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PEDAGOGIES OF PLAY AND PARTICIPATION: TEACHERS' PRACTICES IN SUPPORTING NUMBER SENSE IN EARLY MATHEMATICS

Roy Venketsamy

Associate Professor, Department of Early Childhood Education, University of KwaZulu-Natal, South Africa

Abstract

Background: Play-based pedagogy represents a fundamental shift from traditional, structured instruction toward a learner-centred approach in early mathematics. Drawing on the philosophies of Fleer and Montessori, this approach posits that mathematical concepts are best internalised through discovery rather than rote learning. Despite its importance, mathematics is frequently perceived as a daunting subject, often instilling anxiety in young learners from an early age. This study argues that framing mathematics as a dynamic "game of numbers" can mitigate this phobia and foster a more positive attitude towards the subject. Guided by Vygotsky's Social Development Theory, this research explored how social interaction and communication facilitate mathematical understanding. The primary objective of this article is to investigate Grade 1 teachers' experiences in implementing play-based pedagogy to teach number sense, and to explore how social interaction within play supports young learners' mathematical understanding, confidence, and positive attitudes toward mathematics.

Method: A qualitative approach, situated within the interpretivist paradigm, was employed to investigate the experiences of four Grade 1 teachers from primary schools in Mpumalanga Province, South Africa, regarding the implementation of play-based strategies for teaching number sense.

Results: The findings indicate that play-based pedagogy significantly enhances learners' confidence and ease in grasping foundational numerical concepts. Through social interaction, learners developed critical problem-solving skills and showed increased capacity for critical thinking and decision-making.

Discussion: The evidence suggests that communicative play serves as a vital channel for mathematical literacy. Therefore, this paper recommends that play-pedagogy be formalised in early grade mathematics to ensure a robust cognitive and affective foundation for future learning.

Keywords: Early Grade Mathematics, Interpretivist Paradigm, Number Sense, Play-based pedagogy, Social Development Theory

1. Introduction

Early mathematics education plays a critical role in shaping early grade learners' long-term academic pathways and their capacity for analytical thinking and problem-solving (Chen, 2025). Despite the importance of mathematics in the early grades, Stoehr (2017)found that mathematics is often perceived as difficult and intimidating, a perception that can give rise to anxiety at an early stage and impede both participation and conceptual understanding. Therefore, the author opines that teacher-centred approaches that rely heavily on repetition, memorisation, and procedural drills may secure short-term performance, but they seldom nurture curiosity or deep mathematical insight. Therefore, contemporary scholarship increasingly calls for learner-centred pedagogies that foreground engagement, exploration, and the active construction of meaning (Bowie & Graven, 2024; Spaull & Qvist, 2022; Ntshangase & Venketsamy, 2022).

Fleer (2021) and Montessori (2014)agree that play-based pedagogy has gained prominence in early childhood education because it embeds learning within purposeful, enjoyable, and socially mediated experiences. Rather than positioning learners as passive recipients of knowledge, Ekeh et al. (2022) found that play invites experimentation, dialogue, and collaboration, thereby supporting cognitive growth alongside emotional development. Empirical evidence suggests that when children actively engage in mathematical play, they are more likely to internalise foundational numerical concepts than when they are exposed solely to rigid, procedure-driven instruction (Louw & Claassens, 2023).

Within the South African context, curriculum reforms have underscored the importance of holistic development and interactive learning (Department of Basic Education (DBE), 2011). However, classroom implementation remains uneven, shaped by variations in teacher preparedness, limited resources, and enduring pedagogical traditions. Although many teachers acknowledge the pedagogical value of play, they frequently encounter difficulties translating this understanding into sustained and effective classroom practice (Ntshangase & Venketsamy, 2022).

Against this backdrop, the present study examines Grade 1 teachers' experiences of implementing play-based strategies to teach number sense in Mpumalanga Province. Drawing on social constructivist principles, it explores how communication, interaction, and collaborative problem-solving contribute to the development of early mathematical literacy. By conceptualising mathematics as a dynamic "game of numbers," the article contends that communicative play can ease anxiety while building confidence, reasoning, and informed decision-making among young learners.

Number Sense as a Foundation for Early Mathematical Thinking

Mamogale (2019) state that number sense is widely recognised as a critical determinant of later mathematical competence, serving as the conceptual foundation upon which formal mathematical reasoning is constructed. Chen (2025) and Selepe and Mphahlele (2025a) believe that rather than representing a narrow set of computational skills, contemporary scholarship positions number sense as a multidimensional construct encompassing magnitude understanding, numerical relationships, estimation, and flexible problem-solving. According to Al-Hassan et al. (2025), when learners develop these competencies in the early years, they are better equipped to engage with abstract mathematical concepts in subsequent schooling.

Recent research by Selepe and Mphahlele (2025a) and Venketsamy and Hu (2023) underscores the importance of pedagogical approaches that prioritise the development of conceptual understanding over procedural memorisation. For example, Venketsamy and Wilson (2020) argue that technology-enhanced mental mathematics activities can significantly strengthen number sense by promoting engagement and conceptual clarity. Their extension of the Technological Pedagogical Content Knowledge (TPACK) framework highlights the importance of aligning pedagogical strategies with content knowledge to create inclusive learning environments. Therefore, the author believes that this perspective challenges traditional teacher-centred models that prioritise correct answers over mathematical reasoning.

According to Abrahamson and Bakker (2016), mathematical cognition is deeply connected to physical and sensory experiences. Way and Cartwright (2025) demonstrate that embodied activities in early grade settings support the development of number sense by enabling learners to represent numerical ideas through movement and interaction. Such findings reinforce the view that mathematical understanding is not purely symbolic but emerges through experiential engagement with the environment (Mamogale 2019).

The author opines that equally significant is the role of early numeracy experiences beyond the classroom. A community-based study on number stories revealed that opportunities for mathematical talk between caregivers and children promote reasoning and strengthen conceptual understanding (Zhang et al., 2024). Drawing on sociocultural theory, Zhang et al. (2024) and Koltcheva (2025) emphasise that learning is mediated through participation in meaningful practices, suggesting that number sense development is inseparable from language and social interaction.

Despite strong evidence supporting conceptual approaches, persistent challenges remain. Ahmad et al. (2025) and Selepe and Mphahlele (2025b) concur that teachers often demonstrate sound pedagogical knowledge yet require ongoing professional development to integrate innovative strategies effectively. This gap signals a broader systemic issue: while policy increasingly advocates learner-centred mathematics instruction, classroom practice frequently lags behind. Hence, the DBE (2011) emphasises that positioning number sense as foundational necessitates not only theoretical clarity but also meaningful pedagogical transformation in classroom practice. It emphasises that recognising number sense as foundational requires both clear theoretical understanding and meaningful changes in classroom teaching practices. However, the author argues that developing this competence requires learning environments that encourage exploration, open dialogue, and flexible thinking. In this context, play and active participation become powerful ways to nurture early mathematical understanding.

Play and Participation as Sociocultural Pathways to Learning

According to Alkhudiry (2022), Vygotsky's sociocultural perspectives view learning as a socially mediated process in which knowledge is constructed through interaction and shared activity. Therefore, Fleer (2021) agrees that play is increasingly understood not as mere recreation, but as a purposeful pedagogical practice capable of supporting higher-order thinking. Fleer (2021) Montesorri (2014) agree that carefully structured mathematical games can strengthen learners' number knowledge while also nurturing more positive attitudes toward mathematics. Their findings indicate that playful learning environments tend to lower anxiety and encourage intellectual risk-taking conditions that are essential for meaningful engagement and deep understanding.

The integration of cultural resources into play-based mathematics further broadens learners' access to conceptual understanding (Rosa, 2023;Venketsamy, 2022). Jasmaniah et al. (2024) argue that culturally responsive play activities, including indigenous games and storytelling, embed mathematical ideas within familiar contexts, thereby enhancing relevance and meaning for young learners. This approach aligns with multisensory

learning theory, which holds that engaging multiple modes of experience strengthens retention and comprehension (Fleer & Hedegaard, 2010). The author opines that culturally grounded play also advances inclusive practice by accommodating diverse linguistic, cognitive, and social backgrounds.

Venketsamy's work offers valuable insight into the role of culturally situated play in mathematics education (Venketsamy, 2024). In a qualitative study on ethnomathematics, Venketsamy (2024) found that participation in cultural games contributed to measurable improvements in learners' mathematical knowledge and skills, despite teachers' initially limited understanding of ethnomathematical concepts. The study's call for targeted professional development echoes a recurring theme in early mathematics research: innovative pedagogies require sustained institutional and professional support if needed to be implemented effectively.

Similarly, Ntshangase (2022) observe that although national curriculum frameworks endorse play-based learning as a vehicle for holistic development, teachers often encounter structural constraints and pedagogical uncertainties in practice. Swargiary (2025) found that these tensions underscore the challenge of translating sociocultural theory into consistent classroom enactment, particularly within contexts shaped by resource limitations and entrenched instructional traditions.

Further evidence of the pedagogical potential of participation emerges from research on imaginary play interventions. Drawing on Fleer's Conceptual PlayWorld approach, Hedges et al. (2025) demonstrate how imagination, narrative, and collaborative problem-solving can transform teachers' mathematical practices while easing children's transition into formal schooling. By positioning learners as active contributors to shared meaning-making, such approaches reflect core Vygotskian principles, especially the view that cognitive development unfolds through guided participation within socially organised activity (Hardman, 2022). At the same time, Fleer (2021) cautions against idealising play. Without deliberate pedagogical intent, play can become detached from curricular aims and lose its conceptual focus. Effective play-based mathematics, therefore, depends on purposeful design and what Grimmond et al. (2022) describe as intentional participation, in which teachers strategically scaffold dialogue, inquiry, and reflection. The author argues that play and participation are not just add-ons, but key elements in developing mathematical understanding. They provide the social and cognitive conditions needed for reasoning, language development, and conceptual learning. However, their effectiveness ultimately depends on how carefully teachers implement and guide play in their classrooms.

Teachers' Enactment of Play-Based Pedagogy in Early Mathematics

Teachers play a central role in bridging the gap between pedagogical theory and learners' classroom experiences (Venketsamy & Wilson, 2020). Grimmond et al. (2022) argue that contemporary research has shifted focus from questioning whether play benefits learning to examining how educators implement it effectively. Ekeh et al. (2022) found that overly structured pedagogical approaches can hinder the development of essential skills in young learners, whereas group-based play fosters communication, collaboration, and active engagement. Their study further highlights the importance of professional development in enhancing teachers' confidence and competence in applying play-based strategies.

The position teachers adopt within play contexts also significantly influences mathematical outcomes. Studies on Mathematical Playworlds demonstrate that educators assume diverse pedagogical roles from facilitator to co-player to create conditions for intentional mathematical learning (Fleer & Hedegaard, 2010). Engaging "within" children's play allows teachers to guide conceptual exploration while preserving learner agency, challenging traditional distinctions between instruction and play and suggesting a continuum of pedagogical possibilities (Ntshangase, 2022). South African scholarship highlights contextual factors that shape classroom enactment. Ntshangase and Venketsamy (2022) identify constraints such as limited resources, curriculum pressures, and variable teacher preparation, while Venketsamy, Sing, and Smart (2020) argue that teacher training must prioritise inclusivity and diversity to support safe, equitable learning environments, particularly for neurodiverse students. These findings indicate that meaningful pedagogical change cannot occur independently of broader systemic reform.

Ethnomathematics research further points to a disconnect between teachers' classroom practices and their theoretical understanding. While educators often incorporate games into instruction, they may lack the conceptual language to articulate their pedagogical purpose (Rosa, 2023; Venketsamy, 2024). This gap has implications for professional identity, as teachers who comprehend the theoretical underpinnings of play are better positioned to implement it with intention and clarity. Emerging innovations, including technology-enhanced mathematics instruction, add additional complexity. Such tools can support engaging and inclusive pedagogy, yet teachers require sustained guidance and training to integrate them effectively into curricula (Selepe & Mphahlele, 2025b). Together, these challenges illustrate that teacher enactment is shaped by the interplay of knowledge, beliefs, and structural conditions.

The author argues that there is a clear need for research that explores teachers' real experiences with implementing play-based pedagogy. By understanding how educators balance policy requirements, classroom realities, and diverse learner needs, we can identify ways to make mathematics instruction more effective and meaningful. Filling this gap is crucial for improving both theory and practice in early mathematics education.

Theoretical framework

This study is grounded in Vygotsky's Social Development Theory, which posits that learning is fundamentally social and occurs through interaction with more knowledgeable others (Taber, 2025) . Knowledge is first constructed on the interpersonal plane before being internalised individually. Central to this framework is the Zone of Proximal Development (ZPD), defined as the distance between what learners can achieve independently and what they can accomplish with guidance (Hu, 2024). Play-based environments naturally activate the ZPD because they encourage collaboration, imitation, and scaffolded problem-solving (Fleer, 2021; Ntshangase, 2022).

Ntshangase and Venketsamy (2022) agree that within mathematics classrooms, communicative play creates opportunities for teachers to model strategies while gradually transferring responsibility to learners. Therefore, Fleer (2021) agrees that as children engage in counting games, sorting activities, or pattern construction, they receive immediate feedback from peers and educators, enabling cognitive growth. Hence, this theory also emphasises language as a mediational tool. Mathematical dialogue, questioning, explaining and negotiating support metacognition and reasoning. When learners verbalise their thinking during play, abstract concepts become accessible and meaningful (Ekeh et al. 2022). Thus, Vygotskian theory provides a robust lens for examining how social interaction within playful contexts fosters number sense and mathematical literacy.

2. Method

This study employed a qualitative approach situated within an interpretivist paradigm to explore teachers' lived experiences and the meanings they attach to play-based pedagogy (Maree, 2020). Creswell (2023) agrees that the interpretivist lens was particularly suitable, as it emphasises the significance of context, perception, and socially constructed realities. Four Grade 1 teachers from primary schools in Mpumalanga Province participated, selected through purposive sampling to ensure direct experience with implementing play-based strategies in mathematics instruction. Data were collected via semi-structured interviews, which facilitated reflective dialogue on classroom practices, perceived benefits, and implementation challenges (Cohen et al., 2018). This approach allowed participants to articulate their pedagogical decisions while providing the researcher with opportunities to probe emerging insights. Thematic analysis was conducted to identify patterns across the dataset, with codes developed inductively and organised into broader categories encompassing learner engagement, confidence, communication, and conceptual understanding (Creswell, 2023). Ethical approval was obtained from a South African university, and all participants provided informed consent. Measures were taken to ensure confidentiality and anonymity throughout the research process (Cohen et al., 2018).

3. Findings

The thematic analysis of the semi-structured interviews revealed that implementing play-based pedagogy for number sense transforms the classroom from a space of passive reception to one of active, social construction. Three dominant themes emerged, each supported by the lived experiences of the participants.

Theme 1: Mitigating Math Anxiety and Enhancing Learner Confidence

Mitigating math anxiety and nurturing learner confidence are critical challenges in early mathematics education. Lake (2019) found that negative emotional experiences in mathematics can hinder engagement, limit risk-taking, and impede conceptual understanding, particularly in foundational grades. Strategies that actively address anxiety while promoting supportive, interactive learning environments can enhance learners' self-efficacy and willingness to engage with mathematical tasks (Venketsamy & Ntshangase, 2023). Within this context, play-based pedagogical approaches offer promising avenues for building confidence, encouraging experimentation, and cultivating positive attitudes toward mathematics from an early age. In this study, participants consistently reported that shifting mathematics from "work" to "play" helped reduce the emotional barriers commonly linked to early numeracy. By presenting activities as games, the usual evaluative pressures that hinder early numeracy are eased, fostering learners' confidence and enthusiasm for mathematics.

P1:*"Before I started using counting games, some of my learners would literally freeze when I pulled out a worksheet. Now, when I say 'Let's play the Number Shop,' their faces light up. They aren't afraid of being wrong because it's just a game."*

P2:*"Confidence is the biggest change. In play, the children take risks. They try to guess the next number in a pattern without looking at me for the 'correct' answer first. They have ownership now."*

P3:*"I noticed that the quiet learners, the ones who usually hide in the back, are the loudest during our indigenous stone-throwing games. The anxiety is gone because the social interaction feels natural, not forced."*

The shift from formal worksheets to play-based learning has reshaped the classroom dynamic by replacing "math freeze" with open enthusiasm. By gamifying lessons, teachers stripped away the paralysing fear of being wrong, allowing learners to claim ownership over their own logic and take intellectual risks without looking to the teacher for constant validation. This shift is significant to those quiet learners. When lessons include social interaction, such as indigenous stone-throwing games, anxiety disappears, allowing once-passive observers to become more vocal and confident participants in mathematics lessons.

Theme 2: From Rote Memorisation to Deep Conceptual Understanding

A shift from rote memorisation to deep conceptual understanding is central to mathematics learning. Although memorisation enables short-term recall, it often limits learners' ability to apply concepts, reason critically, and solve novel problems (Spaull xxxx). Encouraging strategies that promote exploration, discussion, and hands-on engagement support meaningful comprehension, helping learners connect procedures to underlying mathematical principles and develop lasting cognitive skills. The findings in this study revealed that tactile and collaborative play allow learners to go beyond procedural drills. By manipulating physical objects and engaging in "mathematical talk," learners internalised magnitude and numerical relationships as suggested by the ZPD framework.

P2:*"In the past, they could recite numbers 1 to 20 but didn't know what '7' actually felt like. When we use blocks and play 'Building Houses,' they see that 7 is bigger than 5. It's no longer just a symbol on the board; it's a physical reality."*

P4:*"Working in groups is essential. I heard two learners arguing over how to share 10 counters. Through that 'play' argument, they actually discovered the foundation of division and subtraction on their own."*

P1:*"Using 'Number Stories' helps them bridge the gap. We don't just do sums; we play out a story about birds in a tree. They aren't memorising 5 + 2 = 7; they are visualising the arrival of those two birds."*

It can be argued that through play-based activities, learners can move beyond memorising numbers to gaining a deeper understanding of them. Using blocks, storytelling, and collaborative games, learners experience numbers as tangible and meaningful. They can therefore explore mathematical relationships through discussion and problem-solving, and build foundational concepts like addition, subtraction, and division in an engaging, hands-on way.

Theme 3: Fostering Critical Thinking and Autonomous Decision-Making

To develop critical thinking and autonomous decision-making in mathematics, learners should be given the opportunity to foster critical thinking. It is important that teachers encourage analysis, problem-solving, and thoughtful choice-making, where learners can make decisions about their learning and understanding. Critical thinking and decision-making skills lay the foundation for lifelong learning and confident engagement with complex mathematical tasks (Ekeh et al., 2022). The findings in this study revealed that play-based strategies encouraged learners to act as "informal mathematicians" who evaluate alternatives and justify their logic. Teachers observed that the "Game of Numbers" approach required learners to think strategically rather than waiting for teacher-led instructions.

P4:*"When we play strategy-based games, I see them stopping to think. They ask themselves, 'If I move this many steps, will I win?' That is a high level of mathematical reasoning happening in a six-year-old."*

P3:*"The most powerful moments are when they justify their choices. One learner told his peer, 'No, that's not a pattern because the red bead is in the wrong place.' He wasn't just following my rule; he was applying logic."*

P2:*"I've become more of a facilitator. I watch them experiment with different ways to solve a puzzle. If one way doesn't work, they don't give up; they collaborate and try a different strategy. That is critical thinking in action."*

Play encouraged learners to experiment with strategies, evaluate alternatives, and justify their answers. It was noted that such behaviours reflected emerging critical thinking skills essential for mathematical proficiency. Overall, communicative play functioned as a channel for mathematical literacy by integrating cognitive, social, and emotional development.

4. Discussion

The findings of this study revealed that using play-based learning for number sense can change how Grade 1 classrooms function. Instead of sitting quietly and memorising, learners can become active in the learning process by exploring math through social interaction and play. These results can be understood through Vygotsky's Social Development Theory and recent research in early mathematics education.

Feeling Safe and Reducing Anxiety

One key finding was that games helped reduce "math freeze" and anxiety. By turning lessons into a "Game of Numbers," teachers lowered the pressure on students, making math less intimidating. This supports Stoehr (2017), who found that fear of math can block understanding. Playful learning gives children the confidence to take risks, as Fleer (2021) and Montessori (2014) suggest. For example, Participant 3 noticed that quiet learners became more talkative during indigenous games, showing how play naturally encourages social interaction and builds self-confidence (Ntshangase & Venketsamy, 2022).

Learning Through Doing

The study also found that using hands-on activities helped children move beyond memorising numbers to gaining a deeper understanding of them. Using blocks and "Number Stories," learners could see and touch math, which matches research by Way and Cartwright (2025) that shows understanding grows through experience. Observing learners negotiate and argue over counters highlighted the Zone of Proximal Development (Hu, 2024), showing how children learn from each other. Through these playful discussions, they grasp concepts like subtraction and division even before formal teaching (Ekeh et al., 2022; Taber, 2025).

Developing Thinking Skills

Play also encouraged higher-level thinking. When learners explained their choices or tested strategies in games, they practised reasoning and reflecting like real mathematicians (Hardman, 2022). This approach moves away from teacher-led drills (Chen, 2025) and supports "intentional participation," where teachers guide but let children explore and solve problems together (Grimmond et al., 2022). This kind of learning builds skills for long-term problem-solving and critical thinking. Therefore, play-based learning in Grade 1 classrooms helps bridge the gap between policy and actual teaching (DBE, 2011). By combining social interaction, cultural context, and purposeful play, teachers can reduce math anxiety while building a strong, confident foundation for number sense. Children not only learn better but also feel supported and motivated in the process.

5. Conclusions

This study found that using play-based learning in Grade 1 helps children feel less anxious about math, understand concepts more deeply, and develop critical thinking skills. Instead of just memorising numbers, learners actively explore math together and learn from each other. The study had some limits, including only four teachers and challenges with resources and teacher readiness. Based on the findings, the study recommends providing teachers with continuous ongoing training on how to use play effectively, including games and stories that reflect children's culture, and providing adequate and appropriate cultural resources and support so that all learners can benefit from meaningful, engaging math lessons.

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