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# Enhancing Mathematical Skills of Learners in the Early Childhood Phase Through Play-Based Learning: A Review of Literature

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**Abstract**

This theoretical article examines the crucial role of play-based learning (PBL) in enhancing the mathematical skills of children in the Early Childhood Phase, referred to as Foundation Phase (Grade R-3) learners, within a South African context. The article argues that the traditional approach to teaching early childhood mathematics, where teachers typically instruct while learners listen and repeat, is often rigid and lacks engagement. For learners to thrive in mathematics and truly comprehend the subject, they need to be actively involved in 'doing' mathematics. PBL is an approach to teaching and learning that uses various forms of play as a medium for learning. The objectives of the article are: a) to explore alternative methods for teaching mathematics to learners in the Early Childhood Phase, and b) to highlight the benefits and value of play as a mode for teaching and learning mathematics. As a theoretical paper, it does not include a methodology section; rather, relevant literature was analysed to support and justify the claims and to address the research questions. The study found that PBL can enhance the development of the vestibular system, which can positively impact learners' cognitive abilities, including mathematical skills. The study is significant for both learners and teachers in the Early Childhood Phase, as it provides an opportunity for teachers to utilise alternative, play-related, and enjoyable methods to teach mathematics. The paper concludes that a child-centred, play-based curriculum encourages and promotes learning in a playful setting through discovery, investigation, problem-solving, imaginative thinking, and creative thinking.

**Keywords:** Foundation Phase, Early Childhood Phase, mathematical skills, mathematics, play-based learning, play

## 1. Introduction and Background

Early childhood education (ECE) refers to a comprehensive approach to education policies and programmes for learners from birth to approximately nine years of age (Department of Education, 2001; Denham, Bassett, & Zinsser, 2012). Basic education in South Africa consists of four phases: phase 1 is the Foundation Phase (Grades R–3), which is part of the Early Childhood Phase; phase 2 is the Intermediate Phase (Grades 4–6); phase 3 is the Senior Phase (Grades 7–9); and the fourth phase is the Further Education and Training Phase (Grades 10–12). Foundation Phase and Intermediate education are provided by primary schools, which can be independent or public institutions. The Foundation and Intermediate phases form part of ECE. Grade R is the reception year, the year before formal schooling (Meier & Machaba, 2021; Department of Basic Education, 2011). Three subjects are compulsory in the Foundation Phase in South Africa, namely, mathematics, life skills, and languages. Education provided for Grade R is more informal, and the subjects should be taught through PBL (Department of Education, 2001). However, PBL should not be limited to Grade R but should also be implemented in other grades, especially Grades 1, 2, and 3. This paper is grounded in Vygotsky's Constructivist Learning Theory, which argues that social interaction through engagement promotes cognitive development and a better understanding of the world.

The paper argues that traditional, authoritarian methods of teaching mathematics are often formal, rigid, boring, monotonous, and lack engagement (Landsberg, Krüger, & Swart, 2019; Vogt, Hauser, Stebler, Rechsteiner, & Urech, 2020). Therefore, teachers need to employ more stimulating, engaging, exploratory, enjoyable, and rewarding approaches to teaching the subject in order to foster a better understanding and appreciation of mathematics. One such approach is play-based learning (PBL). Research indicates that young learners, particularly those in the Early Childhood Phase, can benefit from PBL due to its considerable value and advantages (Del Toro Alonso, Gútiez Cuevas, & Torres González, 2021; Catalano, Albulescu, Stan, Mestic, & Ani-Rus, 2023; De Witt, 2021). The Early Childhood Phase is the period when learners begin to develop foundational mathematical skills

that they will utilise and build upon throughout their schooling years and beyond. Consequently, it is crucial that their understanding of mathematics is firmly established during this phase. In the early grades, learners should encounter mathematical experiences that provide numerous opportunities 'to do, talk and record' their mathematical thinking (Meier & Machaba, 2021; Dicker & Naude, 2019). Although this paper focuses on the teaching of mathematics in Early Childhood, it should be noted that the Early Childhood curriculum is integrated, and subjects are interrelated. Therefore, PBL can also be applied to teaching other subjects within the Early Childhood Phase.

Much research reports on the significance of play-based instruction and learning in pre-school education and in Grade R, but limited research examines PBL for Grades 1-3 (Vogt et al., 2020; Dicker & Naude, 2019). Therefore, this paper focuses on PBL and the teaching of mathematics in the Early Childhood Phase. The aim of the study was to explore the main research question:

How does the implementation of play-based learning strategies influence the development of mathematical skills in the Early Childhood Phase?

This article explores:

a) PBL and teaching as an alternative approach to teaching mathematics in the Early Childhood Phase; and

b) the benefits of PBL for teachers and learners in the Early Childhood Phase.

The significance of this research is substantial for both learners and teachers in the Early Childhood Phase, as it centres on exploring the transformative impact of learning through play on the mathematical abilities of learners. By proposing PBL as a viable alternative to conventional teaching methods, the article presents teachers with a fresh perspective on improving mathematics instruction in the Early Childhood Phase. This approach has the potential to foster genuine enthusiasm for mathematics in learners as they engage in enjoyable activities and interactive exercises that promote a deeper conceptual understanding of mathematical concepts. The study paves the way for more engaging and effective educational methodologies by highlighting the limitations of conventional teaching methods and suggesting an alternative that uses play as a vehicle for learning.

As teachers, we realised that many learners in the Early Childhood Phase and beyond struggle due to inadequate mathematical skills. This deficiency often stems from challenges in grasping fundamental mathematical and numerical concepts. A significant portion of these learners do not find mathematics engaging, largely due to the prevalent use of the conventional "teach and listen" approach to teaching. The reliance on rote learning and memorisation further compounds these difficulties. This study delves into a theoretical exploration of the important role that PBL plays in aiding Early Childhood learners in improving their mathematical skills. The conventional approach to teaching mathematics in the Early Childhood Phase, which relies on teacher-directed instruction and repetition, has limitations due to its lack of learner involvement within the pedagogical context. The absence of key elements, such as engagement and enjoyment, hampers the effectiveness of this approach, making it difficult for learners to excel in and comprehend mathematical concepts. To address this challenge, learners need to actively engage in learning mathematics, rather than being passive recipients of information that they simply repeat (Gocheva-Ilieva, Kulina, & Ivanov, 2020). To tackle this issue, this article underscores PBL as a pedagogical approach that seamlessly integrates play into the teaching of mathematics.

## 2. Theoretical Framework

The theoretical framework that underpins this study is Vygotsky's Constructivist Learning Theory. This theory comprises three stages:

a) *cognitive learning:* involves thinking about concepts and ideas, such as mathematical concepts;

b) *motoric learning:* entails doing activities to understand concepts or ideas, for example, playing with puzzles or blocks;

c) *socio-cultural learning*: occurs through interacting with others while learning; play provides a valuable social context that can foster interaction with more knowledgeable individuals, such as teachers.

Vygotsky asserts that playful learning creates a zone of proximal development (ZPD) where learners are motivated to learn and are encouraged to do so while being guided and assisted by teachers (Mokoena & Materechera, 2015). This theory is pertinent to this study, as Landsberg et al. (2019) acknowledge that the constructivist view necessitates a shift from the traditional approach of direct, formal teaching to a more facilitative role by teachers in the learning process. In this approach, learners are required to be actively engaged in activities (e.g., through playing) that support their understanding of mathematics.

Figure 1. Play-based learning

## 3. Literature Study

### *3.1 Play-Based Learning*

PBL is an approach to teaching that involves using various forms of play as a means of learning (Catalano et al., 2023). Play is widely recognised as a way to engage learners in their own learning, especially during early childhood years (Murtagh, Sawalma, & Martin, 2022). This child-centred approach emphasises the importance of active physical participation, exploration, and discovery by engaging learners in playful activities such as games, puzzles, and other hands-on experiences (Catalano et al., 2023). PBL focuses on the "unplugged method," where learners engage in play through physical activities without the use of technologies like tablets or computers. Play is considered the most effective way for young learners to acquire knowledge, as it combines enjoyment with self-motivation (Preedy & Sanderson, 2018). Through play, learners develop their understanding of themselves, the world, and life, as well as relationships between objects and people, which can result in a deep understanding. Learners gain age-appropriate experiences through play that contribute to their overall development and learning (Catalano et al., 2023). Play provides learners with opportunities to express and work through challenges, helping them to find ways to address them (Preedy & Sanderson, 2018). Moreover, play fosters numerous opportunities for developmental growth. It stands as a primary activity in which learners participate and enjoy, forming the foundation for holistic development across physical, mental, social, and emotional domains. Play acts as a bridge that connects cognitive, emotional, and physical development (Murtagh et al., 2022; Taner Derman, Şahin Zeteroğlu, & Ergişi Birgül, 2020), offering tactile, proprioceptive, vestibular, visual, and auditory development opportunities (Del Toro Alonso, Gútiez Cuevas, & Torres González, 2021). PBL can enhance the development of the vestibular system, which positively impacts learners' cognitive abilities, including mathematical skills (MacKenzie & Carolan, 2019). Proper vestibular function is essential for balance, spatial control, and athletic performance. A vestibular system that functions poorly may cause delays in motor skills and negatively affect classroom activities. According to De Waal (2019), academic performance, particularly in mathematics, is influenced by learners' balance and coordination.

According to research, learners are most effective when they are actively engaged in the learning process. Learning should occur in a socially interactive environment, connect to prior knowledge, and be applicable to the world they live in. Such an approach should provide opportunities for learners to explore and discover, while also offering guidance and meaningful feedback to help them achieve the desired learning outcomes (Murtagh et al., 2022). Interactive media, as part of a PBL tool, can serve as an educational aid in early childhood, enabling teachers to innovate with digital media to enrich learning experiences across various knowledge areas, thus helping learners engage more fully in the learning process. This approach is particularly effective when it involves child-centred, play-oriented, hands-on activities aligned with curriculum goals (Papadakis, 2020). When learners first encounter concrete experiences, they develop abstract thoughts, which contribute to intellectual growth. Many learners struggle with reading and writing because they lack the experience of engaging with concrete movement activities, such as playing with shapes, lines, ordering, rhythm, sequencing, and numbers. This gap in abstract reasoning often stems from the introduction of abstract concepts before learners have had the opportunity to physically experience them, particularly before the age of six (De Jager, 2020).

In addition to providing information about the body and movement, the vestibular system and proprioception serve as the primary relays for all other sensory information. A well-functioning vestibular system is crucial for learners' conceptual understanding and learning. Movement is essential for the vestibular system’s development in order for it to work and function properly. Through constant movement, learners can fully engage all their senses, particularly the vestibular system. Movement is highly important for the development of a well-functioning human body.

Movement awakens the senses, strengthens the vestibular system, and supports interhemispheric integration.

Frequent exposure to physical activities and sensory input can help learners achieve neurodevelopmental maturity (Karabulut, 2013). While having fun, learners repeat and correct various movements repeatedly, supporting the natural development of praxis by allowing learners to play (De Jager, 2020).

According to Ellis et al. (2019), studies show that learners perform better in mathematics and reading activities if they engage in extra physical activities. Learners use the medium of PBL to explore, experiment, and be creative during the learning process. By allowing learners to manipulate and investigate objects without adult interference during exploration, they develop, learn, and discover in their own way (Catalano et al., 2023). The early childhood development phase in education is a crucial stage that lays the groundwork for academic and social success. Catalano et al. (2023) report that learners who participated in a play-based programme performed better across all academic areas than those in more academic programmes. Playing and learning involve processes that shape the brain's architecture; practice and repetition may lead to the pruning and editing of neural connections, while exploration, repetition, and review support the formation of new connections and more complex neural networks (Wood, 2013). STEM (science, technology, engineering and mathematics) as part PBL, encompasses evidence-based knowledge and practices in science, technology, engineering, and mathematics. Learners engage in practices that promote inquiry-driven thinking, enabling them to solve real-world problems through authentic learning experiences (Papadakis, 2020). There is evidence showing how early exploration, observation, and comparison in play influence learners' later STEM learning. Play involving counting and other basic mathematical operations helps young learners approach formal mathematics with greater confidence (Walsh, McGuinness, & McMillan, 2017).

Figure 2. Cognitive development

### *3.2 Motor Development and Cognitive Development*

Movement is the product of a well-coordinated brain and a medium through which learners engage with and comprehend the world (Blythe, 2017). Conventional classrooms require learners to sit still and only listen to the teacher. However, many learners crave movement (Tancredi, Wang, Li, Yao, Macfarlan, & Ryokai, 2022). Motor skills are sequences of movements that generate effective actions in order to master and complete a particular task (Fernández-Méndez, Contreras, Mammarella, Feraco, & Meneghetti, 2020). For the brain to handle the challenges of formal education effectively, it requires exposure to and the acquisition of skills in a diverse range of sensory and motor experiences (Karabulut, 2013). Through active exploration and interaction with others, learners acquire a variety of cognitive skills, including problem-solving, critical thinking, adaptability, and self-control, in the context of play (Catalano et al., 2023). Learners require movement for their physical and cognitive development. Motor and physical functions are two of the most important aspects of human behaviour necessary for conceptual understanding (Flores, Coelho, Mourão-Carvalhal, & Forte, 2023). Certain cognitive and motor tasks involve the simultaneous activation of the prefrontal cortex, cerebellum, and connection structures, indicating a connection between motor and cognitive development. As a foundation, motor-exploratory competence generates a developmental process that may influence cognitive development, which, in turn, may impact academic achievement (Fernández-Méndez et al., 2020). Fine motor skills are movements produced by small muscle groups engaged in precise activities, indicating two different competencies: motor coordination and visual integration, as well as their integration (Flores et al., 2023).

According to Fernández-Méndez et al. (2020), several studies indicate a correlation between motor proficiency and academic success across a variety of academic fields. When learners are engaged, their curiosity and creativity are stimulated. When learning is enjoyable, learners spend more time exploring, investigating, and learning through play (Catalano et al., 2023).

Learners develop mathematical skills during the Early Childhood Phase through PBL. During this phase, learners engage in various forms of play, such as manipulative play, constructive play, and socio-dramatic play, which

provide opportunities for exploration, problem-solving, and imaginative thinking (Fernández-Méndez et al., 2020). Neural networks are influenced by physical activity, resulting in significant cognitive gains. Certain cognitive and motor regions of the brain are simultaneously activated during mathematical problem-solving (Flores et al., 2023).

Figure 3. Mathematical development

### *3.3 Mathematical Development*

Early childhood learners naturally integrate mathematical concepts into their everyday lives, developing complex mathematical knowledge. Early childhood education provides an enriched learning environment in which learners actively engage in mathematical activities through PBL. Learners' interests in their daily activities serve as their first encounters with mathematics, fostering mathematical development and thinking (Lavidas, Apostolou, & Papadakis, 2022). It is important to involve learners in mathematical activities from an early age. The introduction of mathematical activities at an early childhood level will help learners to develop a positive attitude towards mathematics and an understanding of how they will use it in the future. Learners do not naturally understand mathematics; they need informal encounters, such as PBL, to become aware of mathematical concepts. Learners must gradually learn and use mathematical concepts during the Early Childhood Phase, where they acquire fundamental concepts that will serve as the basis for more complex mathematical ideas later in their academic careers (Taner Derman et al., 2020). The foundation for reading and success in mathematics and science in secondary school is built when learners engage in movement-based activities and games before entering Grade 1 and when they use their creativity to solve problems (De Jager, 2020)

Mathematics is a critical subject that forms the foundation of various disciplines. Before entering school, learners develop mathematical skills through numerals and quantities. As a prerequisite for mathematical reasoning, this typically involves an informal acquisition of knowledge known as basic numerical skills (Flores, Coelho, Mourão-Carvalhal, & Forte, 2023). Mathematical skills are an important tool for the development of cognitive, creative, logical, and problem-solving abilities, as well as critical thinking skills (Taner Derman et al., 2020).

In the Early Childhood Phase, mathematical tasks are based on concrete and practical activities requiring the manual manipulation of objects and body movement to comprehend mathematical principles, such as categorising and arranging objects and numbers (Fernández-Méndez et al., 2020). Learners' motor abilities at specific stages in their development can provide teachers with valuable insight into their developmental levels and the reasons behind their actions (Blythe, 2017). Play activities can be employed to make mathematics enjoyable. Mathematics is present in our daily lives - we find examples of mathematical ideas when we are cooking, watching football, and tracking the passage of time (Taner Derman et al., 2020). To prevent mathematics anxiety in learners, or to reduce it if already present, strategies such as the use of creative materials and play-based activities, as well as small group teaching, can demonstrate the connection between mathematics and daily life. Learners have the opportunity to develop basic mathematical concepts through play-based activities, which also allow them to expand their language skills by introducing new words and ideas (Taner Derman et al., 2020). Teachers who regularly use play-based activities and deliberately focus on the underpinnings of mathematical concepts report that learners show greater confidence in their mathematical thinking (Cohrssen, Church, & Tayler, 2016).

## 4. Findings

This research presents a compelling argument for altering the way mathematics is typically taught during the Early Childhood Phase. This study contributes to the conversation about educational approaches and their effects on learners by demonstrating how PBL can enhance cognitive development and mathematical abilities.

Ultimately, the study supports an urgent plea for a paradigm shift towards learner-centred, play-oriented instruction, which could transform the way mathematics is taught in the Early Childhood Phase. The findings of the article emphasise the necessity for a child-centred, play-based curriculum that not only promotes learning but also fosters

exploration, investigation, problem-solving, imaginative thought, and creativity. As a result, learners are likely to not only understand mathematical concepts more deeply but also develop a passion for the subject. Through this holistic, child-centred, play-based approach, teachers may pave the way for a new era of mathematics education that equips learners with the skills and enthusiasm necessary for future success.

## 5. Conclusion

Mathematics is a fundamental part of our everyday lives and is a basic skill needed to cope with life. It is well established that Foundation Phase learners (early childhood learners) in South Africa perform at a lower level in mathematics compared to their counterparts in the rest of the world (Naude, 2017). The reasons for this poor performance are multifaceted. One contributing factor appears to be the manner in which mathematics is often taught in the Foundation Phase (early childhood phase). In many schools, learners are taught through a tell-and-listen approach, which is teacher-centred and does not allow for active engagement and exploration of mathematical activities and concepts. As a result, learners are not motivated to learn mathematics because they do not enjoy it, and they find some mathematical concepts difficult to grasp. This study argues that the conventional, traditional approach to teaching young learners is limited and proposes that more focus should be given to PBL due to its numerous advantages. Play can be used as a mode of learning for young learners in all their subjects, particularly in the learning of mathematics. It thus has cognitive and educational value because it promotes the understanding of certain mathematical concepts.

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Both authors contributed equally to the paper.

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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No additional data are available.

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