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TEACHING MATHEMATICS THROUGH PLAY BASED LEARNING IN EARLY CHILDHOOD EDUCATION

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Abstract

It has been acknowledged that no single method is suitable for every child and that the early childhood teachers, who are in the greatest position to know them, should decide what is best for each child. Therefore, it will be appropriate to examine the fundamental ideas of suitable and successful mathematics practice rather than suggesting particular methods. Researchers in early childhood education have acknowledged the value of learning through play. Pre-mathematics aims to foster children's interest in mathematics for everyday application as well as their mathematical knowledge, abilities, and values. This paper looked at teaching mathematics through play based learning in early childhood education. Teachers' understanding, pedagogies, and techniques to improve their teaching are necessary for mathematics instruction in early childhood education. The paper also suggested some free Play-Based Activities in learning Mathematics in early childhood education which include Origami, construction of blocks, singing and Music and Who is big, let's eat' game and guidelines for early childhood educators utilising play-based learning to teach mathematics. It was recommended that early childhood educators should make every effort to consider subjects that support play-based learning, review their curricula beforehand to identify areas, in which play-based learning might be included, adhere to the recommendations for teaching mathematics through play-based learning and early childhood educators should receive in-service training on how to teach mathematics through play-based learning.

***Keywords**: Teaching, Mathematics, play-based, early childhood, play-based activities*

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Introduction

Teaching young toddlers requires a great level of skill. Early childhood educators use a delicate and nuanced combination of interactions, pedagogies, beliefs, and provision to teach mathematics. It has been acknowledged that no single method is suitable for every child and that the practitioner, who is in the greatest position to know them, should decide what is best for each child. Therefore, it will be appropriate to examine the fundamental ideas of suitable and successful mathematics practice rather than suggesting particular methods. These ideas stem from the pedagogy statement of the Early Childhood Mathematics Group (ECMG, 2022), which indicates that this unique pedagogy is about apprenticeship, sense-making, and discovery.

In psychology and education, the phrase "learning through play" is frequently used to refer to how kids pick up knowledge from their environment (Puteh & Ali, 2013). Throughout the teaching and learning process, this student-centered method makes use of play activities. According to Bazdis (2008), the best curriculum strategy for kids is learning through play since it connects with their innate traits as play enthusiasts. In order to lead and support their students during play activities, teachers should consider the needs and interests of their students when using this technique (Marouf, Che-Ani & Tawil, 2015).

Researchers in early childhood education and psychology, including Jerome Bruner, Eric Erikson, Lev Semanovich Vygotsky, Maria Montes Sori, and Jean Piaget, have acknowledged the value of learning through play. They claimed that games serve as learning tools and that play is an activity. The majority of preschool-aged children (age's two to seven) are in their preoperational level, according to Piaget's theory, where they learn concepts through object play (Piaget, 1962). Building their ideas and principles through concept understanding enables kids to grasp abstract topics through tangible learning experiences without feeling rushed.

Play is regarded as an integral element of a pupil's childhood; therefore incorporating play into the curriculum can improve teaching and learning outcomes. Children can learn and comprehend the challenges around them in an engaging and significant method through play activities. According to several early childhood development experts, play activities help children's minds develop socially, physically, cognitively, and emotionally (Seifert, 2004). Children can engage in conversations and exchange information with classmates and adults during these activities. Through play activities, they can also progressively adjust to the unfamiliar surroundings (Goldstein, 2012).

Early mathematics instruction is crucial because it lays the groundwork for later comprehension of more complex mathematical ideas (Bakar, 2017). Pupils' enthusiasm in learning mathematics is cultivated when they acquire knowledge of early mathematics through meaningful and direct encounters in a fun setting (Ginsburg et al., 2008). Preschoolers should study concepts like pre-numbers, early numbers, number operations, measurements, shapes, time, and places based on their developmental stages. These are crucial parts of learning early mathematics.

Learning early mathematics starts with the discovery of things like building blocks, making a sand castle and measuring water, according to the National Association for the Education of Young Children (2009). Additionally, children should be able to utilise mathematics as a tool for problem-solving, exploration, and discovery when studying the subject through play-based activities. The most important skill for daily living is mathematical aptitude (Cragg & Gilmore, 2014). Children's fundamental mathematical development starts when they

manipulate numbers in their environment and interact with actual objects or things that have quantity or characteristics like various colours, sizes, and shapes. Piaget (1962) asserts that any typical youngster may grasp mathematics effectively if the activities and approaches are engaging. Children's number concepts are shaped by logical reasoning in mathematics, which calls for experience, social interaction, time, language, and an awareness of the children's views.

Learning mathematics does not occur in a vacuum or apart from other subjects. It is a crucial component of the child's overall development. It is understood to be related to various facets of growth, including linguistic, emotional, social, physical, and personal. In order to practice mathematics in a way that is appropriate for each child's developmental stage and builds upon their specific experiences, it is necessary to use culturally and socially sensitive methods. Pre-mathematics aims to foster children's interest in mathematics for everyday application as well as their mathematical knowledge, abilities, and values (Curriculum Development Centre Lusaka, 2016; Ministry of Education, Science, Vocational Training and Early Education Lusaka, 2013). Learning should be practical since children should manipulate items to learn mathematics. For a strong foundation of mathematical concepts and abilities for subsequent schooling, informal mathematical activities should also be carried out (Nakawa, 2020).

Early childhood mathematics education is essential for children because mathematical skills in the early years are important for learning outcomes and performance in later schooling, and children need to be exposed to challenging and appropriate mathematical learning for their cognitive and affective development (Vogt et al. 2018; Weisberg, Hirsh-Pasek & Golinkoff 2013). There are unique techniques for thinking and acting in mathematics, as well as certain knowledge and ideas that contribute to its uniqueness. Instead than using a diluted kind of pedagogy intended for much older students, these call for developmentally appropriate pedagogies that foster mathematical thinking, knowledge, concepts, and behaviours (Duncan et al. 2007).

How to best educate children and get them ready for a society that is always changing, becoming more technologically advanced, and becoming more globalised is a crucial question in the twenty-first century. Play-based learning is a crucial method. A pedagogical philosophy known as "play-based learning" aims to integrate learning and play. According to Wood (2004), play-based learning encompasses all of the pedagogical choices, methods, and strategies that early childhood professionals employ to support or improve learning and teaching through play, as well as how they plan the play-based learning environment and provide for play and play-based approaches to learning and teaching.

According to earlier research, playing is a crucial component of pedagogy that should be examined in order to support children's cognitive and affective development (Vogt et al. 2018; Worthington & Van Oers 2016; Brandt 2013; Thomas, Warren & De Vries 2011; Vogel 2013). The national curriculum and syllabus of many nations, including some African nations (such as Kenya, Zimbabwe, Zambia, and South Africa), as well as countries in the world (such as Japan, Korea, Germany, and Australia), place a strong emphasis on the value of play in teaching and learning because it is essential for the development of young children.

Activities that people or groups voluntarily pursue for their own delight are referred to as play. It has a significant impact on the emotional, social, and cognitive development of children (American Psychology Association, 2022). Children learn self-control, language, numeracy, and social and cognitive skills through play (Meaney et al., 2014; Copple & Bredekamp, 2009). Montessori, Reggio Emilia, and Froebel all saw play as a successful

pedagogy for children's learning since children learn while they play (Samuelsson & Carlsson, 2008).

Several studies on playing have highlighted the significance of a connection between playing and children's culture and environment (Worthington & Van Oers, 2016). Play has been considered a vehicle for learning that is important for children in terms of their mental and physical development (Vogt et al. 2018; Singer 2013; Hauser 2005). However, the meaning and interpretation of playing at the implementation level differ depending on social and cultural settings.

Commercial arithmetic, algebra, numbers, geometry, and measures are all included in pre-mathematics at the reception level. Children are specifically given the chance to draw and pronounce the names of various shapes, including squares, triangles, rectangles, and circles, in their native tongues when it comes to the syllabus and textbooks on shapes (Ministry of Education, Science, Vocational Training and Early Education Lusaka, 2013).

According to Clements and Sarama (2011), geometry has gotten less attention in early childhood education in the United States than numbers and calculations. This is also true for the rest of the world. According to recent research on geometrical thinking, geometric form is crucial in early childhood education in general (Villarroel & Ortega, 2017). The significance of teaching geometry in early childhood mathematics education was further emphasised by Clements and Sarama (2011), who noted that it also helps children comprehend number and arithmetic concepts (Arcavi, 2003). Additionally, Clements and Sarama (2014) identified some critical elements pertaining to children's shape knowledge.

First, culture has an impact on children's shape choices. Children in the United States have a preference for symmetrical, closed shapes. The second is that youngsters learn about shapes through play and are capable of much more than just memorising the names of different forms. Similar to this, Cohrssen et al. (2017) underlined the importance of geometry and spatial reasoning in early childhood mathematics instruction. Nevertheless, geometry has been largely disregarded, and teachers have not provided opportunity for children to improve their thinking skills. The writers did not focus on two-dimensional shapes; instead, they primarily addressed children's spatial reasoning.

According to Villarroel and Ortega's (2017) research, the development of children's graphical expression skills is accompanied by the usage of geometric shapes in early childhood mathematics. These investigations showed that young children may relate to forms in a variety of ways before starting primary school. However, neither the creation of form lessons nor the impact of the children's cultural background on their shape learning in the classroom was the main topics of their discussion.

When specific learning objectives are set and children receive adult assistance in learning new things, guided play is a successful approach. While free play can help young children become familiar with mathematical concepts in their surroundings, it is also necessary for them to learn new concepts in the classroom because some mathematical concepts are difficult for them to understand without adult help or intervention. The supervision of adults, such as instructors, is also essential in guided play. This is due to the fact that whether or not guided play can assist children in meeting the learning goals established in the classroom depends on the support of adults (Weisberg et al. 2013).

A child's early years are a very formative time in their lives, and learning mathematics is essential to ensuring that their eventual academic success reflects their capacity for creativity,

critical thinking, and analysis in the classroom. Historically, maths has been viewed as unsuitable for early childhood teaching. According to Ginsburg (2009), preschoolers are thought to be cognitively incapable of thinking mathematically or of learning the subject on purpose. Accordingly, formal education in mathematics has generally been delayed until the first grade (Starkey et al., 2004).

But as the twenty-first century has begun, the focus has shifted to producing convincing evidence that children possess a high degree of mathematical proficiency from birth and that their ability to abstract is determined by their cognitive development in early childhood education (Alsina & Salgado, 2021).

Developmental psychologists now focus on what young children can achieve rather than what they can't do (Hachey, 2013). Accordingly, children from birth until they start primary school are typically the focus of current research on early childhood mathematics (Björklund et al., 2020). Psychologists' perspectives on teaching maths to children have evolved, and they are currently creating new curricula dedicated to enhancing mathematical proficiency from infancy (Sarama & Clements, 2009).

Early childhood mathematics education has garnered increasing international attention in recent years (Tsamir et al., 2011), and it is now regarded as crucial for addressing the needs of a knowledge-based society and overcoming mathematical illiteracy (Clements & Sarama, 2013). According to this consensus on the importance of mathematics education, teaching maths to young children has numerous benefits for them in the short and long term at school. Since mathematics proficiency is the best indicator of future success in the subject, early childhood education is crucial (Simoncini et al., 2020; Watts et al., 2018).

Early acquisition of mathematical abilities can improve academic performance and adult employment prospects (Lee, 2017; Anders and Rossbach, 2015). Accordingly, fostering children's mathematics skills early on is essential to ensuring their long-term academic performance (Watts et al., 2018). Teachers' understanding, pedagogies, and techniques to improve their teaching are necessary for mathematics instruction in early childhood education (MacDonald et al., 2021: Murphy et al., 2019).

In order to align daily activities with curriculum objectives and modern teaching methods, teachers must have a thorough understanding of early childhood mathematics, as well as an awareness of the needs of young children, curiosity, ability, creativity, critical thinking, and problem-solving skills and comprehension (Wood & Hedges, 2016). Using grade-appropriate tests given to all students over the course of two consecutive school terms, Murtagh et al. (2022) investigated the relationship between play-based learning and mathematical achievement in Palestinian elementary school students. Forty teachers from eight schools received training in play-based pedagogies and follow-up support visits from program staff, while four matched schools served as the control group. The results showed that the intervention group outperformed the control group in both terms.

Importance of play-based learning in teaching mathematics in early childhood

1. Constructive play is an excellent way to teach mathematical concepts including geometry (shapes), fractions, space, and area.
2. Through play pedagogy, kids acquire basic ideas and positive attitudes towards science and math (Henniger, 2012).
3. Young learners' linguistic, fine motor, gross motor, and personal-social abilities are all developed through play-based mathematical education.

4. Developing the early foundation of mathematical concepts is relevant for future educational outcomes (Vogt et al., 2018);
5. Learning mathematics in early childhood helps to build a strong base for understanding higher mathematical concepts (Bakar, 2017)
6. Mastery of number concepts in early childhood education lays the groundwork for advanced mathematical skills in primary and secondary schools.
7. Organised play pedagogy can be used to address early level issues with number ideas and operations (Chin & Zakaria, 2015).
8. The use of play pedagogy in early childhood education has a lasting beneficial impact on students' acquisition of more complex mathematical concepts.
9. Students can apply mathematical skills to solve problems in everyday life when they are taught using play pedagogy (Cragg & Gilmore, 2014).
10. Children learn to arrange and match blocks by building specific structure
11. Block games are another way that kids learn addition, subtraction, multiplication, and division.
12. By improving balance and hand-eye coordination, playing with blocks also helps young children comprehend addition, subtraction, and division (Goldstein, 2012).

Free Play-Based Activities in learning Mathematics in early childhood education

Origami: In early childhood education, there are a variety of play-based math learning activities, such origami. Origami is a Japanese paper folding technique that comes from the Japanese words "ori," which means folded, and "gami," which means paper (Ramirez, 2015). Despite being frequently linked to Japanese culture, origami has always been a part of the world. In western nations, the practice of folding paper into various shapes and sizes is also referred to as "paper crane." Although paper folding has been practiced since the Edo period (1603-1867), origami has developed into a modern invention that allows for the creation of complex designs without the need for paper cutting (Sakamoto & Okada, 2013).

There are other creative designs that include electronics to enable the origami shapes to move. It is therefore not surprising that origami is used in preschools around the world as a creative activity for kids, but also because it helps them develop their cognitive, affective, and motor skills as well as their understanding of space and area (Brady, 2008). The art of paper folding has many applications, particularly in mathematics. Preschoolers can benefit greatly from origami, particularly while learning geometry, as they sometimes struggle to comprehend mathematical formulae and applications. Children can enjoy themselves while solving mathematics problems in an organised and methodical manner by using origami (Oguz, 2016).

Origami can improve a variety of mathematical skills in children, according to Ramirez (2015). According to the National Centre for Education Statistics (2003), geometry is one of the weakest areas of mathematics among students. Including origami in learning activities has been shown to increase children's understanding of formulas, labels, and geometrical concepts while increasing their interest in studying. Additionally, origami stimulates students' thinking skills and other learning modalities, such as the art of folding paper, which has been shown to improve children's spatial visualisation skills through hands-on experience (Ku & Jie, 2012).

Another subject that most students are afraid of is fractional operations and concepts. Fractions can be illustrated in a tactile and tangible way with origami. By simply folding the paper into the appropriate forms, students can use origami to demonstrate fraction concepts like half, one-third, or one-quarter (Figure 1) (Huang, 2012). The paper can also be folded

continually to represent the concept of infinity. Additionally, by requiring kids to solve problems through trial-and-error tries, origami helps them develop their problem-solving abilities (Koning & Tabbers, 2011).

Preschool teachers can choose a random shape and ask the kids to copy the arrangement; there are several ways to get the desired form or pattern, and there isn't a wrong answer.

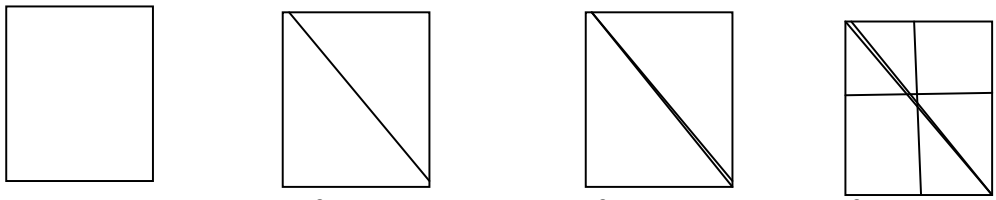


Figure 1: Fraction through paper folding.

According to research by Brady (2008), children who employ origami principles do better in mathematics since they are frequently utilised to enhance children's manual dexterity and support mathematical topics like geometry and algebra. Depending on how intricate the patterns are, origami may be entertaining and addictive as well as difficult. Because origami has no age restrictions, anyone can use it, from kids to adults. Adults can use it to develop their creativity and focus, while kids can appreciate learning maths in new ways. It is anticipated that origami will enhance users' competency and durability in this cutthroat environment by utilising the entire spectrum of knowledge and abilities required for this craft of paper folding (Ramirez, 2015).

Construction of Blocks: Children's intellect, social skills, physical development, and creativity all benefit from playing games that are appropriate for their developmental stage (Chin & Zakarian, 2015; Goldstein, 2012). Through unstructured "play" activities, kids can develop their creativity and critical thinking skills. In addition to origami, building blocks (Figure 2) are frequently used to help kids develop their mathematical abilities because they are both cost-effective and well-liked by kids.

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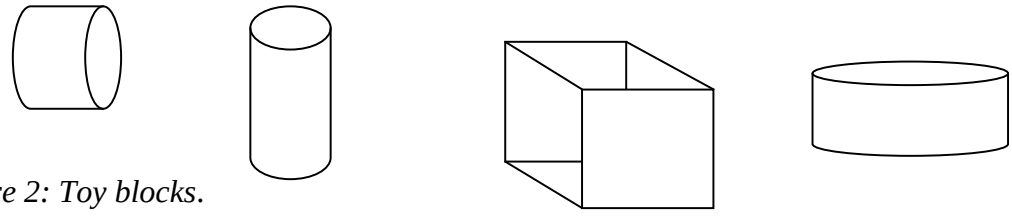


Figure 2: Toy blocks.

This activity's adaptability lets kids use their imaginations freely by varying the ways they can play. In addition to learning how to create shapes with blocks, children will also learn about balance, mathematical principles, construction techniques, and even how to solve problems (Drew et al., 2008). In terms of social interaction, block games motivate kids to

collaborate more with their peers (Lynch & Simpson, 2010). For younger kids, playing a game with building blocks can be their first group activity, and for older kids, it teaches them the value of working together to solve problems.

Block games can benefit youngsters in their physical development when they handle, organise, and match corresponding blocks to form a specified structure (ECA Council, 2003). In addition to strengthening their grasp, the exercise improves their hand-eye coordination. Block games also assist preschoolers in learning addition, subtraction, multiplication, and division, among other mathematical topics. Younger children will pick up words like colour, size, form, and position, while school-age children learn about gravity, geometry, and balancing. Children can also construct structures using their imaginations when playing block games (Goldstein, 2012). They could feel the fulfilment that comes from making their own innovations.

Singing and Music: Mathematics is always a hard and challenging subject among young children, but this view might go away if teachers play a different pace from the typical classes. The secret to teaching maths in preschools is to make every lesson as engaging, innovative, and fun as possible. Using singing or lessons with musical accompaniment is other strategy preschool teachers can use to teach maths to their students. According to research, when teachers employed rhythms and particular tempos in songs and chants, students learnt more quickly and effectively (Neila, 2013). Therefore, combining singing and music is a fun way for kids to learn about maths while also developing their language and listening skills.

Music and mathematics have a strong and lasting relationship, especially in the early years (Awopetu, 2016). The fact that young children have been unintentionally learning maths in their early dance and music programs further heightens the excitement. Geometry is one of the mathematical concepts taught through music, where kids learn the fundamentals through dancing, playing instruments, and following patterns. Children's spatial-temporal thinking abilities and spatial awareness are enhanced by movements that follow a specific paradigm, such as "front and back" and "in and out," which are crucial for the development of their mathematical foundation (Deasy, 2002).

In addition, kids can discover patterns in music and mathematics. According to Kenney (2005), simple chants and rhymes can help young children learn to comprehend and manipulate models. Children can recognise various musical elements by listening to segments of the song. As a result, when children are exposed to mathematical patterns during lessons, their comprehension improves. Additionally, a child's early childhood mathematics curriculum might incorporate a variety of counting rhymes, number songs, and finger activities. Counting steps in dance and playing musical instruments introduce toddlers to both music and mathematical ideas in their early stages of learning.

For example, the lyric of Once I Caught a Fish Alive song represents a counting rhyme for young children learning about numbers.
One, two, three, four, five
Once I caught a fish alive,
Six, seven, eight, nine, ten,
Then I let it go again.
Why did you let it go?
Because, it bit my finger so.
Which finger did it bite?

This little finger on my right.
(Count from 1 to 10)
One, two, three, four, five,
Once I caught a fish alive,
Six, seven, eight, nine, ten,
Then I let it go again.

1. **Who is big, let's eat' game**

Who is big, let's eat' is an example of employing play pedagogy in teaching geometry, number ideas, and mathematical operations in early years. 'Who is huge, let's eat' is utilised for establishing the number concept. The green cards (1–10) and red cards (1–10) are both face down on the table in this play. This play involves two students, one of whom chooses a number from a red card and the other from a green card. After comparing the cards, the teacher decides which number is larger and will be eaten (imaginary). Children acquire number concepts in this way (Chin & Zakaria, 2015). Children can also learn about numbers through music and singing. For this reason, the early childhood curriculum should incorporate finger play, counting rhyme, and number songs. By counting dancing steps and playing instruments, kids can learn mathematical, melodic, and pattern concepts (Kenney, 2005).

Guidelines for early childhood educators utilising play-based learning to teach mathematics

i. Teachers ought to foster children's curiosity, curiosity, engagement with the world, and creative approaches to problem-solving (Izumi & Taylor et al., 2014).
ii. In the early grades, elementary mathematics should be taught with materials such as measuring water, sandcastles, and building blocks (Cragg & Gilmore, 2014).
iii. Early childhood education should use a variety of play activities to teach mathematics.
iv. Children's physical, mental, creative, and social skills all benefit from the proper play chosen for the suitable subject (Chin & Zakaria, 2015).
v. Practitioners' understanding of the normal developmental paths in mathematics should influence early mathematics practice.
vi. Young children learn mathematics through play, and they require time to: (i) engage with adults while playing; (ii) follow and develop their own ideas and choices; and (iii) take part in episodes that are led by adults.
vii. Teachers need to recognise that diverse child groups have different needs and cultures.
viii. Teachers should also understand that running a classroom calls for multitasking, quick decision-making every day, and flexibility and adaptation to unforeseen circumstances.

Conclusion

One could draw the conclusion that play-based learning is a successful approach to teaching mathematics in early childhood education since it helps students develop their number concepts, construct imaginative structures, improve their mathematical abilities, and comprehend addition, subtraction, and division.

Recommendations

The following suggestions were put forth to make mathematics in early childhood education more engaging:

1. Early childhood educators should make every effort to consider subjects that support play-based learning.

2. Early childhood educators should review their curricula beforehand to identify areas in which play-based learning might be included

3. Early childhood educators should adhere to the recommendations for teaching mathematics through play-based learning.

4. Early childhood education maths instruction should be more play-based and practical than theoretical.

5. Early childhood educators should receive in-service training on how to teach mathematics through play-based learning.

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