronounced due to systemic and infrastructural limitations. Research from Kenya, Nigeria, and Rwanda reveals that limited access to technological resources, unreliable electricity supply, and high costs of robotics kits significantly restrict adoption in early childhood settings (Muriithi et al., 2019; Chigona, 2019). In many African

countries, robotics initiatives are often introduced through donor-funded or non-governmental programmes, which may lack sustainability once external support is withdrawn. Furthermore, disparities between urban and rural schools exacerbate inequitable access to robotics-based learning, raising concerns about digital exclusion from an early age.

Evidence from Southern Africa, particularly South Africa, highlights similar challenges, with studies indicating that teacher confidence and professional competence play a decisive role in determining the success of robotics integration. Research conducted in foundation phase classrooms shows that while educators generally hold positive attitudes towards technology, many lack practical skills and pedagogical strategies for integrating robotics into play-based learning (Mtebe & Raisamo, 2014). In addition, inadequate institutional support, large class sizes, and limited technical assistance further constrain teachers' ability to implement robotics effectively. These challenges underscore the importance of sustained professional development and school-level support systems to ensure meaningful technology integration.

In the Zimbabwean context, challenges affecting the implementation of robotics in ECD teaching and learning are closely linked to broader structural and policy-related issues within the education system. Although national policies advocate for the integration of Information and Communication Technologies (ICTs) to improve educational outcomes, empirical studies indicate that many ECD centres lack basic technological infrastructure, including electricity, internet connectivity, and age-appropriate digital resources (Ministry of Primary and Secondary Education, 2017). Additionally, ECD educators in Zimbabwe often receive limited training in educational technology, with most professional development programmes focusing on general ICT skills rather than robotics-specific pedagogy. Financial constraints, particularly in rural and peri-urban schools, further limit access to robotics kits and maintenance support.

Collectively, the literature demonstrates that challenges affecting robotics integration in ECD classrooms are multifaceted and context-specific, encompassing issues of teacher preparedness, infrastructure, curriculum alignment, and policy support. While global experiences illustrate the pedagogical potential of robotics, evidence from African and Zimbabwean contexts highlights the need for locally responsive strategies that address systemic constraints. These challenges point to a critical gap in contextually grounded research that examines how robotics can be sustainably and equitably implemented in Zimbabwean ECD classrooms, taking into account the realities of teacher capacity, resource availability, and institutional support structures.

Strategies for Supporting Effective Use of Robotics in Early Childhood Education

The literature consistently highlights teacher professional development as a fundamental strategy for strengthening the effective integration of robotics in Early Childhood Development (ECD) classrooms. Studies from Europe, North America, and Asia emphasise that educators' confidence and competence in using robotics are directly linked to the quality and frequency of training received (Bers, 2018; Eguchi, 2019). Effective professional development programmes are characterised by a focus on both technical skills and pedagogical application, enabling teachers to design developmentally appropriate, play-based robotics activities that align with early childhood learning principles. Research further suggests that ongoing training, rather than one-off workshops, is essential for sustaining effective practice, as it allows educators to reflect on classroom experiences, share best practices, and adapt robotics activities to diverse learner needs. Such capacity-building initiatives are critical for ensuring that robotics is integrated meaningfully rather than treated as an isolated or optional classroom activity.

In addition to teacher training, curriculum alignment and policy support are widely identified as essential components for the successful implementation of robotics in ECD settings. International literature indicates that when robotics is explicitly embedded within national or institutional curriculum frameworks, educators are more likely to integrate it consistently into teaching and learning activities (Sullivan & Bers, 2016). Clear policy guidelines provide direction on instructional goals, assessment approaches, and age-appropriate use of robotics, reducing uncertainty and resistance among educators. Furthermore, curriculum integration ensures that robotics supports broader educational objectives, such as early numeracy, literacy, and social development, rather than functioning as a stand-alone technological intervention. The absence of such policy clarity has been shown to result in fragmented implementation and limited pedagogical impact, particularly in early childhood contexts.

Collaboration and multi-stakeholder partnerships are further recognised in the literature as effective strategies for strengthening robotics use in early childhood education. Partnerships involving government ministries, teacher training institutions, private sector organisations, and non-governmental organisations have been shown to enhance resource mobilisation, improve access to robotics kits, and support large-scale teacher training initiatives (Bers & Tu, 2021). In many developing contexts, such partnerships have enabled schools to overcome financial constraints by providing low-cost or donated resources, technical expertise, and mentorship opportunities. Collaborative initiatives also promote sustainability by building local capacity rather than relying solely on external interventions, thereby ensuring that robotics programmes can be maintained over time.

Within the Zimbabwean context, the literature stresses the need for context-sensitive and inclusive strategies that respond to local realities and systemic constraints. Researchers argue that low-cost robotics solutions, shared resource models, and community-based support initiatives are particularly relevant for under-resourced ECD centres (Ministry of Primary and Secondary Education, 2017). Integrating locally available materials and culturally relevant learning activities can enhance the relevance and acceptability of robotics in early childhood classrooms. Furthermore, aligning robotics initiatives with existing national education reforms and teacher education programmes can strengthen coherence and sustainability. Despite these proposed strategies, empirical evidence on their implementation and effectiveness in Zimbabwean ECD settings remains limited, highlighting a critical gap in the literature that necessitates further contextually grounded research.

METHODOLOGY

A qualitative case study research design was adopted to facilitate an in-depth exploration of the lived experiences of Early Childhood Development (ECD) teachers integrating robotics into their classroom practices. Qualitative case study approaches are particularly appropriate when the aim is to gain rich, contextualised understanding of complex educational phenomena within real-life settings (Yin, 2018). In this article, the case study design enabled a detailed examination of how robotics is implemented in ECD classrooms, how educators interpret its pedagogical value, and how contextual factors influence its use. By focusing on a bounded context, namely selected primary schools in Harare, the approach allowed for nuanced insights into teaching practices, classroom interactions, and institutional realities shaping robotics integration in early childhood education.

The participants comprised ten ECD educators drawn from urban and peri-urban primary schools in Harare, Zimbabwe. Purposive sampling was employed to select participants who had direct experience with the use of technology and robotics-related activities in early grades, ensuring that the data collected were information-rich and relevant to the research focus (Creswell & Poth, 2018). This sampling strategy enabled the inclusion of educators with varying levels of teaching experience and access to technological resources, thereby capturing diverse perspectives on robotics integration. Data were generated through semi-structured interviews and non-participant classroom observations. The semi-structured interviews provided flexibility for participants to articulate their perceptions, experiences, and challenges in their own words, while classroom observations allowed for direct examination of instructional practices, learner engagement, and the practical application of robotics in ECD settings.

Data analysis was conducted using thematic analysis, following the systematic procedures outlined by Braun and Clarke (2006). This method involved familiarisation with the data through repeated reading of interview transcripts and observation notes, followed by the generation of initial codes representing meaningful units of information. These codes were then organised into broader categories and refined into themes that captured recurring patterns related to pedagogical opportunities, implementation challenges, and support needs. Thematic analysis was selected for its flexibility and suitability for identifying both explicit and underlying meanings within qualitative data, making it particularly effective for educational research. The rigorous application of this analytical process enhanced the credibility and trustworthiness of the findings by ensuring that themes were grounded in participants' accounts and classroom evidence.

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RESEARCH FINDINGS AND DISCUSSION

Enhanced Learner Engagement

Teachers generally perceived the integration of robotics in Early Childhood Development (ECD) classrooms as a significant catalyst for enhancing learner engagement. The majority of participants indicated that robotics activities stimulated children's interest, curiosity, and active participation during lessons. Teachers highlighted that the hands-on and interactive nature of robotics enabled learners to engage more meaningfully with learning tasks compared to traditional instructional methods. One participant explained that robotics tools allowed children to interact physically with learning materials, thereby sustaining attention and motivation throughout the lesson. As Teacher B noted:

"When children use robots, they become more excited and focused. They want to touch, explore, and see how things work, which makes them participate more actively in class."

This response suggests that robotics promotes experiential learning, where learners are actively involved in constructing knowledge rather than passively receiving information.

Several teachers further emphasised that robotics activities encouraged collaboration and peer interaction, which enhanced engagement at both cognitive and social levels. Learners were reported to work together to solve problems, share ideas, and assist one another in completing tasks, fostering a sense of shared responsibility and enjoyment in learning. Teacher D highlighted this collaborative dimension by stating:

"Robotics makes children work as a team. They talk to each other, try different ideas, and help one another when something does not work."

Such findings align with sociocultural perspectives of learning, which emphasise the role of social interaction in cognitive development. The collaborative nature of robotics activities appeared to create inclusive learning environments where learners felt motivated to contribute and remain engaged.

In addition, teachers observed that robotics enhanced learners' willingness to participate verbally and ask questions during lessons. Participants reported that children displayed increased confidence and enthusiasm, particularly when experimenting with robotic tools and observing immediate outcomes of their actions. Teacher C echoed this view, noting:

"Robotics makes lessons enjoyable. Children ask more questions and are eager to try again when they make mistakes. They do not fear getting things wrong."

These findings suggest that the integration of robotics in Early Childhood Development (ECD) classrooms contributes to reduced learner anxiety by fostering a supportive, exploratory, and non-threatening learning environment, a view that aligns with research indicating that play-based and hands-on technologies promote emotional security and sustained engagement among young learners (Bers, 2018; Eguchi, 2019). The teachers' perceptions that robotics enhances motivation, attention, and active participation are consistent with studies conducted in early childhood settings in Europe and North America, which report that interactive robotics tools encourage curiosity, collaborative problem-solving, and learner agency (Kazakoff & Bers, 2014; Sullivan & Bers, 2016). However, some researchers caution that increased engagement is not an automatic outcome of technology use, arguing that without appropriate pedagogical scaffolding, robotics may lead to surface-level excitement rather than deep learning (Plowman & McPake, 2013). This divergence suggests that while robotics holds significant potential to transform early learning environments into dynamic and engaging spaces, its effectiveness is highly dependent on intentional instructional design and teacher mediation. Within the Zimbabwean ECD context, these findings reinforce the importance of aligning robotics integration with developmentally appropriate pedagogical practices to ensure that learner engagement translates into meaningful and sustained learning outcomes.

Challenges Faced by ECD Educators When Implementing Robotics in Their Teaching

Despite acknowledging the pedagogical benefits of robotics in Early Childhood Development (ECD) classrooms, teachers reported a range of challenges that hinder effective implementation. One of the most frequently cited challenges was limited professional training and inadequate digital competence among educators. Several participants expressed that they lacked sufficient knowledge and confidence to integrate robotics meaningfully into teaching and learning activities. Teacher F noted:

"I was introduced to robotics, but I do not feel fully trained. Sometimes I fear making mistakes in front of the learners because I am still learning how the technology works."

This response indicates that insufficient training not only affects teachers' technical skills but also undermines their confidence, which may limit the frequency and depth of robotics use in ECD classrooms.

Another major challenge identified by participants related to resource and infrastructural constraints, particularly in under-resourced schools. Teachers highlighted the shortage of robotics kits, unreliable electricity supply, and lack of appropriate classroom space as significant barriers. Teacher B explained:

"We have very few robotics materials, and sometimes there is no electricity. Even if we want to use the robots, the situation does not allow us."

Such challenges suggest that the successful integration of robotics is heavily dependent on the availability of basic infrastructure and resources, without which innovative teaching approaches become difficult to sustain.

Participants also raised concerns regarding limited institutional and policy support. Some teachers indicated that there was no clear guidance from education authorities on how robotics should be incorporated into the ECD curriculum. This lack of direction created uncertainty and inconsistency in implementation. Teacher D remarked:

"There are no clear guidelines on how robotics should be used in ECD. We are trying on our own, but sometimes we are not sure if we are doing the right thing."

This response highlights the need for well-articulated policy frameworks and curriculum guidelines to support educators in aligning robotics activities with national educational objectives.

In addition, teachers identified time constraints and curriculum pressure as barriers to robotics integration. Participants reported that the existing curriculum demands left limited time for planning and conducting robotics activities, which often require extended periods for exploration and experimentation. Teacher H stated:

"The curriculum is already full. Robotics needs time, but we are expected to complete many topics, so it becomes difficult to fit it in."

This finding suggests that without curriculum flexibility, teachers may struggle to prioritise robotics despite recognising its educational value.

Overall, the findings indicate that while ECD educators demonstrate positive attitudes towards the integration of robotics in their classrooms, several interrelated challenges impede its effective and sustainable implementation. Limited professional training and insufficient digital competence emerged as key barriers, reflecting the broader literature which shows that technology integration is highly dependent on educators' knowledge and confidence (Bers, 2018; Eguchi, 2019). Without structured opportunities for skill development, teachers may underutilise robotics or restrict its use to superficial activities, limiting the pedagogical benefits for learners. Resource and infrastructural constraints further exacerbate these challenges, as inadequate access to robotics kits, unreliable electricity, and insufficient classroom space hinder regular and meaningful application of technology (Chigona, 2019; Muriithi et al., 2019). The lack of clear policy guidance and curriculum integration was also highlighted, aligning with prior research that emphasizes the importance of institutional support and coherent frameworks to facilitate consistent adoption of educational technologies (Mtebe & Raisamo, 2014). Additionally, time pressures and rigid curricular demands were identified as significant barriers,

corroborating findings from studies in early childhood education where technology activities are often deprioritised in favour of mandated learning outcomes (Plowman & McPake, 2013). Collectively, these challenges suggest that for robotics to achieve its potential in ECD classrooms, there must be coordinated interventions encompassing professional development, infrastructural investment, policy support, and curriculum flexibility. Such holistic support is critical for enabling educators to move beyond isolated or superficial technology use and to create sustained, meaningful learning experiences that enhance engagement, problem-solving, and collaborative skills among young learners.

Recommendations for Supporting Effective Use of Robotics in Early Childhood Education

Teachers consistently highlighted the need for continuous professional development as a key mechanism for improving robotics integration in ECD classrooms. Several participants indicated that while they valued the potential of robotics, limited training constrained their ability to implement it effectively. Teacher F stated:

"I need more training to feel confident using these robots in the classroom. Sometimes I don't know how to guide the children properly."

Similarly, Teacher H added:

"Even when I have the robots, I feel unsure about designing activities that are meaningful and age-appropriate."

These responses underscore that professional development should focus on both technical skills and pedagogical strategies, supporting teachers to design developmentally appropriate, interactive, and collaborative robotics activities. Research supports this need, noting that sustained training and mentoring increase educators' competence and confidence, which directly improves learner outcomes (Bers, 2018; Eguchi, 2019).

Participants also emphasised the importance of policy and curriculum support to provide clear guidance for robotics use. Teacher D reflected:

"There is no clear guidance on how we should include robotics in our daily lessons. Sometimes it feels like we are just experimenting without direction."

Teacher B similarly remarked:

"If there were curriculum guidelines, I think more schools would be able to use robotics effectively."

These statements suggest that national and institutional policies should explicitly integrate robotics into the ECD curriculum, providing both instructional guidance and assessment strategies. Such alignment ensures consistency across classrooms and supports educators in translating robotics into meaningful learning experiences (Mtebe & Raisamo, 2014).

Another key recommendation identified by teachers was the need for adequate resources and infrastructure. Limited access to robotics kits, unstable electricity, and inadequate classroom space were reported as significant barriers. Teacher C explained:

"We have very few robots, and sometimes we have to share them between classes. It makes it hard to keep all the children engaged."

Teacher E added:

"Without electricity or proper space, even the best lessons cannot work properly."

These observations reinforce the necessity of equitable resource allocation, particularly in under-resourced and rural schools, to ensure all learners can benefit from robotics integration (Chigona, 2019; Muriithi et al., 2019).

Finally, teachers highlighted **collaboration and contextual adaptation** as essential for sustainable implementation. Teacher A noted:

"Working with other teachers and sharing ideas about robotics lessons really helps me improve. It also makes planning easier."

Teacher G further emphasised:

"Using simple, low-cost tools or local materials makes it easier for all schools to try robotics, even when budgets are tight."

These reflections indicate that partnerships between schools, government agencies, NGOs, and the community can support resource mobilisation, mentoring, and adaptation to local contexts. Low-cost and contextually appropriate solutions ensure that robotics is inclusive, sustainable, and relevant to learners' everyday experiences (Bers, 2018; Chigona, 2019).Overall, these findings suggest that the effective and sustainable use of robotics in ECD classrooms requires coordinated support through professional development, policy guidance, adequate resources, collaboration, and contextual adaptation. When these elements are in place, educators are better equipped to create interactive, engaging, and developmentally appropriate learning environments that maximise the pedagogical benefits of robotics.

CONCLUSIONS

The integration of robotics in ECD classrooms in Zimbabwe holds significant pedagogical potential, particularly in enhancing learner engagement and fostering critical thinking. However, the realisation of these opportunities is hampered by inadequate teacher preparation and systemic resource limitations. Addressing these challenges requires coordinated efforts across policy, training, and investment.

REFERENCES

1. Arfé, B., Vardanega, T., Montuori, C., & Lavano, S. (2019). Coding in primary grades: Children's engagement and development of computational thinking. Metin (2022) मध्ये पुनरावलोकन केल्यानुसार.
2. Benitti, F. B. (2012). Exploring the educational potential of robotics in schools: A systematic review. Computers & Education.
3. Bers, M. U. (2018). Coding as a playground: Programming and computational thinking in the early childhood classroom. Routledge.
4. Bers, M. U., & Tu, Stein. (2021). Robotics and social-emotional learning in early childhood. Early Childhood Education Journal.
5. Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101.
6. Business Daily News Zimbabwe. (2025). Education 5.0 and the future of Zimbabwean classrooms.
7. Chigona, A. (2019). Digital divide and education in Africa. Madyembwa et al. (2025) मध्ये सारांशित केल्यानुसार.
8. ConnectNigeria. (2025). EduTech initiatives and robotics in Nigerian preschools.
9. Creswell, J. W., & Creswell, J. D. (2018). Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.). SAGE Publications.
10. Di Lieto, M. C., Inguaggiato, E., Castro, E., Cecchi, F., Cioni, G., Dell'Omo, M., ... & Sgandurra, G. (2020). Educational robotics intervention of executive functions in preschool children
11. Eguchi, A. (2019). Robotics as a learning tool for educational transformation. Proceeding of International Conference on Educational Robotics.
12. Institute of Entrepreneurs Zimbabwe. (2025). Robotics for Every Child (REACH) program report.
13. Journal of Education. (2025). Play-based technologies in South African foundation phase classrooms.
14. Kazakoff, E. R., & Bers, M. U. (2014). The impact of computer programming on sequencing ability in early childhood. International Journal of Child-Computer Interaction.

15. Lim, C. P., & Smith, I. (2020). Technology integration in Asian early childhood settings. Journal of Early Childhood Research.
16. Madyembwa, S., et al. (2025). Digital literacy and curriculum reforms in Zimbabwe.
17. Mavuru, L., et al. (2024). ICT readiness among Zimbabwean educators.
18. Metin, S. (2022). The impact of educational robotics on the development of children's spatial reasoning and computational thinking skills. International Journal of Technology in Education.
19. Ministry of Primary and Secondary Education (MoPSE). (2017). Curriculum framework for primary and secondary education (2015-2022). Government of Zimbabwe.
20. Mtebe, J. S., & Raisamo, R. (2014). Investigating the potential of robotics in Southern African classrooms. International Journal of Education and Development using ICT.
21. Muriithi, P., et al. (2019). Challenges of digital integration in East African schools. Madyembwa et al. (2025) मध्ये सारांशित केल्यानुसार.
22. Shonkoff, J. P., & Phillips, D. A. (2017). From neurons to neighborhoods: The science of early childhood development. National Academies Press.
23. Sullivan, A., & Bers, M. U. (2016). Robotics in the early childhood classroom: Learning outcomes from an 8-week curriculum. European Early Childhood Education Research Journal.
24. UNICEF. (2019). Early childhood development: A statistical snapshot. UNICEF.
25. Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Harvard University Press.
26. Wanjiku, J., et al. (2019). Resource constraints in technology-enhanced learning. African Journal of Educational Studies.
27. Zingwena, T., & Kuyayama, A. (2025). Pedagogical competence and ICT use in Zimbabwean ECD.