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EFFECTS OF KNOWLEDGEABLE MATHEMATICS PEDAGOGICAL SIMULATION TEACHERS' ON MATHEMATICS ATTAINMENT AMONG GRADE THREE CHILDREN IN LOITOKITOK, SUB-COUNTY, KAJIADO COUNTY, KENYA

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ABSTRACT

Based on Gardner's theory of multiple intelligences, the study examined various sources of mathematical pedagogical simulation methods and their impact on the academic achievement of third-grade children in mathematics in Loitokitok Sub-County, Kajiado County, Kenya. It is argued here that mathematics pedagogical simulation methods, knowledgeable teachers, and the ability to utilise talented peers in areas other than mathematics enhance mathematics attainment in a mathematics classroom.

Using a quasi-experimental design with pre- and post-test assessments in 12 schools, 1,842 participants were selected for the study using stratified random sampling. Data were collected using pre-test and post-test assessments, classroom observations, and questionnaires to assess the children's and teachers' dispositions. Results indicate statistically significant improvements in mathematics performance for the intervention group. Prior to the intervention, 48.60% of the control group and 37.70% of the intervention group scored below average. Following the intervention, the percentage of underachieving children decreased to 29.70%, while in the intervention group, fell to 7.80%. The proportion of children performing above average rose from 51.40% to 70.30% in the control group and from 62.30% to 92.90% in the intervention group. The study also revealed that children had favourable attitudes towards their knowledgeable teachers and peers who were talented in areas other than mathematics, with 47.4% and 31.6% of children performing above-average scores.

Recommendations include incorporating teachers, and peers who are knowledgeable in mathematical pedagogical simulation methods into the mathematics curriculum and infusing these methods to teacher training to improve mathematics educational outcomes sustainably.

Keywords: *Mathematical pedagogical simulation method, knowledgeable teachers; Mathematical attainment*

INTRODUCTION

The efficacy of mathematical education is contingent upon teachers' perceptions of the mathematics subject, which in turn shape their pedagogical approaches. Research highlights the importance of these intellectual resources in shaping children's learning experiences (Hung-His, 2021; Odunosu Olusesan & Abel, 2016). Studies have consistently shown that teachers' subject matter knowledge is a critical determinant of children's achievement in mathematics (Hung-His, 2021). Teachers with a robust academic background in mathematics tend to be more effective in the classroom, thereby fostering children's learning outcomes (Olisama Odumosu & Udafi, 2021).

The core relationship between teachers' content knowledge and children's mathematics attainment is well-documented, with research suggesting that teachers' quality has a more pronounced impact on children's achievement. Research in mathematics education suggests that teachers' mathematical intellectual resources significantly influence children's academic learning experiences (Yang, Kamaruduma, & Sulaiman, 2024). This has led mathematics research to focus on subject matter knowledge, as research suggests that teachers often lack foundational mathematical content knowledge for teaching mathematics (Drake, Noble, & Reske, 2025). The study by Thomas-Laing and Karlene (2024) suggests a strong connection between teachers' pedagogical content knowledge and mathematics attainment.

Further studies by Danien & Claire (2022) found that children gain the most in math when assigned effective teachers. However, despite the aforementioned research outcome robust studies have shown that teachers use rote teaching and learning approach that emphasizes memorization without fostering a deep and relatable understanding of the mathematics concepts and instructional methods that fail to engage children are particularly widespread among third-grade children in Kenya (Kenya National Examination Council, 2021; Njaru,2016; Uwezo, 2016).

In many classrooms, the mathematical pedagogical simulation strategies employed primarily prioritize memorization over relating the development of mathematics concepts to their daily lives. This focus on recalling mathematics facts and procedures can hinder children's abilities to grasp underlying mathematical principles.

As a result, they often find themselves struggling not only to grasp theoretical aspects of mathematics but also to apply these concepts in practical, real-world situations. The disconnect between memorizing information and achieving a true understanding of mathematical ideas has significant implications for children's overall academic performance and their confidence in dealing with mathematics (Olisama, Odumosu & Udafi, 2021). Thus, there is a pressing need for teaching methods that promote a more profound comprehension of mathematical concepts, enabling children to effectively apply their understanding of mathematical concepts understanding in various

mathematical contexts. In light of Gardner's theory of multiple intelligences, this research seeks to explore teachers and peer tutoring as sources of mathematics pedagogical simulation methods, creating emotionally rich mathematics learning environments that connect mathematical concepts to children's live experiences in Loitokitok Sub-County.

The efficacy of implementing diverse sources of mathematical pedagogical simulation methods integrating teachers' mathematical knowledge and peer tutoring mathematical simulation methods has been substantiated by mathematics education research as conducive to enhancing children's mathematical concepts understanding and engagement. The present study aims to not only investigate how these methods affect children's performance in mathematics but also to examine how children's and teachers' attitudes toward these methods influence children's mathematics academic outcomes.

Despite ongoing efforts to improve mathematics education, many grade three children in Loitokitok Sub-County, Kajiado County, Kenya, continue to perform below the official required mathematics curriculum standards (Kenya National Examinations Council, 2021; Njaru, 2016; Uwezo, 2016). The reliance on conventional and disconnected instructional strategies has resulted in low academic achievements in mathematics and low engagement among grade three children.

This study addresses the critical need to contextualize and engage different sources of mathematics pedagogical simulation strategies to enhance logical-mathematical cognition, exploring how knowledgeable mathematics teachers and peer tutoring mathematical pedagogical simulation methods may improve the academic mathematics attainment of grade three children.

RESEARCH QUESTIONS

The following attempted to answer the following three research questions:

i) How do teachers knowledgeable in mathematics pedagogical simulation methods affect grade 3 children's performance in mathematics?

ii) What is the perceived importance of peer-teaching as a source of pedagogical simulation in Grade 3 mathematics?

iii) What are Grade 3 children's attitude to Pedagogical simulation methods through their mathematics classroom through their peers?

REVIEW OF RELATED LITERATURE

Research (Drake, Noble, & Reske, 2025) indicates that mathematics, especially in primary school teachers' curricula, lacks sufficient mathematical content knowledge for effective mathematics teaching. Drake, Noble, & Reske's (2025) study highlights the need for improving teachers' mathematical knowledge and classroom practices. The study by Thomas-Laing and Karlene (2024) emphasizes that a deep understanding of pedagogical content knowledge is essential for effective mathematics teaching.

Thomas-Laing and Karlene's study argues that mathematical knowledge encompasses not only the subject matter itself, but also the best ways to teach it to children. Another study by Yang, Kamaruduma, and Sulaiman(2024) found that intellectual resources in mathematics have a significant impact on children's academic achievement in the classroom. Olisama, Odumosu, and Udafi (2021) investigated the effects of teacher preparation in children's achievement in mathematics. The research design employed was a quantitative study. The research targeted mathematics teachers and their grade three students.

The sample size was 150 teachers with 1,200 students. The results found a strong correlation between the level of mathematical content knowledge possessed by teachers and student achievement metrics in mathematics. The key takeaway was that consistent practice with effective teachers over extended periods led to substantial gains in students' mathematical understanding and skill levels.

Hung-Hsi (2021) conducted a study to explore the relationship between teachers' mathematics knowledge and students' engagement in learning. The study employed longitudinal study. The study targeted primary school teachers and students across multiple grades. The sample size was 300 teachers, including data on 2,500 students. The findings highlighted that when teachers were equipped with versatile pedagogical simulation methods, students exhibited greater mathematical engagement and understanding. Teachers' deep content knowledge fostered better instructional decisions, resulting in positive learning outcomes.
Lindmeier et al. (2020) examined the influence of teacher knowledge on student achievement in mathematics. The research was descriptive in nature. The target population was primary school mathematics teachers. The sample size was 170 teachers. The findings revealed that the quality of instructional approaches, particularly relating to teachers' understanding of number sense, was inversely related to their effectiveness in employing mathematics pedagogical simulation methods. The study underscored the necessity for teachers to be well-versed in mathematical concepts to adequately foster student success in mathematics.

Scott et al. (2014) explored the effects of classroom peer teaching on mathematics learning outcomes. The study was experimental. The target population was the grade three students. The sample size was 180 students in two classes (one for peer teaching and one for traditional teaching). The findings found significant improvements in mathematics scores among students engaged in peer teaching, particularly those with interpersonal intelligence. Cooperative learning environments fueled by peer interactions have been shown to enhance problem-solving skills and motivation, vital for mathematical success.

Peterson, Carpenter, and Fennema(1989) investigated the association between elementary teachers' pedagogical content knowledge, self-

efficacy, and students' mathematics achievement. The study adopted a correlational research design. The study targeted early grade teachers and their students in elementary schools. However, the sample size was 210 teachers and 300 students. The research established a notable positive correlation between teachers' mathematical self-efficacy and their pedagogical content knowledge, which translated into improved students' mathematics problem-solving skills. Teachers with stronger mathematical knowledge and confidence were observed to employ more effective teaching strategies, leading to heightened student engagement and achievement.

This study draws on theoretical framework comprising Gardner's (1983; 1993; 1999; 2009; 2011;2012; 2020) theories of multiple intelligences (MI) that argue against biased mathematics instruction to provide the use of pedagogical simulation methods in the classroom and a classroom climate that provides an emotionally rich real-world teaching learning context for mathematics (Armstrong, 2017; Eisner, 2002; Gardner, 2011;2012;2020; Sylvester, 1995; Witherell, 2000). Gardner (1983; 1993; 2011; 2012; 2020) established an original list of seven (7) bits of intelligence, then expanded this list to nine (9) bits of intelligence and contests the idea of single intelligence in our classrooms.

From the perspective of Gardner's Multiple Intelligences (MI) theories, children who are gifted in areas other than mathematics can be supported in learning mathematics through non-routine mathematics pathways, helping them learn mathematics effectively (Gardner, 2011, 2020; Kassell, 1998). The intervention group in this study was deliberately delineated and supported by various types of pedagogical simulation methods for mathematics, including mathematical stories, games with a mathematical component, music with a mathematical component, drama with a mathematical component, and mathematics discussions. Finally, they were allowed to use simulation methods at least three times a week to learn and to teach mathematical concepts through the above pedagogical simulation methods. The use of MI theories reflects two theoretical perspectives: 1) the importance of contextualizing mathematics teaching and learning of children's mathematical learning, and 2) experiential teaching and learning of mathematics to provide a non-routine natural pathway for presenting mathematical concepts in the classroom.

METHODOLOGY

A quasi-experimental design was adopted, employing pretest and posttest mathematics assessments across two non-equivalent control groups. This design allowed the researchers to implement an instructional intervention, where one group of grade three students received the varied sources of the mathematical pedagogical simulation support, while the control group did not. The study took place in Loitokitok Sub-County, Kajiado County, Kenya, where the target population encompassed 120 primary schools, 110 headmasters, 579 teachers, and approximately 3,500 grade three students.

Stratified random sampling was employed to select 12 schools with a sample size of 1,842 participants comprising 12 headmasters, 36 teachers, and 1800 children.

Data collection instruments included several tailored tools such as grade three children's mathematics attainment tests (both pre-test and post-test), semi-structured observation schedules for classroom instructional strategies, and various questionnaires designed to gauge both teachers' and students' attitudes towards the mathematical pedagogical simulation methods employed. The teachers' attitudes were measured via a five-point Likert-scale questionnaire, while the students' attitudes were assessed through a semi-structured interview schedule.

Data analysis involved quantitative statistical approaches, such as calculating means, standard deviations, and utilizing Pearson Chi-Square tests to validate the null hypotheses. Qualitative data was thematically analyzed and presented using descriptive statistics, frequency distribution tables, and graphical representations. The study aimed for reliability and validity through pilot testing of the instruments and expert consultations, employing approaches such as Cronbach's alpha coefficient for internal consistency and inter-rater validity verification.

RESULTS AND DISCUSSIONS

The dependent variable (mathematics academic performance) was measured through tests to grade three children before and after the intervention, with both pre-test and post-test scores obtained through mathematics pedagogical simulation approaches. The pre-test was given before the mathematics pedagogical simulation methods intervention, and it provided a benchmark for the children's initial mathematical achievement levels. On the other hand, the post-test was administered after the intervention to measure any changes or improvements in mathematics attainment that resulted from the intervention. By comparing the pre-test and post-test results, the effectiveness of the mathematics pedagogical simulation approaches employed with third-grade learners could be assessed.

Children scoring more than 25 out of 50 were classified as above average in achievement on both the pre-test and post-test, while those scoring below 25 out of 50 were categorized as below average in both assessments. This classification was used to evaluate the impact of the sources of the pedagogical simulation method on children's academic performance. The results were subsequently analyzed with frequency tables and Pearson Chi-square Tests.

Table 1 below presents the findings of this analysis:

Table 1: Mathematics Academic Performance in Control and Experimental Groups

Academic Attainment		Control		Experimental		Chi-square	df	Sig.
		Count	Column N %	Count	Column N %			
pretest	below average	437	48.60%	339	37.70%	21.755	1	.000*
	above average	463	51.40%	561	62.30%			
Post-test	below average	267	29.70%	64	7.10%	152.551	1	.000*
	above average	633	70.30%	836	92.90%			
* The Chi-square statistics are significant at the .05 level.								

The findings presented in Table 1 indicate a significant improvement in mathematical academic performance among the intervention group compared to the control group. Prior to the intervention, 48.60% of the control group and 37.70% of the intervention group were classified as below average, highlighting a notable disparity between the two groups before the implementation of the mathematics pedagogical simulation methods. Following the intervention, the percentage of under-performing students in the control group decreased to 29.70%, while the number of under performers in the intervention group plummeted to an impressive 7.10%. Simultaneously, the proportion of students performing above average rose from 51.40% to 70.30% in the control group and from 62.30% to 92.90% in the intervention group.

A Chi-square value of 152.551, with a significance level of .000, further confirms the positive impact of the mathematical pedagogical simulation methods taught by knowledgeable teachers in the intervention group.

These methods, which included engaging activities such as mathematical stories, games, drama, music, discussions and peer tutoring, seemed to significantly enhance children's mathematical achievement. These strategies, by making learning more engaging and fun, are expected to improve children's grasp and recall of mathematical topics among grade three children. The substantial difference in post-test scores between the intervention and control groups highlights the effectiveness of knowledgeable teachers in instructing mathematics using mathematical pedagogical simulation methods to foster mathematical success among the grade three children. Nonetheless, it is crucial to note that 7% of the children in the intervention group still did not achieve above-average results, even after the implementation of these innovative teaching strategies.

This phenomenon could probably be due to mathematics anxiety, a well-documented issue that negatively impacts mathematical performance. As noted by Richardson and Suinn (1972) and Johnston-Wilder (2018) and Para & Johnston-Wilder(2023) mathematics anxiety encompasses the tension and emotional responses that obstruct one's ability to work with numbers and solve mathematical problems successfully in everyday life. McAnallen (2010) further emphasizes that such anxiety often leads to avoidance behaviors, preventing children from developing essential mathematical skills and making informed decisions about their future careers.

Puteh and Khalin (2016) identified a negative correlation between mathematics anxiety and academic achievement, while Zakaria et al. (2012) and Carey et al. (2019) established that higher levels of anxiety are associated with poorer academic performance. This suggests that children's grasp of mathematics is closely linked to their mathematics self-confidence and mathematics self-efficacy. Further studies by Karimi and Venkatesan (2009), Woodard (2002) and Johnston-Wilder et al. (2020) associate the existence of a negative relationship between mathematics anxiety and mathematics academic attainment, indicating that high anxiety levels can lead to subpar performance.

Additionally, research by Lew and Hwang (2019) and Milovanović (2020) demonstrates that mathematics anxiety is significantly connected to lower academic achievements. Research within the mathematics field, such as the work by Carey et al. (2019), shows that even young children can develop mathematics anxiety. While this assumption may extend beyond the focus of the current study, it underscores the necessity to investigate whether some grade three children in Kenya have indeed experienced mathematics anxiety and how effective interventions might be implemented. Research into mathematics resilience (Cousins et al., 2019; Johnston-Wilder, 2018; Para & Johnston-Wilder, 2023) posits that instructional strategies designed to bolster protection against mathematics anxiety could serve as a crucial remedy.

Peer-Teaching as a source of Pedagogical Simulation and Mathematics academic attainment

The perceived importance of peer-teaching as a source of pedagogical simulation method was evaluated through a questionnaire, and the results were analysed using frequency tables and Pearson Chi-Square tests. The results are presented in the Table 2.

Table 2: Classroom Peer-Teaching as a source of Mathematical Pedagogical simulation method and Mathematics academic attainment

Peer-Teaching		academic attainment				Pearson Chi-square Tests		
		below average		above average				
		Count	Column N %	Count	Column N %	Chi-square	df	Sig.
The classroom teacher introduces mathematics concept using peer teachers in the classroom as a source of mathematics pedagogical simulation methods	Not Observed	10	58.80%	2	10.50%	13.958	3	.003*
	Ineffective	4	23.50%	2	10.50%			
	Somewhat Effective	2	11.80%	9	47.40%			
	Effective	1	5.90%	6	31.60%			
The classroom teachers use classroom peers gifted in areas other than mathematics to present mathematics concepts in the classroom until the end of the	Not Observed	9	52.90%	4	21.10%	14.884	3	.002*
	Ineffective	5	29.40%	0	0.00%			
	Somewhat Effective	2	11.80%	9	47.40%			
	Effective	1	5.90%	6	31.60%			

mathematics lesson								
The children appear to be at ease while learning mathematics concepts through peer tutoring in the classroom until the end of the mathematics lesson	Not Observed	12	70.60%	4	21.10%	13.958	3	.003*
	Ineffective	2	11.80%	0	0.00%			
	Somewhat Effective	2	11.80%	9	47.40%			
	Effective	1	5.90%	6	31.60%			

The results presented in Table 2 above indicate that there is a significant independence between the use of peer-teaching as a source of mathematics pedagogical simulation methods and mathematics academic attainment. In classrooms where peer teaching was somewhat effective or effective above-average performance was attained. Specifically, 47.4% and 31.6% of children performed above-average scores when peer-teaching methods were somewhat effective or practical, respectively, compared to only 10.5% when peer-teaching was ineffective or not observed (Chi-square = 13.958, p = .003).

Continuous use of peer teaching until the end of the mathematics lesson was also perceive to lead to higher rates of above-average attainment, with 47.4% of children performing above average when peer teaching was somewhat effective or practical, compared to 21.1% when it was not observed (Chi-square = 14.884, p = .002).

Children felt more at ease and performed better when peer teaching was effectively used, with 47.4% achieving above-average scores compared to 21.1% without peer teaching (Chi-square = 13.958, p = .003).

These findings are consistent with the literature, which suggests that peer teaching as a source of pedagogical simulation methods can significantly improve mathematics learning. Versatile teachers and peers in the mathematics classroom who are gifted in curriculum areas outside of mathematics (competences beyond mathematics) can serve as effective sources of pedagogical simulation methods (Armstrong, 2017; Bell, 2012; Coskungonullu, 2013; Fuini & Gray, 2008; Haynes, 2020). Such approaches foster a positive classroom climate and improve teaching and learning interactions (Barwell, 2011; Brophy, 2010).

Research indicates that children with strong interpersonal intelligence, who excel in collaborative learning environments, benefit significantly from peer teaching (Gardner, 2020; Fuini & Gray, 2008). These children's love for mathematics can be nurtured through group work and peer interactions, leading to more successful learning outcomes (Coskungonullu, 2013). This suggests that peer teaching is an effective strategy to improve mathematical attainment by leveraging children's natural interpersonal skills and collaborative tendencies.

Children's Attitude towards Mathematical Peer-Teaching Pedagogical Simulation

Lastly, the relationship between children's attitudes towards mathematical peer-teaching pedagogical simulation and their mathematics academic attainment among grade three children was assessed. The analysis focused on children's enjoyment, nervousness, and overall feelings toward learning mathematics through peer-teaching methods. The results obtained from the analysis are presented in the Table 3.

Table 3: Children's Attitude towards Mathematical Peer-Teaching through Pedagogical Simulation and Mathematics Academic Attainment

Children's attitude towards mathematical peer-teaching pedagogical simulation		Academic Attainment				Pearson Chi-Square Tests		
		below average		above average				
		Count	Column N %	Count	Column N %	Chi-square	df	Sig.
Do you enjoy mathematics when peers teachers teach you in the classroom?	No	193	58.50%	484	32.90%	86.942	2	.000*
	not sure	85	25.80%	429	29.20%			
	yes	52	15.80%	557	37.90%			
Are you under strain when peers present mathematics concepts embedded in, music in the classroom?	No	193	58.50%	464	31.60%	107.35	2	.000*
	not sure	94	28.50%	429	29.20%			
	yes	43	13.00%	577	39.30%			
Are you under strain when peers present mathematics concepts embedded in the classroom mathematics-discussions in the classroom?	No	180	54.50%	480	32.70%	73.71	2	.000*
	not sure	100	30.30%	449	30.50%			
	yes	50	15.20%	541	36.80%			
Do you feel definite positive towards mathematics when the classroom teacher uses peers to teach mathematics concepts in the classroom?	No	186	56.40%	506	34.40%	74.759	2	.000*
	not sure	94	28.50%	409	27.80%			
	yes	50	15.20%	555	37.80%			

The results in Table 3 show some significant independence between children's attitudes towards mathematical peer-teaching pedagogical simulation methods and their mathematics academic attainment. For instance, 37.9% of children who enjoyed learning mathematics from peers achieved above-average scores, compared to 15.8% of those who did not enjoy it (Chi-square = 86.942, p = .000). Additionally, 39.3% of children who were not under strain when peers presented mathematics concepts embedded in music had above-average scores, compared to 13.0% who felt strain (Chi-square = 107.35, p = .000). Furthermore, 36.8% of children who were not under strain when peers presented concepts in classroom discussions achieved above-average scores, compared to 15.2% who were under strain (Chi-square = 73.71, p = .000).

Finally, 37.8% of children who felt positive about peer-teaching methods achieved above-average scores, compared to 15.2% who did not feel positive (Chi-square = 74.759, p = .000). These findings suggest that positive attitudes towards mathematical peer-teaching pedagogical simulation methods significantly enhance students' mathematics performance.

CONCLUSION AND RECOMMENDATIONS

Grade three marks a pivotal stage in primary mathematics education, transitioning children toward upper primary schooling where expectations intensify.

This study provides practical recommendations that can inform stakeholders about effective mathematics pedagogical strategies, potentially enhancing young children's improved mathematics learning experiences and achievements. The findings contribute to existing literature on mathematical pedagogical simulation methods by contextualising successful practices within the Kenyan educational framework and offer avenues for policymakers to enhance curriculum and teacher training towards sustainable improvements in mathematics academic educational outcomes.

The research concluded that there are significant positive effects of various sources of mathematics pedagogical simulation methods on the mathematics attainment of grade three children in Loitokitok Sub-County, Kajiado County, Kenya. Importantly, the study indicates that teachers' attitudes towards these innovative mathematics pedagogical approaches and the interactive nature of the learning environment contribute greatly to children's mathematics success. Despite the overall improvements noted, the probable prevalence of mathematics anxiety among some children's remains a critical concern, suggesting that additional support is necessary to address mathematical emotional barriers in our mathematics classrooms as a result, the study supports the incorporation of varieties of sources of mathematical pedagogical methods into the mathematics curriculum, as well as the need of continued in-depth teacher training in creating an effective mathematical pedagogical simulation learning environment in mathematics classrooms with the ultimate goal of improving mathematics academic educational outcomes for all children.

This study recommends that policymakers should provide in-depth training on teaching using diverse sources of mathematics pedagogical simulation methods. Teachers should be provided with in-depth training on teaching using diverse sources of simulation methods to sustain mathematically emotionally rich mathematics learning environment and endorse policies that encourage the use of diverse sources of mathematical pedagogical simulation methods.

The findings from this research provided insight into the relationship between the knowledgeable teachers and peer mathematics tutoring and mathematics academic attainment among the grade three children. Further research is needed with different grade levels to clarify the relationship of diverse sources of mathematical simulation methods and mathematics academic achievement.

Finally, this study can be replicated with other grade levels in a different geographical region, different schools set up and different grade levels may offer more rich and insightful data pertaining to a relationship between mathematics pedagogical simulation methods and mathematics academic attainment. Further, the study underscores the need for investigating the reason as to why 7% of the children participating in the intervention group performed poorly in mathematics.

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