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Effects of Simulation-Based Mathematics Pedagogy on Grade Three Pupils' Mathematics Achievement: Evidence from Loitokitok Sub-County, Kenya

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Abstract

Grounded in Gardner's theory of multiple intelligences, this study examined the effectiveness of simulation-based mathematics pedagogy in improving Grade Three pupils' mathematics achievement in Loitokitok Sub-County, Kenya. Specifically, the study investigated whether integrating diverse pedagogical simulation methods into mathematics instruction could enhance pupils' academic performance. A quasi-experimental design was employed involving 954 participants selected through stratified random sampling. Data were collected using pre-tests, post-tests, and classroom observation questionnaires. Quantitative data were analysed using descriptive statistics and Pearson's Chi-square test, while qualitative data were analysed thematically. The findings revealed a substantial improvement in mathematics achievement among pupils exposed to simulation-based pedagogy, with above-average attainment increasing from 62.3% to 92.9% in the experimental group. The results indicate that instructional approaches incorporating mathematical storytelling, educational games, music, drama, and classroom discussions create meaningful learning experiences that foster higher mathematics achievement. These findings provide empirical evidence supporting simulation-based pedagogy as an effective instructional approach for primary mathematics education. The study recommends integrating simulation-based pedagogical strategies into the Grade Three mathematics curriculum and strengthening teachers' professional development to support their effective classroom implementation. Future research should investigate the long-term effects of simulation-based pedagogy on pupils' mathematical achievement and affective learning outcomes.

Keywords: Simulation-based mathematics pedagogy, Mathematics achievement, Multiple intelligences, Primary mathematics education

Abstrak

Berlandaskan teori kecerdasan majemuk Gardner, penelitian ini bertujuan untuk mengkaji efektivitas pedagogi matematika berbasis simulasi dalam meningkatkan prestasi belajar matematika siswa kelas III di Sub-Kabupaten Loitokitok, Kenya. Secara khusus, penelitian ini menyelidiki apakah penerapan berbagai metode simulasi pedagogis dalam pembelajaran matematika dapat meningkatkan hasil belajar matematika siswa. Penelitian ini menggunakan desain kuasi-eksperimen yang melibatkan 954 partisipan yang dipilih melalui teknik stratified random sampling. Data dikumpulkan menggunakan tes awal (*pre-test*), tes akhir (*post-test*), dan angket observasi kelas. Data kuantitatif dianalisis menggunakan statistik deskriptif dan uji Chi-Square Pearson, sedangkan data kualitatif dianalisis secara tematik. Hasil penelitian menunjukkan adanya peningkatan yang signifikan pada prestasi belajar matematika siswa yang mengikuti pembelajaran berbasis simulasi, dengan persentase siswa yang mencapai kategori di atas rata-rata meningkat dari 62,3% menjadi 92,9% pada kelompok eksperimen. Temuan ini menunjukkan bahwa pendekatan pembelajaran yang mengintegrasikan kegiatan seperti bercerita matematika (*mathematical storytelling*), permainan edukatif, musik, drama, dan diskusi kelas mampu menciptakan pengalaman belajar yang lebih bermakna sehingga meningkatkan prestasi belajar matematika siswa. Hasil penelitian ini memberikan bukti empiris bahwa pedagogi matematika berbasis simulasi merupakan pendekatan pembelajaran yang efektif untuk pendidikan matematika di sekolah dasar. Oleh karena itu, penelitian ini merekomendasikan integrasi strategi pembelajaran berbasis simulasi ke dalam kurikulum matematika kelas III serta penguatan program pengembangan profesional guru agar implementasinya di kelas dapat berlangsung secara optimal. Penelitian selanjutnya disarankan untuk mengkaji dampak jangka panjang pedagogi berbasis simulasi terhadap prestasi belajar matematika siswa maupun aspek afektif pembelajaran.

Kata kunci: Pedagogi matematika berbasis simulasi, Prestasi belajar matematika, Kecerdasan majemuk, Pendidikan matematika sekolah dasar

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Introduction

Mathematics learning remains one of the greatest challenges in primary education, with many children experiencing persistent difficulties in developing conceptual understanding and mathematical reasoning. Studies conducted across different educational contexts consistently report that a substantial proportion of primary school learners struggle to achieve expected mathematics competencies, particularly during the early grades (Fuson et al., 2005; Kenya National Examinations Council [KNEC], 2018; Nag et al., 2014; Piper et al., 2016). Similar challenges have been documented in Kenya, where national assessments indicate that many Grade Three pupils perform below curriculum expectations (KNEC, 2019, 2021; Uwezo, 2016). Since mathematical competence serves as a foundation for subsequent learning and STEM development (Claessens & Engel, 2013; Shaughnessy, 2012; UNESCO, 2011), improving mathematics instruction at the primary level remains an educational priority.

One promising approach is simulation-based mathematics pedagogy, which creates meaningful, authentic, and emotionally engaging learning experiences that help pupils develop mathematical understanding. Mathematics pedagogical simulation methods have been shown to significantly improve children's mathematical knowledge and conceptual understanding by presenting mathematical ideas through multiple representations and connecting receptive and expressive mathematical thinking (Courtier et al., 2021; Goldin, 2014). Rather than teaching mathematics as isolated procedures, simulation-based pedagogy integrates mathematical concepts into contextualized activities that encourage active participation and meaningful learning. Grounded in constructivist learning theory and Gardner's Theory of Multiple Intelligences (Gardner, 1983, 1993, 2020), this approach recognizes that children possess diverse intellectual strengths that can be utilized to facilitate mathematical learning. Likewise, Vygotsky's socio-constructivist theory (1978) emphasizes that mathematical knowledge develops through social interaction, dialogue, and collaborative learning, making simulation-based activities particularly suitable for primary mathematics classrooms.

Simulation-based mathematics pedagogy can be implemented through various instructional approaches that accommodate different learning preferences. These include mathematical storytelling (Colgan, 2014; Trakulphadetkrai, 2018, 2019; Bjorklund & Palmer, 2020), educational games (Abramovich, 2010; Ke, 2008; Rittle-Johnson & Jordan, 2016), music-integrated mathematics instruction (An & Capraro, 2011; An et al., 2013; Sanders, 2018), drama-contextualized learning (Asuman et al., 2010), and mathematics discussion-based instruction (Hufferd-Ackles et al., 2004; Murphy, 2013; Coulter, 2021). These pedagogical approaches engage multiple sensory and cognitive pathways, creating rich learning environments that improve pupils' conceptual understanding, mathematical communication, engagement, and achievement (Courtier et al., 2021). Consequently, teachers are encouraged to employ diverse simulation strategies that align with pupils' interests, learning preferences, and prior experiences while promoting collaborative learning and mathematical discourse.

Previous studies have demonstrated positive effects of individual simulation-based instructional approaches on mathematics learning. Mathematical storytelling has been shown to improve conceptual understanding (Bjorklund & Palmer, 2020), games enhance mathematical engagement and achievement (Ke, 2008; Rittle-Johnson & Jordan, 2016), music strengthens mathematical pattern recognition (An et al., 2013), drama facilitates conceptual visualization (Asuman et al., 2010), and classroom discussion develops mathematical reasoning (Hufferd-Ackles et al., 2004). However, most previous studies have examined these instructional approaches separately, with limited evidence comparing multiple simulation-based mathematics pedagogies within a single instructional framework. Furthermore, little empirical evidence is available regarding their effectiveness among Grade Three pupils in Kenya, despite the country's persistent challenges in primary mathematics achievement. This represents an important research gap that warrants further investigation.

The Kenyan context further highlights the urgency of this study. More than half of Grade Three pupils are unable to solve mathematics tasks expected at Grade Two level (Uwezo, 2016), while national assessment reports consistently indicate mathematics performance below expected proficiency levels (KNEC, 2019, 2021). Exploratory studies conducted by Njaru (2016, 2021) similarly revealed persistent challenges experienced by both teachers and pupils during mathematics instruction in Loitokitok Sub-County. These findings suggest that improving mathematics achievement requires instructional approaches that move beyond traditional teacher-centered practices toward learning environments that actively engage pupils through diverse pedagogical experiences. In addition, recent studies have recommended further investigation into how simulation-based instructional methods influence mathematics achievement across different educational contexts and how teacher professional development can strengthen their classroom implementation (Njaru et al., 2025; Pan et al., 2022).

Therefore, this study aimed to investigate the effects of simulation-based mathematics pedagogy on Grade Three pupils' mathematics achievement in Loitokitok Sub-County, Kenya. Specifically, the study examined the effectiveness of mathematical storytelling, educational games, music, drama, classroom discussion, and peer-tutoring discussion as instructional approaches for improving pupils' mathematics achievement. By integrating multiple simulation-based pedagogical strategies within a single quasi-experimental study grounded in Multiple Intelligences Theory and socio-constructivist learning theory, this research extends existing literature beyond studies that focus on individual instructional methods and provides empirical evidence to inform mathematics teaching practices in primary education.

Method

This study employed a quasi-experimental design to investigate the impact of mathematics pedagogical simulation methods on the mathematics attainment of grade three children in Kenya. The study involved testing the mathematics attainment of two non-equivalent control groups before and after the intervention. The research was conducted in grade three classrooms, a critical stage marking the transition from early elementary school education to full primary schooling. Children in this stage, typically aged 7-8 years, require a solid mathematics foundation. However, despite its importance, grade three children consistently underperform in mathematics, with 61% unable to read grade 2 mathematics tasks (Uwezo, 2016). Similar concerns were raised by the Kenya National Examinations Council (2010, 2021) and Njaru (2016, 2021), highlighting the need for effective interventions.

The intervention group received mathematics instruction using various pedagogical simulation methods, including mathematical storytelling, games-based simulation, music-mathematics simulation, drama-contextualized simulation, and mathematics discussion-based simulation. The control group received traditional mathematics instruction without these simulation methods. The study involved 12 grade three classrooms, 36 grade three teachers, and 1,800 grade three children, who were selected to participate in the research. To ensure the rights and privacy of the participants, confidentiality was assured, and informed consent was obtained from parents and guardians. The children were also informed of their right to withdraw from the study without any consequences, and participation was entirely voluntary, with minimal risk of psychological stress. To protect the identities of the participants, pseudonyms were used throughout the study.

The intervention group received mathematics instruction using a range of pedagogical simulation methods, including mathematical storytelling, games-based simulation, music-mathematics simulation, drama-contextualized simulation, and mathematics discussion-based simulation. In contrast, the control group received traditional mathematics instruction without these innovative simulation metho assess the effectiveness of the intervention, mathematics attainment was evaluated before and after the

intervention using a standardized test. The data collected were then analysed using statistical methods to compare the performance of the intervention and control groups.

The study adhered to strict ethical guidelines, ensuring that informed consent was obtained from parents and guardians, and children were aware of their right to withdraw without consequences. Confidentiality and anonymity were maintained throughout the study, and the risk of psychological stress was minimised. While the quasi-experimental design provided valuable insights, it is acknowledged that it may not establish causality, and the findings may have limited generalizability to other contexts. Therefore, future research should investigate the long-term effects of mathematics pedagogical simulation methods, explore the impact of teacher training on the effectiveness of simulation methods, and conduct comparative studies across different grade levels and contexts.

The raw data underwent rigorous validation and editing prior to being coded into thematic categories aligned with the research objectives. Quantitative data pertaining to mathematics attainment were subjected to statistical analysis, with results presented in frequency distribution tables, percentages, and mean scores. Conversely, qualitative data were analysed thematically and evaluated using descriptive statistics, with findings presented in frequency tables. To test the statistical null hypotheses, chi-square tests were employed, providing a robust framework for inferring significance and relationships within the dataset.

Result and Discussion

This study examined the effectiveness of simulation-based mathematics pedagogical approaches in improving the mathematics achievement of Grade Three pupils. Six instructional approaches—mathematical storytelling, games, music, drama, classroom discussion, and peer-tutoring discussion—were implemented in the experimental classrooms and evaluated using a 28-item classroom observation questionnaire together with pupils' mathematics achievement data. Pearson's Chi-square analysis was employed to examine the association between the implementation of each pedagogical approach and pupils' mathematics achievement. The findings revealed a statistically significant positive relationship between the implementation of simulation-based mathematics pedagogy and mathematics achievement ($p < .05$), indicating that pupils exposed to these instructional approaches consistently achieved higher mathematics scores than those receiving conventional instruction.

Overall, the results demonstrate that simulation-based mathematics pedagogy provides an effective instructional framework for enhancing mathematics learning in primary classrooms. Across all instructional approaches, including mathematical storytelling, games, music, drama, classroom discussion, and peer-tutoring discussion, pupils in the experimental group recorded a greater proportion of above-average mathematics achievement than those in the control group. These findings suggest that engaging pupils through diverse and interactive learning experiences creates more meaningful opportunities for conceptual understanding and active participation in mathematics learning.

The following sections present the effectiveness of each simulation-based pedagogical approach in greater detail. For each instructional strategy, pupils' mathematics achievement was classified into two categories: above-average (scores >25/50) and below-average (scores ≤25/50). Frequency distributions and Pearson's Chi-square tests were then used to examine the relationship between the implementation of each simulation-based pedagogical approach and pupils' mathematics achievement. The findings for each instructional strategy are presented sequentially in the following subsections.

Table 1. Mathematical story pedagogical simulation and mathematics academic attainment.

Story		Academic attainment below average		above average		Pearson Chi-square Tests		
		Count	Column N %	Count	Column N %	Chi-square	df	Sig.
The classroom mathematics teacher introduces mathematics concept through mathematical story to address continuum of children's mathematics concepts in the classroom	Not Observed	4	23.50%	0	0.00%	9.707	3	.021*
	Ineffective	6	35.30%	3	15.80%			
	Somewhat Effective	5	29.40%	7	36.80%			
	Effective	2	11.80%	9	47.40%			
The classroom mathematics teacher present mathematics concepts to children through mathematical story pedagogical simulation methods until the end of the mathematics lesson	Not Observed	11	64.70%	3	15.80%	13.528	3	.004*
	Ineffective	3	17.60%	1	5.30%			
	Somewhat Effective	1	5.90%	6	31.60%			
	Effective	2	11.80%	9	47.40%			
The children appear to be at ease while learning mathematics concepts through mathematical story until the end of mathematics lesson	Not Observed	9	52.90%	4	21.10%	14.884	3	.002*
	Ineffective	5	29.40%	0	0.00%			
	Somewhat Effective	1	5.90%	6	31.60%			
	Effective	2	11.80%	9	47.40%			

* The Chi-square statistic is significant at the .05 level.

The use of mathematical stories as a pedagogical simulation method was found to have a significant positive impact on mathematics academic attainment. As shown in Table 1.1, when mathematical stories were used effectively, 47.4% of children achieved above-average results, compared to 0% in the control group where mathematics simulation methods were not used (Chi-square = 9.707, p = .021). The consistent use of mathematical stories until the lesson's end also led to 47.4% above-average scores compared to 15.8% in the control group (Chi-square = 13.528, p = .004) of mathematical stories. Children also felt more comfortable and performed better when they used mathematical stories effectively, with 47.4% achieving above-average scores compared to 21.1% scores in the control group (Chi-square = 14.884, p = .002).

These findings are consistent with existing research that shows that teaching mathematical concepts through mathematical stories can improve logical-mathematical cognition proficiencies (Bjorklund & Palmer, 2020; Pentimonti et al., 2024; Trakulphadetkrai, 2018; 2019). Studies argue that mathematical stories connect children emotionally with the mathematics content (Egan, 2005; Ewing & Monroe, 2018; Van den Heuvel-Panhuizen et al., 2016), making mathematics concepts easier to comprehend and more interesting. This method provides an effective non-routine way of teaching complex mathematical concepts (Trakulphadetkrai, 2018; 2019) and can significantly improve mathematics academic attainment (Farrugia & Trakulphadetkrai, 2020; Purpura et al., 2017). These

findings emphasise the value of mathematical stories for improving children's understanding of mathematical concepts and improving mathematics performance. The use of mathematical stories in mathematics lessons is interesting, reduces boredom in mathematics lessons, and increases children's motivation to learn mathematics. It removes mathematical barriers and reduces tension between children and teachers, making children feel comfortable, calm, and closer to their teacher and peers.

This study further investigated the relationship between the utilisation of games as a mathematical pedagogical simulation method and the mathematics attainment of third-grade children. The results of the data analysis are presented in the table below, providing insight into the efficacy of games-based simulation in enhancing mathematics performance.

Table 2. Story mathematics pedagogical Simulation method and academic attainment

Games		academic attainment				Pearson Chi-square Tests		
		below average		above average				
		Count	Column N %	Count	Column N %	Chi-square	df	Sig.
The classroom mathematics teacher introduces mathematics concept through games-mathematics pedagogical simulation methods to make sure that all children are involved in mathematics learning activities	Not Observed	12	70.60%	4	21.10%			
	Ineffective	2	11.80%	0	0.00%			
	Somewhat Effective	2	11.80%	9	47.40%			
	Effective	1	5.90%	6	31.60%	13.557	3	.004*
The classroom mathematics teacher presents mathematics concepts to children through games-mathematics pedagogical simulation methods until the end of the mathematics lesson.	Not Observed	12	70.60%	2	10.50%	15.104	3	.002*
	Ineffective	2	11.80%	2	10.50%			
	Somewhat Effective	2	11.80%	9	47.40%			
	Effective	1	5.90%	6	31.60%			
The children appear to be at ease while learning mathematics concepts through games- mathematics based pedagogical simulation method until the end of mathematics lesson.	Not Observed	8	47.10%	4	21.10%	15.295	3	.002*
	Ineffective	6	35.30%	0	0.00%			
	Somewhat Effective	2	11.80%	9	47.40%			
	Effective	1	5.90%	6	31.60%			

* The Chi-square statistic is significant at the .05 level.

Games-based mathematical pedagogical simulation methods have a significant positive impact on mathematics academic attainment. In classrooms where games were effectively used, 31.6% of children achieved above average scores, compared to 10.5% in the control group (Chi-square = 15.104,

p = .002). This approach makes complex mathematical concepts enjoyable and engaging, increasing retention capacity, attention, and interest in mathematics

Robust studies support these findings, showing that game-based learning improves mathematics performance, motivation, and engagement (Dorji, 2024; Kaloo et al., 2024). Games like arithmetic simulations significantly enhance basic arithmetic skills among grade three children (Pareto et al., 2011). Integrating game-based learning into mathematics lessons can harness children's interest in gaming to foster interactive problem-solving and critical thinking (Riley, 2019; Yang & Cheng, 2010). This subsection examines the nexus between music-based pedagogical simulations and mathematics academic attainment, with a focus on elucidating the impact of music integration on children's mathematics learning outcomes. Specifically, it evaluates the effectiveness of music-infused instructional methods in enhancing mathematics performance, as evidenced by the analysis of children's scores presented in the table below.

Table 3. Music Pedagogical simulations and Mathematics Academic attainment

Music pedagogical simulations		academic attainment				Pearson Chi-square Tests		
		below average		above average				
		Count	Column N %	Count	Column N %	Chi-square	df	Sig.
The classroom mathematics teacher presents mathematics concepts to children through music-mathematics pedagogical simulation methods until the end of the mathematics lesson.	Not Observed	7	41.20%	3	15.80%	14.058	3	.003*
	Ineffective	7	41.20%	1	5.30%			
	Somewhat Effective	1	5.90%	6	31.60%			
	Effective	2	11.80%	9	47.40%			
The classroom mathematics teacher introduces mathematics concepts through music-mathematics pedagogical simulation methods to address continuum of children's mathematics concepts in the classroom	Not Observed	8	47.10%	2	10.50%			
	Ineffective	6	35.30%	2	10.50%			
	Somewhat Effective	1	5.90%	6	31.60%			
	Effective	2	11.80%	9	47.40%	14.531	3	.002*
The classroom mathematics teacher provides children with sufficient time to internalize and mathematize mathematics concepts.in the classroom.	Not Observed	14	82.40%	4	21.10%	13.512	2	.001*
	Ineffective	0	0.00%	0	0.00%			
	Somewhat Effective	1	5.90%	6	31.60%			
	Effective	2	11.80%	9	47.40%			

Music-based pedagogical simulation methods have a significant positive impact on mathematics academic attainment. When effectively used, 47.4% of children achieved above-average scores, compared to 5.3% when ineffectively used (Chi-square = 14.058, p = .003). Similarly, introducing mathematics concepts with music simulation methods led to 47.4% above-average scores, compared to 10.5% without (Chi-square = 14.531, p = .002). These findings align with robust studies suggesting music-mathematics-based pedagogical methods enhance mathematical cognition proficiency (An & Capraro, 2011; An, Capraro, & Tillman, 2013; Akın, 2025). Incorporating musical elements like melody, rhythm, and scales improves children's understanding of complex concepts like number

operations and geometry (Beer, 1998; Harkleroad, 2006). Music contextualizes mathematics, making abstract concepts more relatable (Faurel, Flood & Wilson, 2006; Shanders, 2018).

This approach also boosts motivation, self-reflection, and creates a collaborative learning environment (Peterson, 2005; Robertson & Lesser, 2013). Children learning mathematics through music exhibit better outcomes, with music interventions showing a small to moderate positive effect on mathematics achievement (g = 0.36). Empirical studies underscore the potency of music-based interventions in augmenting mathematics achievement, suggesting that melodic and rhythmic elements can facilitate numerical cognition and problem-solving skills (Hall, 2022; Linnavalli & Putkinen, 2024). For instance, music-infused mathematics instruction has been shown to enhance cognitive flexibility, creativity, and spatial-temporal skills, all of which are germane to mathematics proficiency (Hall, 2022; Linnavalli & Putkinen, 2024). The forthcoming analysis will shed light on the efficacy of music-based pedagogical simulations in improving mathematics academic attainment, with implications for instructional design and practice.

This subsection examines the impact of drama-based pedagogical simulations on the mathematics academic attainment of grade three children. Specifically, it investigates the relationship between the utilisation of drama as a teaching method and the subsequent mathematics performance of participants. The results of the frequency tables and Pearson Chi-square tests are presented in Table 4 below:

Table 4. Efficacy of Drama-Based Pedagogical Simulations in Mathematics Academic Attainments

Drama-Pedagogical Simulation		academic attainment				Pearson Chi-square Tests		
		below average		above average				
		Count	Column N %	Count	Column N %	Chi-square	df	Sig.
The classroom mathematics teacher introduces mathematics concept in the class through drama-mathematics pedagogical simulation methods to address the continuum of children's mathematical concepts	Not Observed	10	58.80%	4	21.10%	13.958	3	0.003*
	Ineffective	4	23.50%	0	0.00%			
	Somewhat Effective	2	11.80%	9	47.40%			
	Effective	1	5.90%	6	31.60%			
The classroom mathematics teacher presents mathematics concepts to children through drama-mathematics pedagogical simulation methods until the end of rhe 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 children appear to be at ease while learning mathematics concepts through mathematics-drama based pedagogical simulation method until the end of mathematics lesson	Not Observed	14	82.40%	3	15.80%	16.082	3	.001*
	Ineffective	0	0.00%	1	5.30%			
	Somewhat Effective	2	11.80%	9	47.40%			
	Effective	1	5.90%	6	31.60%			

Drama-based pedagogical simulations significantly enhance mathematics academic attainment, with 47.4% of children achieving above-average scores when drama methods were somewhat effective or effective (Chi-square = 13.958, p = .003). Continued drama use until the end of lessons yielded similar improvements, with 47.4% achieving above-average scores compared to 21.1% without drama

(Chi-square = 13.958, p = .003). Children felt more at ease and performed better with dramaturgical methods, with 47.4% achieving above-average scores compared to 15.8% without drama (Chi-square = 16.082, p = .001) [1].

These findings align with recent studies suggesting drama-based instruction promotes collaborative learning, taps into diverse intelligence preferences, and fosters deeper mathematical understanding through role-playing (Gardner, 2020; Armstrong, 2014; Anderson, 2002). Drama connects learning to real-life content, improving children's ability to internalize mathematical concepts (Catterall, 2002; McMaster, 1998). Drama-based instruction leverages children's multiple intelligence, creating a more effective and meaningful mathematics learning experience (Gardner, 2020) Robust empirical studies further suggest that drama-based pedagogical simulations can significantly enhance mathematics learning outcomes by fostering engagement, creativity, and critical thinking (Duong, 2022; Lee, 2024). Drama-based approaches have been shown to promote deeper understanding of mathematical concepts, improve problem-solving skills, and increase children's motivation (Duong, 2022; Lee, 2024). The data analysis elucidates the efficacy of drama-based pedagogical simulations in improving mathematics academic attainment, with implications for instructional design and practice.

This subsection elucidates the nexus between mathematics discussion pedagogical simulation methods and mathematics academic attainment, with a focus on elucidating the impact of discourse-based approaches on children's comprehension and performance. The effectiveness of this method was assessed using questionnaires, and the results were analysed using frequency tables and Pearson Chi-square tests, as presented in the table below:

Table 5. Mathematics Discussion Pedagogical Simulation Method and Mathematics Academic Attainment

Mathematics-discussion		academic attainment				Pearson Chi-square Tests		
		below average		above average				
		Count	Column N %	Count	Column N %	Chi-square	df	Sig.
The classroom mathematics teacher introduces mathematics concepts through music-mathematics pedagogical simulation methods to address continuum of children's mathematics concepts in the classroom	Not Observed	8	47.10%	2	10.50%			
	Ineffective	6	35.30%	2	10.50%			
	Somewhat Effective	1	5.90%	6	31.60%			
	Effective	2	11.80%	9	47.40%	14.531	3	.002*
The classroom mathematics teacher present mathematics concepts to children through classroom mathematics-discussions pedagogical simulation methods until the end of mathematics lesson	Not Observed	10	58.80%	3	15.80%	13.526	3	.004*
	Ineffective	4	23.50%	1	5.30%			
	Somewhat Effective	1	5.90%	6	31.60%			
	Effective	2	11.80%	9	47.40%			
The children appear to be at ease while learning mathematics concepts through mathematics-discussions based	Not Observed	9	52.90%	3	15.80%	13.624	3	.003*
	Ineffective	5	29.40%	1	5.30%			
	Somewhat Effective	1	5.90%	6	31.60%			
	Effective	2	11.80%	9	47.40%			

simulation methods until the end of mathematics lesson

Mathematics discussion-based pedagogical simulations significantly enhance academic attainment, with 47.4% of children achieving above-average scores when discussions were effectively used, compared to 10.5% without (Chi-square = 14.531, p = .002). Consistent discussion use yielded similar improvements, with 47.4% achieving above-average scores versus 15.8% without discussions (Chi-square = 13.526, p = .004). Children felt more at ease and performed better with effective discussions, with 47.4% achieving above-average scores versus 15.8% without (Chi-square = 13.624, p = .003)

These findings align with empirical studies emphasising the benefits of math discussions in promoting classroom "math talk", fostering dialogue, and enhancing mathematical understanding (Murphy, 2013; Hufferd-Ackles et al., 2004; Wagganer, 2015; Suurtamm et al., 2015). Social constructivism theory supports this approach, suggesting children learn better in groups with shared agency (Bermejo et al., 2021; Johnston & Johnston, 2021). Math discussions help children understand concepts, improve cognitive proficiency, and develop a positive disposition toward mathematics (Johnston Wilder & Lee, 2019; 2020; Susperreguy & Davis-Kean, 2016; Von Spreckelsen et al., 2019).Robust studies underscore the potency of mathematics discussions in fostering deep understanding, critical thinking, and problem-solving skills (Kazemi & Hintz, 2024; Staples & Newton, 2023). Discussion-based approaches have been shown to promote mathematical reasoning, argumentation, and sense-making, leading to improved academic attainment (Kazemi & Hintz, 2024; Staples & Newton, 2023). Furthermore, mathematics discussions have been found to enhance student engagement, motivation, and self-efficacy, all of which are critical predictors of mathematics achievement (Middleton et al., 2022). This subsection examines the impact of peer teaching as a source of pedagogical simulation on mathematics academic attainment. Data were collected using a questionnaire and analysed using frequency tables and Pearson Chi-Square tests.

Table 6. Relationship between initiated classroom Peer-Teaching as a source of Pedagogical simulation method and Mathematics academic attainment in Loitokitok Sampled Public Primary Schools

Mathematics-discussion		academic attainment				Pearson Chi-square Tests		
		below average		above average				
		Count	Column N %	Count	Column N %	Chi-square	df	Sig.
The classroom mathematics teacher introduces mathematics concepts through music-mathematics pedagogical simulation methods to address continuum of children's mathematics concepts in the classroom	Not Observed	8	47.10%	2	10.50%			
	Ineffective	6	35.30%	2	10.50%			
	Somewhat Effective	1	5.90%	6	31.60%			
	Effective	2	11.80%	9	47.40%	14.531	3	.002*
The classroom mathematics teacher present mathematics concepts to children through classroom	Not Observed	10	58.80%	3	15.80%	13.526	3	.004*
	Ineffective	4	23.50%	1	5.30%			
	Somewhat Effective	1	5.90%	6	31.60%			

mathematics-discussions pedagogical simulation methods until the end of mathematics lesson	Effective	2	11.80%	9	47.40%			
The children appear to be at ease while learning mathematics concepts through mathematics-discussions based simulation methods until the end of mathematics lesson	Not Observed	9	52.90%	3	15.80%	13.624	3	.003*
	Ineffective	5	29.40%	1	5.30%			
	Somewhat Effective	1	5.90%	6	31.60%			
	Effective	2	11.80%	9	47.40%			

The results of the study indicate that peer teaching, as a pedagogical simulation method, had a statistically significant positive impact on students' mathematics academic attainment (Akın, 2023). Specifically, when peer teaching was implemented with a somewhat effective or effective approach, 47.4% and 31.6% of students, respectively, achieved above-average scores, compared to only 10.5% when peer teaching was ineffective, $\chi^2(2) = 13.96$, $p = .003$. The consistent application of peer teaching strategies led to higher academic achievement, with 47.4% of students scoring above average, compared to 21.1% in the control group. Furthermore, students reported feeling more comfortable and performed better when peer teaching was implemented effectively, with 47.4% achieving above-average scores, compared to 21.1% in the control group.

These findings are consistent with previous research, which suggests that peer teaching, as a pedagogical simulation method, can significantly enhance mathematics learning (Armstrong, 2017; Bell, 2012; Coskungonullu, 2013; Fuini & Gray, 2008; Haynes, 2020). For instance, Armstrong (2017) argues that peer teaching promotes active learning, social interaction, and cognitive development. Similarly, Bell (2012) notes that peer teaching can foster a sense of community and cooperation in the classroom, leading to improved academic outcomes. The use of versatile teachers and peers in the mathematics classroom, who possess competencies in areas beyond mathematics, can serve as effective sources of pedagogical simulation methods, fostering a positive classroom climate and improving interactions between teaching and learning (Barwell, 2011; Brophy, 2010). As Barwell (2011) suggests, this approach can help to create a more inclusive and supportive learning environment, where students feel encouraged to participate and engage with mathematical concepts.

Research indicates that children with strong interpersonal intelligence, who excel in collaborative learning environments, benefit significantly from peer teaching (Gardner, 2020; Fuini & Gray, 2008). According to Gardner (2020), children with strong interpersonal skills are well-suited to peer teaching, as they are able to communicate effectively and work collaboratively with their peers. Furthermore, nurturing children's love of mathematics through group work and peer interactions can lead to more successful learning outcomes (Coskungonullu, 2013). As Coskungonullu (2013) notes, peer teaching can help to promote a growth mindset and a love of mathematics in students, leading to improved academic achievement and a more positive attitude towards mathematics.

Conclusion

In conclusion, this study demonstrates that simulation-based mathematics pedagogy is an effective instructional approach for improving Grade Three pupils' mathematics achievement in Loitokitok Sub-County, Kenya. The findings revealed a substantial increase in above-average mathematics achievement among pupils in the experimental group, rising from 62.30% to 92.90%. The implementation of mathematical storytelling, games, music, drama, classroom discussion, and peer-

tutoring discussion significantly enhanced pupils' mathematics achievement, promoted active engagement, and created more meaningful and learner-centred mathematics learning experiences. These findings provide empirical evidence that integrating multiple simulation-based pedagogical approaches within a single instructional framework is more effective than relying solely on conventional teacher-centred instruction, thereby extending the current literature on mathematics teaching and learning in primary education.

The findings have important implications for educational practice and policy. Mathematics teachers are encouraged to integrate diverse simulation-based pedagogical approaches into classroom instruction while aligning learning activities with pupils' diverse learning characteristics. Furthermore, schools and educational authorities should provide continuous professional development programmes and supportive policies to facilitate the effective implementation of these innovative instructional strategies. Future research should examine the long-term effectiveness of simulation-based mathematics pedagogy across different grade levels, educational contexts, and learning domains, including mathematical reasoning, problem-solving skills, and learners' motivation toward mathematics, to further strengthen the evidence base for learner-centred mathematics instruction.

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