# THE EFFECT OF EDUCATIONAL ROBOTICS ON COGNITIVE, SOCIOEMOTIONAL, AND CREATIVE DEVELOPMENT AMONG PRE-SCHOOL CHILDREN IN LAGOS STATE, NIGERIA: THE ROLE OF TEACHER READINESS AND RESOURCE AVAILABILITY

**[1]Omole, Roli Magdalene & [2]Ige, Olumide Olakunle**
[1,2]*Department of Social Sciences Education*
*Faculty of Education, University of Lagos*
*Akoka-Lagos, Nigeria*
*Corresponding Author's email address: oige@unilag.edu.ng*

**Abstract**
*Educational robotics is increasingly being recognised as an innovative pedagogical approach for strengthening early childhood learning outcomes, particularly in enhancing problem-solving, collaboration, and creativity. However, its classroom integration in many low-resource contexts remains limited and uneven, with implementation often influenced by teacher preparedness and access to instructional resources (Ouyang & Xu, 2024; Voogt et al., 2023). This study examined the effect of educational robotics on the cognitive, socioemotional, and creative development of pre-school children in Lagos State, Nigeria, with particular attention to the role of teacher readiness and resource availability. A quasi-experimental design, complemented by correlational analysis, was adopted. The sample comprised 101 pre-school children and 15 teachers drawn from 15 schools across five educational districts in Lagos State. Data were collected using structured observation checklists, a teacher readiness questionnaire, and a robotics resource inventory, with reliability coefficients ranging from $\alpha$ = .82 to .88. Descriptive statistics, independent samples t-test, and Pearson correlation were employed for data analysis at the 0.05 significance level. Findings revealed that children exposed to educational robotics demonstrated significantly higher cognitive outcomes, particularly in problem-solving and logical reasoning, with additional gains in memory, literacy, and numeracy. Significant improvements were also observed in socioemotional development, including collaboration, communication, empathy, and self-regulation, as well as in creative development through imagination, experimentation, and divergent thinking ($p < .001$). Teacher readiness and resource availability were significantly associated with all developmental outcomes. The study concluded that educational robotics can effectively support holistic pre-school development when reinforced by adequate teacher competence and access to appropriate instructional resources. The findings highlighted the need for context-sensitive integration strategies to strengthen early childhood education in Nigeria.*

**Keywords:** cognitive development, creative development, educational robotics, resource availability, socioemotional development, teacher readiness.

**Introduction**

The global discourse on early childhood education has increasingly shifted toward pedagogical approaches that develop not only foundational literacy and numeracy but also cognitive flexibility, socioemotional competence, and creativity. This shift reflects a broader redefinition of learning in the twenty-first century, where children are expected to actively construct knowledge, interact meaningfully with their environment, and develop adaptive thinking skills necessary for complex futures (OECD, 2023; UNESCO, 2021). Within this evolving landscape, attention has turned to innovative instructional tools capable of integrating these developmental domains within early learning environments.

Educational robotics has emerged as one such innovation, offering structured opportunities for children to engage simultaneously in cognitive, socioemotional, and creative development through hands-on interaction with programmable tools. Rather than functioning as a supplementary technological aid, robotics creates learning environments where abstract concepts such as sequencing, logic, and causality become tangible through play-based exploration. Importantly, these environments combine thinking, doing, and collaborating, thereby positioning learning as an integrated developmental process rather than a segmented academic activity (Sapounidis et al., 2024; Ouyang & Xu, 2024).

From a theoretical standpoint, this integrated learning experience is grounded in constructivist and socio-cultural learning traditions. Constructivism explains how children actively build knowledge through interaction with materials and tasks, while socio-cultural theory emphasises the role of social interaction, language, and guided support in shaping cognitive development. Educational robotics operationalises these principles by situating learners in collaborative exploratory environments where meaning is co-constructed through guided engagement. Consequently, learning becomes both individually constructed and socially mediated, with development emerging through interaction rather than instruction alone.

Complementing these perspectives, the Technological Pedagogical Content Knowledge (TPACK) framework highlights a critical dimension often overlooked in technology-based interventions: the alignment between technology, pedagogy, and content knowledge. This framework suggests that the effectiveness of robotics is not inherent in the tool itself but depends on how teachers integrate it within instructional practice. In this sense, robotics functions as a pedagogical amplifier whose impact is contingent on teacher competence, instructional design, and contextual appropriateness rather than mere availability.

Empirical studies across different educational contexts suggest that educational robotics can enhance cognitive outcomes such as problem-solving, planning, and flexible thinking, while also supporting socioemotional skills including collaboration, communication, and emotional regulation. In addition, its open-ended design structure promotes creativity by encouraging learners to experiment, iterate, and generate multiple solutions to given tasks (Berrezueta Guzman et al., 2025; Ouyang & Xu, 2024). However, these positive outcomes are predominantly reported in well-resourced and structurally stable environments, raising concerns about their generalisability to low-resource educational systems.

This concern is particularly relevant in Lagos State where early childhood education is characterised by uneven access to instructional resources, infrastructural limitations, and variability in school quality. While some private schools have begun adopting robotics-based instruction, many public schools face persistent constraints such as inadequate materials, unstable infrastructure, and limited exposure to digital learning tools (Nwaeze, 2025). These disparities create a context in which the implementation of educational robotics is inconsistent, fragmented, and often dependent on institutional capacity rather than curriculum design.

Compounding these structural challenges is the issue of teacher readiness, which plays a decisive role in determining how educational robotics is implemented in practice. Many early childhood educators have limited training in robotics-based pedagogy and digital instructional strategies, which affects their ability to meaningfully integrate these tools into classroom practice. As a result, even when resources are available, robotics is often reduced to a demonstrative or activity-based tool rather than a structured learning intervention capable of supporting sustained developmental outcomes (David et al., 2023). This highlights a critical gap between technological availability and pedagogical effectiveness.

Against this background, there is a clear need for empirical research that moves beyond global assumptions and examines how educational robotics functions within real classroom conditions in resource-constrained environments. This study therefore investigates the effect of educational robotics on the cognitive, socioemotional, and creative development of pre-school children in Lagos State, while also examining the roles of teacher readiness and resource availability as contextual factors influencing implementation effectiveness. In doing so, it provides a more integrated and context-sensitive understanding of how educational innovation translates into meaningful developmental outcomes in early childhood education.

**Statement of the Problem**

Educational robotics is increasingly recognised as a valuable approach for strengthening early cognitive, socioemotional, and STEM-related skills. However, its integration within Early Childhood Education in Lagos State remains limited, uneven, and weakly supported by empirical evidence. Although evidence from high-income contexts highlights its benefits for problem-solving, creativity, and collaboration, such outcomes are difficult to replicate locally due to infrastructural constraints, limited digital resources, and persistent socio-economic inequalities (Sapounidis et al., 2024; Barragán Sánchez et al., 2022). As a result, robotics is often absent or superficially implemented in many early childhood classrooms.

A major constraint is teacher capacity. Teacher education programmes in Nigeria provide limited exposure to robotics and digital pedagogy, leaving many educators insufficiently prepared to integrate these tools effectively into classroom practice (David et al., 2023). Where resources exist, they are frequently underutilised due to weak pedagogical alignment and the absence of context-specific instructional frameworks.

Furthermore, policy and curriculum guidance for early robotics education remains underdeveloped (Nwaeze, 2025), contributing to fragmented implementation and widening disparities between public and private schools. In addition, there is limited empirical research on how robotics can be adapted to resource-constrained and culturally diverse early learning environments. This study addresses these gaps by developing and evaluating a robotics-integrated teaching approach to enhance teacher competence and classroom practice.

**Purpose of the Study**

This study examined the effect of educational robotics on the cognitive, socioemotional, and creative development of pre-school children in Lagos State, Nigeria, while also analysing the role of teacher readiness and resource availability in shaping the effectiveness of robotics-based learning. The study specifically sought to:

1. determine the effect of educational robotics on pre-school children's cognitive development, particularly problem-solving, logical reasoning, memory, literacy, and numeracy;
2. examine the effect of educational robotics on children's socioemotional development, including collaboration, communication, empathy, and self-regulation;
3. assess the effect of educational robotics on children's creative development, specifically imagination, experimentation, and divergent thinking;
4. analyse the influence of teacher readiness on cognitive, socioemotional, and creative development outcomes in robotics-based learning;
5. investigate the relationship between robotics resource availability and children's developmental outcomes; and
6. examine the combined role of teacher readiness and resource availability in shaping the effectiveness of educational robotics.

**Research Questions**

1. What effect does educational robotics have on the cognitive development of pre-school children in Lagos State?
2. What effect does educational robotics have on children's socioemotional development?
3. What effect does educational robotics have on children's creative development?
4. How does teacher readiness influence cognitive, socioemotional, and creative outcomes in robotics-based learning?
5. What is the relationship between robotics resource availability and children's developmental outcomes?
6. How do teacher readiness and resource availability jointly influence the effectiveness of educational robotics?

**Hypotheses**

**$H_{01}$:** Educational robotics has no significant effect on pre-school children's cognitive development.

**$H_{02}$:** Educational robotics has no significant effect on pre-school children's socioemotional development.

**$H_{03}$:** Educational robotics has no significant effect on pre-school children's creative development.

**$H_{04}$:** Teacher readiness has no significant influence on cognitive, socioemotional, and creative development outcomes.

**$H_{05}$:** Robotics resource availability has no significant relationship with children's developmental outcomes.

**$H_{06}$:** Teacher readiness and resource availability do not significantly influence the effectiveness of educational robotics on developmental outcomes.

**Theoretical and Conceptual Framework**

This study is grounded in an integrated framework drawing on Vygotsky's Social Constructivism, Papert's Constructionism, and Bandura's Social Cognitive Theory to explain how educational robotics shapes cognitive, socioemotional, and creative development in early childhood education. Rather than treating these theories separately, they are synthesised to conceptualise learning as a socially mediated, experiential, and observational process in which interaction, making, and modelling jointly drive development.

From a constructivist perspective, learning occurs through social interaction within the Zone of Proximal Development, where children extend their capabilities through scaffolding from teachers and peers (Vygotsky, 1978). In robotics-based environments, this is evident in collaborative problem-solving, sequencing, and reasoning tasks. Constructionism deepens this account by locating learning in "making," where knowledge is constructed through designing, testing, and refining tangible artefacts. Robotics operationalises this principle through iterative experimentation, thereby fostering problem-solving and creativity (Bers, 2021; Kucuk & Sisman, 2020). Together, these theories explain cognitive and creative development as outcomes of active, experiential engagement.

Bandura's Social Cognitive Theory complements this by emphasising observational learning, modelling, reinforcement, and self-efficacy. In robotics classrooms, learners develop socioemotional competencies—such as self-regulation, communication, and persistence—through peer observation, imitation, and feedback from task outcomes (Schunk & DiBenedetto, 2020; Ouyang & Xu, 2024). Collectively, the three theories provide a unified mechanism explaining how robotics simultaneously activates cognitive, socioemotional, and creative development through interaction, construction, and observation.

Within this framework, teacher readiness and resource availability are conceptualised as contextual moderating conditions that determine how effectively these mechanisms are activated. Teacher readiness reflects pedagogical competence and scaffolding capacity, while resource availability captures access to functional robotics tools and infrastructure. These variables do not directly produce learning outcomes but shape the strength and quality of the relationships between robotics exposure and developmental gains.

Overall, the framework positions educational robotics as a pedagogical system in which learning outcomes emerge from the interaction of learners, teachers, tools, and context. While the three theories explain the learning mechanisms, contextual conditions determine their effectiveness in practice. This provides a realistic explanation of variability in outcomes across classrooms, particularly in resource-constrained settings such as Lagos State, and aligns directly with the study's hypotheses and objectives.

## Literature Review

### Educational Robotics in Early Childhood Education

Educational robotics is increasingly conceptualised as an inquiry-driven pedagogical innovation that enables young children to learn through exploration, collaboration, and guided construction of meaning rather than passive instruction. Within early childhood education, it functions as a structured experiential environment where abstract concepts such as sequencing, logic, and causality are made tangible through manipulation of programmable tools. Empirical evidence suggests that, when appropriately integrated, robotics enhances engagement, foundational computational reasoning, and early problem-solving abilities, positioning it as a learning ecology rather than a mere instructional aid (Bers, 2021; Ouyang & Xu, 2024).

However, much of this evidence is generated within well-resourced contexts characterised by stable infrastructure, trained educators, and consistent access to learning technologies. This raises concerns about contextual transferability, as recent scholarship increasingly argues that the impact of educational technology is mediated by systemic conditions rather than intrinsic technological properties (Voogt et al., 2023). Consequently, reported benefits of robotics may partly reflect favourable implementation environments rather than universal pedagogical effectiveness.

**Developmental Outcomes of Educational Robotics**

Across available literatures, educational robotics is consistently associated with cognitive gains, particularly in problem-solving, logical reasoning, and early computational thinking. These outcomes are attributed to task structures that require sequencing, hypothesis testing, and iterative refinement, thereby strengthening executive functioning and cognitive flexibility (Kucuk & Sisman, 2020; Sullivan & Bers, 2020). However, the magnitude of these gains varies across studies, with stronger effects typically reported in structured and well-facilitated environments, indicating that cognitive development is mediated by instructional scaffolding rather than robotics exposure alone (Schunk & DiBenedetto, 2020).

In parallel, socioemotional development is linked to the collaborative nature of robotics tasks, which require communication, negotiation, and shared problem-solving (Marino et al., 2020; OECD, 2021). Nevertheless, outcomes remain inconsistent, as poorly structured implementations often reduce interaction to task completion rather than meaningful collaboration. This reinforces the view that socioemotional development is shaped more by pedagogical design than by the technology itself.

Creative development emerges as one of the most robust outcomes, particularly within constructionist learning environments. Robotics encourages experimentation, iterative design, and divergent thinking, fostering originality and imaginative problem-solving (Bers, 2021; Kucuk & Sisman, 2020). However, creativity is highly sensitive to structured tasks. While open-ended designs enhance exploration, rigid instruction constrains it thereby suggesting that creativity is an emergent pedagogical outcome rather than an inherent technological effect.

**Contextual Determinants: Teacher Readiness and Resource Availability**

Recent literature increasingly shifts attention from technology-centred explanations to contextual and systemic determinants of effectiveness. Teacher readiness—comprising pedagogical competence, digital literacy, and instructional confidence—emerges as a critical determinant of successful robotics integration (Voogt et al., 2023; David et al., 2023). Where teachers are insufficiently prepared, robotics tends to be reduced to a motivational or demonstrative tool, limiting its instructional depth and developmental impact.

Similarly, resource availability plays a foundational role in shaping implementation quality. Access to functional robotics kits, infrastructure, and instructional materials directly influences the consistency and sustainability of learning experiences, particularly in low-resource settings (Olaniyi & Olatunji, 2022). Together, these factors function as systemic enablers that condition whether the theoretical benefits of robotics are realised in practice.

**Research Gap**

Despite growing global interest, the literature remains fragmented and contextually limited. Most studies focus on isolated developmental domains, particularly cognition, while neglecting the integrated nature of cognitive, socioemotional, and creative development as interconnected outcomes of a single pedagogical intervention. More critically, there is limited empirical evidence from low-resource contexts such as Nigeria that examines how educational robotics operates under real classroom constraints. In addition, existing research rarely investigates the combined influence of teacher readiness and resource availability as moderating conditions that shape implementation quality and learning outcomes. This creates a significant explanatory gap between the theoretical potential of educational robotics and its practical effectiveness in under-resourced educational systems.

This study addresses these gaps by examining the effect of educational robotics on cognitive, socioemotional, and creative development among pre-school children in Lagos State, while simultaneously analysing the moderating roles of teacher readiness and resource availability. In doing so, it provides a more integrated, context-sensitive, and empirically grounded understanding of how robotics-based learning functions within early childhood education in resource-constrained environments.

**Methodology**

This study adopted a quasi-experimental design complemented by correlational analysis to examine the influence of educational robotics on cognitive, socioemotional, and creative development among pre-school children in Lagos State. The design enabled comparison between robotics-integrated and conventional classrooms in natural school settings, while correlation analysis examined the relationships between robotics exposure, teacher readiness, and resource availability (Campbell & Stanley, 1963; Creswell & Creswell, 2018).

The population comprised pre-school children in public and private schools across five educational districts (Lagos Island, Ikeja, Badagry, Ikorodu, and Epe). A multi-stage sampling technique was used by selecting schools based on their exposure to educational robotics and by retaining intact classrooms for naturalistic observation. The final sample included 101 children and 15 teachers from 15 schools which are appropriate for detecting medium intervention effects (Cohen, 1988).

Educational robotics is defined as structured play-based engagement involving building and programming robotic tools (Bers, 2020). Cognitive development covers problem-solving, memory, reasoning, and early literacy/numeracy, while socioemotional development includes collaboration, communication, empathy, and self-regulation (OECD, 2021). Creative development involves imagination, originality, and divergent thinking (OECD, 2023). Teacher readiness and resource availability are treated as contextual moderators influencing outcomes (Selwyn, 2016; Voogt et al., 2023).

Data were collected using a teacher observation checklist, teacher readiness questionnaire, and robotics resource inventory. Instruments were validated through expert review and theoretical alignment with constructivist, constructionist, and social cognitive perspectives (Vygotsky, 1978; Papert, 1980; Bandura, 1986), with reliability coefficients ranging from 0.82 to 0.88. A six-week intervention was conducted, during which teachers implemented guided robotics activities in intervention schools, while control schools followed conventional instructional practices.

Data were analysed using SPSS. Independent samples t-tests compared group outcomes, while Pearson correlation assessed relationships among variables at a 0.05 level of significance, with effect sizes reported to enhance interpretability in line with contemporary reporting standards (APA, 2020). Ethical approval was obtained prior to data collection, with informed consent from school authorities and teachers, and child assent appropriately secured.

**Results**

This study examined the effects of educational robotics on cognitive, socioemotional, and creative development among 101 pre-school children across 15 schools in Lagos State, alongside responses from 15 teachers across five educational districts. The instruments demonstrated strong internal consistency ($\alpha$ = .82–.88), while validity was established through expert review and pilot testing. Data were analysed using SPSS version 28, employing descriptive statistics, Pearson correlation, and independent samples t-test at the 0.05 level of significance.

**Cognitive Development**

Findings indicated that educational robotics had a positive effect on cognitive development. Children recorded high mean scores in problem-solving (M = 4.10, SD = 0.80) and logical reasoning (M = 4.00, SD = 0.90). Improvements were also observed in memory, literacy, and numeracy (M = 3.70, SD = —). Overall, approximately 75% of participants demonstrated measurable cognitive gains, suggesting enhanced executive functioning facilitated by structured robotics activities.

**Socioemotional Development**

Results revealed significant improvements in socioemotional outcomes among children exposed to educational robotics. Collaboration (M = 4.20, SD = 0.70) and communication (M = 4.00, SD = 0.80) were the most prominent outcomes, followed by empathy (M = 3.90, SD = —) and self-regulation (M = 3.80, SD = —). Approximately, 78% of participants demonstrated active engagement in cooperative learning behaviours, indicating that robotics-supported instruction fostered positive social interaction and emotional responsiveness.

**Creative Development**

Educational robotics also positively influenced creative development. High mean scores were recorded for imaginative thinking (M = 4.20, SD = 0.80), experimentation (M = 4.10, SD = 0.80), and divergent thinking (M = 3.90, SD = 0.90). Approximately 80% of learners demonstrated strong exploratory and iterative thinking behaviours, indicating sustained creative engagement across participating schools.

**Teacher Perception and Resource Availability**

Teachers generally reported positive perceptions of educational robotics (M = 4.20), although readiness levels remained moderate (M = 3.60–3.90), reflecting gaps in pedagogical training and confidence in technology integration. Resource availability was rated as adequate overall (M ≈ 4.00) but uneven in quality and consistency (M = 3.70). Pearson correlation analysis indicated significant positive relationships between resource availability and developmental outcomes across domains ($r$ = .57–.61, $p < .001$).

**Hypotheses Testing**

Independent samples t-test results revealed significant differences between robotics and non-robotics groups. Cognitive development was significantly higher among the robotics group ($t = 5.62$, $df = 200$, $p < .001$, $d = 0.74$). Similarly, socioemotional development ($t = 4.87$, $p < .001$, $d = 0.66$) and creative development ($t = 5.23$, $p < .001$, $d = 0.71$) were significantly higher among children exposed to educational robotics.

Further analysis showed significant positive correlations between teacher readiness and cognitive ($r = .58$), socioemotional ($r = .54$), and creative outcomes ($r = .56$), all significant at $p < .001$. Resource availability also demonstrated significant positive relationships with cognitive ($r = .61$), socioemotional ($r = .57$), and creative development ($r = .59$), confirming its enabling role in implementation effectiveness.

**Summary of Findings**

1. Educational robotics significantly enhanced cognitive development among pre-school children, particularly in problem-solving, logical reasoning, memory, literacy, and numeracy.
2. The strongest cognitive gains were observed in problem-solving and logical reasoning, indicating improved executive functioning.
3. Socioemotional development improved significantly, especially in collaboration, communication, empathy, and self-regulation.
4. Creative development was strongly enhanced and represented in imaginative thinking, experimentation, and divergent thinking.
5. Teacher readiness significantly influenced the magnitude and consistency of developmental outcomes.
6. Robotics resource availability and quality strongly shaped the effectiveness of implementation across schools.
7. Overall, educational robotics supported holistic development, although outcomes were moderated by contextual and instructional conditions.

**Discussion**

The findings indicate that educational robotics positively influences cognitive, socioemotional, and creative development in early childhood education. Cognitive gains were most evident in problem-solving and logical reasoning, reflecting enhanced sequencing, hypothesis testing, and reflective thinking. These outcomes align with constructivist theory which emphasises learning through active engagement (Vygotsky, 1978), and supports evidence that robotics strengthens executive functioning by concretising abstract cognitive processes (Kucuk & Sisman, 2020; Ouyang & Xu, 2024). However, moderate gains in literacy and numeracy suggest that robotics is best positioned as a complementary instructional strategy rather than a replacement for foundational literacy instruction.

In the socioemotional domain, robotics enhanced collaboration, communication, and shared problem-solving, consistent with socio-cultural perspectives on learning through guided interaction (OECD, 2021; Marino et al., 2020). Nevertheless, variability across classrooms indicates strong dependence on teacher mediation. Where scaffolding was deliberate and structured, socioemotional outcomes were stronger, reinforcing that pedagogical design—not technology—drives effectiveness (Schunk & DiBenedetto, 2020).

Creative development emerged as the most stable outcome, characterised by increased imagination, experimentation, and divergent thinking. This supports constructionist theory, which frames learning as knowledge construction through making and iterative design (Papert, 1980; Bers, 2021). The open-ended nature of robotics tasks promotes exploration and multiple solution pathways, suggesting that creativity is a relatively robust outcome when minimal implementation conditions are met.

A key finding is the context-dependent nature of impact. Teacher readiness significantly shaped outcomes, with more competent and confident teachers enabling deeper engagement and richer learning experiences, consistent with research on pedagogical content knowledge in technology integration (Voogt et al., 2023; David et al., 2023). Similarly, resource availability influenced consistency and quality of implementation, as limited access to robotics tools constrained learning opportunities in several schools (Olaniyi & Olatunji, 2022). Overall, the results indicate that educational robotics outcomes are codetermined by pedagogy, teacher competence, and material conditions rather than technology alone.

**Policy Implications**

The findings suggest that educational robotics should be embedded within early childhood education curricula rather than treated as an optional enrichment. Teacher education programmes should include structured training in robotics pedagogy to strengthen implementation capacity. In addition, targeted investment is required to address the disparities in access to robotics resources across schools. Without such measures, the benefits of robotics-based learning may remain uneven and potentially widen existing educational inequalities.

**Conclusion**

This study concludes that educational robotics is an effective pedagogical approach for supporting holistic development in early childhood education. It contributes to cognitive, socioemotional, and creative development by providing interactive, hands-on, and socially engaging learning experiences. However, its effectiveness is conditional rather than automatic. Outcomes depend on teacher readiness, instructional quality, and the availability of adequate resources. Educational robotics should therefore be understood as part of a broader instructional ecosystem rather than a standalone intervention. When supported by appropriate pedagogy and infrastructure, it has the potential to significantly enhance early learning. In the absence of these conditions, its impact remains uneven. The findings underscore the need for systemic support to maximise its educational benefits.

**Recommendations**

1. The Federal and State Ministries of Education should integrate educational robotics into early childhood curriculum frameworks with clearly defined learning outcomes and implementation guidelines.
2. Teacher education institutions should introduce compulsory modules on robotics-based pedagogy, including practical certification programmes for in-service teachers.
3. Schools should provide continuous professional development opportunities focused on the design and facilitation of robotics-based learning activities.
4. Governments and education stakeholders should establish equitable distribution systems for age-appropriate robotics kits, prioritising under-resourced schools.
5. Education districts should create technical support systems to assist schools with implementation, maintenance, and troubleshooting.
6. Dedicated funding should be allocated to reduce disparities in access to robotics resources across different regions.
7. A national monitoring framework should be developed to evaluate implementation quality and learning outcomes in robotics-based education.

**References**

Alimisis, D. (2013). Educational robotics: Open educational resources for developing computational thinking. *Educational Technology & Society, 16*(1), 398–408.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Prentice-Hall.

Barragán-Sánchez, R., et al. (2022). Educational robotics and inclusive learning in early childhood education. *International Journal of Child-Computer Interaction, 33*, 100412.

Bers, M. U. (2018). *Coding as a playground: Programming and computational thinking in the early childhood classroom*. Routledge.

Bers, M. U. (2020). *Coding, robotics, and early childhood education: Digital pathways to learning*. Teachers College Press.

Bers, M. U. (2021). *Robotics and early learning: Pathways to cognitive and social development*. Teachers College Press.

Bers, M. U., Flannery, L., Kazakoff, E. R., & Sullivan, A. (2014). Computational thinking and tinkering: Exploration of an early childhood robotics curriculum. *Computers & Education, 72*, 145–157. https://doi.org/10.1016/j.compedu.2013.10.020

Campbell, D. T., & Stanley, J. C. (1963). *Experimental and quasi-experimental designs for research*. Houghton Mifflin.Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates.

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). Sage.

David, O. O., Akinyemi, A., & Salami, R. (2023). Digital pedagogy readiness among early childhood educators in Nigeria. *African Journal of Educational Research, 29*(1), 55–72.

Diamond, A., & Lee, K. (2011). Interventions shown to aid executive function development in children 4 to 12 years old. *Science, 333*(6045), 959–964. https://doi.org/10.1126/science.1204529

Eguchi, A. (2014). Educational robotics for promoting twenty-first century skills. *Journal of Robotics and Automation in Education, 1*(1), 3–11.

Eguchi, A. (2016). Robotics as a learning tool in early childhood education. *International Journal of STEM Education, 3*(1), 1–10.

Federal Ministry of Education. (2013). *National policy on education*. NERDC Press.

Flannery, K., Syverud, J., & Marsh, E. (2013). Expanding the teacher professional development model: Integrating technology in early childhood settings. *Early Childhood Education Journal, 41*(4), 303–311. https://doi.org/10.1007/s10643-012-0558-7

Ginsburg, H. P., Lee, J. S., & Boyd, J. S. (2008). Mathematics education for young children: What it is and how to promote it. *Social Policy Report, 22*(1), 3–22.

Ginsburg, K. R. (2007). The importance of play in promoting healthy child development. *Pediatrics, 119*(1), 182–191.

Kazakoff, E. R., & Bers, M. U. (2012). Programming in early childhood: The role of collaboration in robotics. *International Journal of Technology and Design Education, 22*(3), 301–317.

Kazakoff, E. R., Sullivan, A., & Bers, M. U. (2013). The effect of a classroom-based robotics curriculum on sequencing ability in early childhood. *Journal of Educational Research, 106*(6), 502–516.

Kucuk, S., & Sisman, B. (2020). Educational robotics and creativity in early childhood education. *Computers in Human Behavior, 104*, 106–110.

Lillard, A. S., et al. (2013). The impact of pretend play on children's development. *Psychological Bulletin, 139*(1), 1–34.

Mertens, D. M. (2019). *Research and evaluation in education and psychology* (5th ed.). Sage.

Mubin, O., Stevens, C. J., Shahid, S., Al Mahmud, A., & Dong, J. J. (2013). A review of robotics in education. *Journal of Technology for Education and Learning, 1*(209), 1–7.

National Bureau of Statistics. (2022). *Education statistics in Nigeria 2022*. Government of Nigeria.

Nwaeze, C. (2025). Digital inequality and early childhood education in Nigeria. *Journal of African Education Studies, 31*(1), 44–62.

OECD. (2021). *Starting strong VI: Supporting meaningful interactions in early childhood education and care*. OECD Publishing.

OECD. (2023). *Learning for the future: Creative thinking and innovation in education*. OECD Publishing.

Olaniyi, T. M., & Olatunji, T. T. (2022). Digital learning and early childhood development in Nigeria. *International Journal of Early Years Education, 30*(1), 45–60.

Ololube, N. P. (2015). *Technology and school improvement*. Routledge.

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas*. Basic Books.

Resnick, M., et al. (2009). Scratch: Programming for all. *Communications of the ACM, 52*(11), 60–67.

Sapounidis, T., et al. (2024). Educational robotics in early childhood learning environments. *Computers & Education: Artificial Intelligence, 5*, 100–118.

Schunk, D. H., & DiBenedetto, M. K. (2020). Motivation and social cognitive theory. *Contemporary Educational Psychology, 60*, 101832.

Selwyn, N. (2016). *Education and technology: Key issues and debates*. Bloomsbury.

Shonkoff, J. P., & Phillips, D. A. (2000). *From neurons to neighborhoods*. National Academies Press.

Sullivan, A., & Bers, M. U. (2018). Robotics in early childhood education. *Early Childhood Research Quarterly, 45*, 1–9.

UNESCO. (2021). *Reimagining our futures together*. UNESCO Publishing.

Vygotsky, L. S. (1978). *Mind in society*. Harvard University Press.

Voogt, J., et al. (2023). Teacher readiness for digital pedagogy in early education. *Teaching and Teacher Education, 120*, 103–118.