

The Building Blocks of Early Mathematics: Learning Developmental Paths For Young Children

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Abstract

This research adopts a descriptive survey method to evaluate the building blocks of early mathematics for young children at primary school level in Ondo State. The research team worked with a sample of ten classroom teachers randomly selected from ten different Primary schools in Ondo City of Ondo State. They used structure questionnaire designed to elicit information for analysis. Data collected from the field was analyzed using descriptive and inferential statistical tools. Frequency counts and mean scores were used to answer the research questions while t-test was used to evaluate the hypotheses at 0.05 level of significance. Results show that teachers face significant challenges, including inadequate instructional aids, cultural limitations, and technological gaps, which hamper effective teaching. The study reveals scaffolded learning, teacher-learner interaction, and learner involvement and engagement as the most effective pedagogical approaches. There is no significant difference between innovative pedagogical approaches and inequities in access to quality education, hence it is recommended that teachers receive ongoing professional development, particularly in the areas of differentiated instruction and the use of technology and play-based learning in early childhood education as this will help them better implement these innovative methods and address the diverse needs of learners. Schools, especially in under-resourced areas, should be equipped with adequate instructional materials, technology, and hands-on manipulatives. Governments and stakeholders should prioritize the provision of these resources to enhance the effectiveness of innovative teaching approaches.

Keywords: Early Childhood, Mathematics, Education, Learning, Pedagogical, Approaches

Introduction

Early Childhood Mathematics Education is a critical phase in a child's educational journey, laying the foundation for future academic success. Mathematics education in early childhood provides fundamental knowledge and skills that determine a child's present and future educational success in Mathematics. The pivotal stage of education, from birth to age eight, requires utmost care and mindfulness to ensure effectiveness and success. The foundational years of early childhood are critical in shaping a child's cognitive and academic future. Within this period, Early Childhood Mathematics Education plays a vital role in laying the groundwork for future success, not only in Mathematics but also across various academic domains. This background explores the significance, trends, challenges, and pedagogical approaches associated with Early Mathematics Education, with a particular focus on the developmental paths young children follow as they build mathematical skills.

Research has consistently shown that early mathematical abilities are strong predictors of later academic achievement, not just in Mathematics but also in other subjects like reading (Claessens & Engel, 2018). This underscores the importance of establishing a solid mathematical foundation during early childhood; defined as the period from birth to age eight. Early childhood education, therefore, seeks to nurture these formative years by addressing the challenges inherent in teaching mathematics to young learners and ensuring that the learning experiences are engaging, developmentally appropriate, and effective. Research has

consistently underscored the importance of Early Mathematics Education in cognitive development and future academic achievement. Early Mathematical skills are strong predictors of later academic achievement, not only in Mathematics but also in reading and overall academic performance. The development of mathematical thinking in early childhood fosters critical cognitive skills such as problem-solving, logical reasoning, and analytical thinking.

In recent years, key trends have emerged in Early Childhood Mathematics Education. The use of digital tools and educational technologies, such as tablet-based games, has become increasingly prevalent. These tools offer interactive and engaging learning experiences that significantly improve children's number sense and arithmetic skills (Papadakis et al., 2021). Play-based learning continues to be a cornerstone of early childhood education. Structured play, where educators guide children's exploration of mathematical concepts, has proven particularly effective in fostering deep mathematical understanding (Pyle & Danniels, 2018). There is a growing emphasis on incorporating culturally relevant pedagogy into Early Mathematics Education. By integrating children's cultural backgrounds and experiences into the curriculum, educators can make learning more relatable and effective (Rogers-Ard et al., 2019). The success of Early Mathematics Education heavily relies on well-trained educators. Ongoing professional development is essential to equip teachers with the latest pedagogical strategies and content knowledge, enabling them to create more effective learning

environments (Sarama & Clements, 2019). Despite its importance, Early Childhood Mathematics Education faces challenges, including inequities in access to quality education, inadequate assessment practices, and teacher preparedness. To address these challenges, researchers and educators have emphasized the need for innovative pedagogical approaches, including play-based learning, storytelling, and literacy integration, hands-on and manipulative-based learning, and technology integration.

Theories such as Piaget's constructivism, Vygotsky's sociocultural theory, and Bruner's cognitive development theory have significantly influenced Early Childhood Mathematics Education. These theories emphasize the importance of active learning, social interaction, scaffolding, and the progression through different modes of representation in developing mathematical concepts in young children. Recent empirical studies have validated the effectiveness of these theories and approaches in enhancing Early Childhood Mathematics Education. However, there is a need for continued research and exploration to address the existing challenges and improve teaching practices, curriculum design, and student outcomes in Early Childhood Mathematics Education.

Objective of the Study

The purpose of this study is to explore and identify effective pedagogical approaches, teacher training methods, and assessment strategies that can enhance Early Childhood Mathematics Education. Specifically, this study intends to:

1. Determine the effective pedagogical approaches in enhancing Early Childhood Mathematics Education.
2. How innovative pedagogical approaches address inequities in access to quality education in Early Childhood Mathematics.
3. Identify the challenges encountered by teachers in the effective teaching of Early Mathematics

Research Question.

1. What are the most effective pedagogical approaches in enhancing Early Childhood Mathematics Education?
2. How can innovative pedagogical approaches address inequities in access to quality education in Early Childhood Mathematics
3. What are the challenges encountered by teachers in the effective teaching of Early Mathematics?

Research Hypotheses

1. There is no significant difference in the effectiveness of various pedagogical approaches (e.g., play-based learning, hands-on learning, technology integration) in enhancing Early Childhood Mathematics Education between public and private schools.
2. Innovative pedagogical approaches (e.g., storytelling, literacy integration, manipulative-based learning) do not significantly reduce inequities in access to quality education in Early Childhood Mathematics.

Methodology

Research Design

The study used a concurrent mixed methods design, combining both quantitative and qualitative approaches. Quantitatively, data were collected using an observation scale to rate teachers' teaching skills. Qualitatively, questionnaires were administered to selected teachers to explore the specific challenges they face when teaching Mathematics in the classroom.

Population of the Study

The population of this study consists of 10 Classroom (Mathematics) teachers across 10 Primary Schools in Ondo West Local Government Area of Ondo state.

Sample And Sampling Technique

The researcher used a simple random sampling technique to choose ten schools from Ondo West Local Government Area of Ondo State. From each selected school, one classroom (Mathematics) teacher was selected. This method ensured that the participants were relevant to the research goals and had expertise in the subject being studied.

Research Instrument

Pedagogical Approaches to Early Mathematics Rating Scale: This tool has two parts. Part A collects demographic information such as the name of the school, class, and age range while Part B contains 10 items rated from excellent (5) to poor (1).

Questionnaire for Teachers: This tool has two parts. Part A collects demographic information such as the teacher's name, gender, and teaching experience while Part B contains five questions to help understand the challenges teachers face.

Procedure for Data Collection

On the day of the Observation, the team addressed a teacher and a class per time and administered the questionnaire. The researchers summarized it for further analysis.

Data Analysis

The collected data was analyzed using Statistical Package for Social Sciences (SPSS) for descriptive statistics. The study used frequency and percentage analysis for the demographic information, while the research questions were tackled using mean analysis.

Results And Discussion

Research Question 1: What are the most effective pedagogical approaches in enhancing Early Childhood Mathematics Education?

S/N	ITEMS	E	V.G	G	F	P	Mean	Remarks
1	Inculcation/Incorporation of children's cultural background & experiences.	1	1	4	1	3	2.60	Poor
2	Use of differentiated instruction to meet the diverse needs of the learners.	1	0	2	3	4	2.10	Poor
3	Learners' response to the current subject matter in relation to past subject matters as regard to scaffolded learning	3	4	3	0	0	4.00	Good
4	Teacher - learning interaction and literacy activities.	4	3	2	1	0	4.00	Good
5	Learners' involvement and engagement in the teaching - learning process	6	1	3	0	0	4.30	Good

Key: E= Excellence; V.G = Very Good; G= Good; F= Fair; P = Poor; Cut -Off Point = 3.00

The table above reveals the most effective pedagogical approaches in enhancing Early Childhood Mathematics Education. This study observed that inculcation/incorporation of children's cultural background & experiences and use of differentiated instruction to meet diverse needs of the learners were rated poorly, with mean values of 2.60 and 2.10, respectively, falling below the 3.00 cutoff

point for being considered effective. Approaches such as learners' response to scaffolded learning, teacher-learner interaction and literacy activities, and learner involvement and engagement in the teaching-learning process, scored higher, with means of 4.00 to 4.30, which were considered effective (above the cutoff point).

Education Question 2: How can innovative approaches address inequalities in access to quality education in Early Childhood Mathematics?

S/N	ITEMS	E	V.G	G	F	P	Mean	Remarks
1	Integration of technology and technological-based activities	1	0	1	1	7	1.70	Poor
2	Utilization of play based learning through games	0	0	0	2	8	1.20	Poor
3	Availability and use of physical and firsthand manipulative	0	0	1	1	8	1.30	Poor
4	Application of storytelling and literacy activities	0	1	2	5	2	2.20	Poor
5	Inculcation of structured play and collaborative learning	0	1	4	3	2	2.40	Poor

Key: E= Excellence; V.G = Very Good; G= Good; F= Fair; P = Poor; Cut -Off Point = 3.00

The table above revealed how innovative approaches can address inequalities in access to quality education in early childhood Education. It shows that the Integration of technology and technological-based activities, utilization of play based learning through games,

availability and use of physical and hands on manipulative, application of storytelling and literacy activities, and inculcation of structured play and collaborative learning are all ineffective with mean values all less than 3.00 cut off point to be considered effective.

Research Question 3: What are the challenges by teachers in the effective teaching of Early Mathematics?

S/N	ITEMS	SA	A	D	SD	Mean	Remarks
1	Inadequate instructional aids, games & manipulative slows the teaching learning process	3	4	3	0	3.00	Agreed
2	The wide gap of disparities between learners seems to be unbridgeable	2	6	1	1	2.90	Agreed
3	Poor cultural background & experiences of the learners poses a limitation to the effective teaching of early mathematics	4	3	2	0	3.10	Agreed
4	Spiral curriculum is impracticable due to unhealthy early mathematics background	2	5	2	1	2.80	Agreed
5	Absence of technology -based activities in the classroom can sometimes make the teaching - learning process less efficient or engaging	1	6	2	1	2.70	Agreed

Key: SA = Strongly Agreed, A = Agreed, D = Disagreed, SD = Strongly Disagreed; Cut -off Point = 2.50

The table above revealed the challenges faced by teachers in effective early mathematics. It shows that majority of the teachers agreed that inadequate instructional aids, games & manipulative greatly slows the teaching learning process, the wide gap of disparities between learners seems to be unbridgeable, poor cultural background & experiences of the learners poses a limitation to the effective teaching of early mathematics, spiral curriculum is impracticable due to unhealthy early mathematics background, absence of

technology-based activities in the classroom can sometimes make the teaching - learning process less efficient or engaging with mean values of 3.00, 2.90, 3.10, 2.80 and 2.70 respectively.

Hypothesis Testing

Research Hypotheses 1: There is no significant difference in the effectiveness of various pedagogical approaches (e.g., play-based learning, hands-on learning, technology integration) in enhancing Early Childhood Mathematics Education between public and private schools.

Variables	N	Mean	St. D.	df	t-calc.	t-table	Decision
Public	3	15.67	1.53.	8	-0.591	2.306	Not Significant
Private	7	17.57	5.32				

The table above shows the summary of t-test analysis on significant difference in the effectiveness of various pedagogical approaches in enhancing Early Childhood Mathematics Education between public and private schools. It reveal that since the t-calculated value (-0.591) is less than the t-table value (2.306), the hypothesis which stated there is no significant difference in the effectiveness of various pedagogical approaches (e.g., play-based learning, hands-on learning, technology integration) in enhancing Early Childhood

Mathematics Education between public and private schools is hereby accepted leading to the conclusion that there is no significant difference in the effectiveness of pedagogical approaches between public and private schools.

Research Hypotheses 2: Innovative pedagogical approaches (e.g., storytelling, literacy integration, manipulative-based learning) do not significantly reduce inequities in access to quality education in Early Childhood Mathematics.

Summary of t-test analysis on significant difference between innovative pedagogical approaches and inequalities in access to quality education in Early Children Mathematics

Variables	N	Mean	St. D.	df	t-calc.	t-table	Decision
Innovative Pedagogical	10	17.00	4.49.	8	1.896	2.306	Significant
Access to Quality Education	10	14.50	2.712				

The table above shows the summary of t-test analysis on significant difference between innovative pedagogical approaches and inequalities in access to quality education in Early Children Mathematics. It revealed that since the t-calculated value (1.896) is less than the t-table value (2.306), the hypothesis which states that innovative pedagogical approaches (e.g., storytelling, literacy integration, manipulative-based learning) do not significantly reduce inequities in access to quality education in Early Childhood Mathematics is hereby accepted. Hence, innovative pedagogical approaches (e.g., storytelling, literacy

integration, manipulative-based learning) do not significantly reduce inequalities in access to quality education.

Discussion of Findings

The findings of the study revealed the effectiveness of pedagogical approaches in enhancing early childhood mathematics education. Scaffolded learning, teacher-learner interaction, and learner involvement and engagement were the most effective pedagogical approaches. These findings are consistent with Vygotsky's theory of scaffolding, which posits that learning is enhanced when learners build upon previous knowledge with the guidance of a

more knowledgeable individual, such as a teacher (Vygotsky, 1978). This supports the idea that teachers' active engagement with students and promoting interaction fosters deeper understanding and retention of mathematical concepts. However, approaches such as incorporation of children's cultural background and differentiated instruction were found to be less effective. These findings diverge from scholars such as Gay (2000), who argue that culturally responsive teaching enhances learning by aligning instructional methods with students' cultural contexts.

The findings of the study discovered innovative approaches to address inequalities in access to quality education. It was revealed that innovative approaches like technology integration, play-based learning, and hands-on manipulatives were rated poorly in addressing inequalities. This contradicts earlier research by Bers (2008), who posited that technology integration in early mathematics education improves access and learning outcomes, especially for marginalized groups. The divergence in findings may stem from the lack of adequate infrastructure or training on how to effectively use technology and play-based learning tools in the schools sampled. For example, inadequate access to technology or insufficient teacher training could limit the benefits of these approaches. Additionally, storytelling and collaborative learning also scored poorly. This is in contrast with Aunio and Niemivirta (2010), who emphasize the importance of using storytelling and collaborative activities in improving mathematical skills and closing the performance gap between learners from diverse socioeconomic backgrounds.

The findings of the study also revealed the challenges faced by teachers in early mathematics education. It showed that teachers face significant challenges, including inadequate instructional aids, cultural limitations, and technological gaps, which hampered effective teaching. These challenges resonate with the findings of Agyei and Voogt (2011), who emphasized the importance of resource availability for the successful implementation of innovative pedagogies. The agreement on these challenges also aligns with the UNESCO (2016) report on the barriers to quality education in low-income countries, particularly the lack of access to resources and technology in rural or underserved areas. The inability to bridge the gap between diverse learners was also a significant challenge. This supports the argument made by Darling-Hammond (2010), who contended that disparities in learning outcomes are often exacerbated by the lack of tailored instructional support for students from varying backgrounds. Without sufficient resources and professional development, teachers struggle to implement differentiated instruction that meets the diverse needs of students.

The finding showed no significant difference in the effectiveness of pedagogical approaches between public and private schools, which corroborates findings by Akinsolu (2010) in a Nigerian context. This suggests that regardless of the type of school, the same challenges in pedagogy prevail, due to systemic issues like resource constraints.

The finding showed no significant difference between innovative pedagogical approaches and inequities in

access to quality education. This disagrees with research by Duncan et al. (2015), who highlighted that when well-implemented, innovative teaching methods such as storytelling and play-based learning significantly improve learning outcomes, especially for students from disadvantaged backgrounds.

Conclusion

The study concludes that while pedagogical approaches especially those that emphasize interaction, engagement, and scaffolding are effective in enhancing early mathematics education, others, particularly those involving cultural inclusiveness and differentiated instruction, are less effective in the current context. Innovative methods such as technology integration and play-based learning, although theoretically beneficial, have not been successfully implemented, leading to poor effectiveness in addressing educational inequalities. Teachers face considerable challenges in delivering effective Early Childhood Mathematics Education due to inadequate resources, technological gaps, and a wide range of disparities among learners.

Despite these challenges, the significant difference observed in the hypothesis testing indicates that innovative teaching approaches, if properly implemented and supported, can help reduce inequalities in access to quality education. Therefore, there is a need for systemic changes in terms of resource allocation, teacher training, and infrastructure development to enhance the effectiveness of these approaches.

Recommendations

Based on the findings, the researcher proposes the following recommendations:

1. **Improved Teacher Training:** Teachers should receive ongoing professional development, particularly in the areas of differentiated instruction and the use of technology and play-based learning in early childhood education. This will help them better implement these innovative methods and address the diverse needs of learners.
2. **Increased Access to Resources:** Schools, especially in under-resourced areas, should be equipped with adequate instructional materials, technology, and hands-on manipulatives. Governments and stakeholders should prioritize the provision of these resources to enhance the effectiveness of innovative teaching approaches.
3. **Promotion of Culturally Inclusive Pedagogy:** Given the low effectiveness of incorporating cultural backgrounds in the current study, policy makers should put in more efforts on designing and implementing culturally responsive teaching methods that align with the learners' socio-cultural realities. Training institutes should ensure that teachers are trained in how to integrate students' cultural experiences effectively into their teaching.
4. **Support for Technological Integration:** Schools need better access to technology, including hardware, software, and internet access. Additionally, Government parastatals and training institutions should endeavor to train teachers on how to effectively use technology in teaching mathematics to young children.

5. Reduction of Educational Inequalities: The ministry of Education should scale up innovative pedagogical approaches and support schools through targeted interventions, particularly in underserved communities. Government should enact special programs focusing on equitable access to quality education, ensuring that all children, regardless of socioeconomic background, succeed in early mathematics education.

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