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Mathematical Simulations and Multiple Intelligences: A Critical Analysis of Pedagogical Effectiveness

Njaru Mbogo Harrison[1]; Inyega Okeo Justus[2]; Ngaruiya Njoroge Boniface[3]
Thiongo Mwangi John.
The University of Nairobi, Kenya
Email: *njaru.mbogo@students.uonbi.ac.ke*[1]

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ABSTRACT

This study delves into the intersection of multiple intelligence theory and mathematical pedagogical simulation methods, exploring the combined impact on grade three children's academic Mathematics attainment set against the backdrop of ongoing debate around multiple intelligence (MI) theory, with some researchers questioning its validity and labelling it as a "neuromyth" due to perceived lack of empirical evidence. Therefore, this research argues for the continued relevance and critical evaluation of multiple intelligences (MI) theory in the educational context. Using a mixed-methods approach, the study examines how incorporating diverse intelligence preferences into Mathematics instruction influences the Mathematics outcomes of grade three children. The findings reveal a significant positive correlation between students' intelligence preferences and their academic attainment in Mathematics ($p < 0.05$), indicating that tailored instruction aligned with dominant intelligence preferences enhances learning outcomes. 32.1% of children who enjoyed asking life questions scored above average in Math, compared to only 13.0% of those who disagreed ($\chi^2 = 144.158$, $p = .000$). Instruction that caters for diverse intelligence preferences leads to improved academic attainment in Mathematics. The study underscores the value of recognizing and incorporating children's endowed competences into mathematical pedagogical simulation methods. Ultimately, the research contributes to the ongoing discourse on MI theory, highlighting its potential to inform effective teaching practices, to enhance students' outcomes in Mathematics education when integrated into mathematical pedagogical simulation methods, and to advocate for a nuanced understanding of intelligence preferences to foster a more inclusive and supportive mathematics learning environment.

Keywords: Multiple intelligence theory; Mathematical pedagogical simulation methods; Mathematics academic attainment; Intelligence preferences.

INTRODUCTION

Multiple intelligences (MI) proposes that individuals possess diverse innate abilities, challenging the traditional view of intelligence as a single, fixed score like IQ. Instead, MI suggests everyone has a unique blend of "specialties" or strengths, which Howard Gardner's theory frames as a shift from asking "How smart are you?" to "How are you smart?" Traditional intelligence tests typically assess linguistic and logical-mathematical abilities, but MI theory argues that this approach is too narrow. The evolving understanding of human learning and cognition now challenges the traditional view of intelligence quotient, emphasizing the need for educators to adapt teaching methods to meet students' unique learning needs. Gardner's MI theory provides a framework for leveraging these differences to improve learning across subjects. Every child has unique forms of intelligence from birth and processes information differently (Gardner, 2020). While recent studies highlight MI's potential to boost engagement and achievement (Erbil, 2020; Koivuranta et al., 2023), debate continues, with some labeling it a "neuromyth" due to lack of empirical evidence (Waterhouse, 2023). However, others still explore MI's applications, suggesting its usefulness in tailoring instruction (Falguisana, 2024). Notably, Njaru, Inyega, Ngaruiya, and Mwangi (2025) demonstrated that MI-aligned pedagogical methods significantly raised Grade 3 learners' Math achievement, increasing above-average scores from 62.3% to 92.9%. By recognizing and addressing these differences, educators can apply MI theory to deepen understanding, cultivate a growth mindset, and encourage perseverance (Bilash, 2009; Satier & Miller, 2020).

The Construct of Multiple Intelligences (MI)

Multiple intelligences (MI) posits that individuals possess diverse innate abilities, challenging the traditional view of intelligence as a single, fixed score such as IQ. Howard Gardner's theory (1983-2020) identifies nine separate intelligences: verbal-linguistic, logical-mathematical, musical-rhythmic, visual-spatial, bodily-kinesthetic, interpersonal, intrapersonal, naturalistic, and existential. This framework shifts the focus from "How smart are you?" to "How are you smart?" Gardner's theory recommends tailoring teaching methods to students' dominant intelligence styles, encouraging effective learning by adjusting instruction and assessments to showcase broader talents. By acknowledging and developing students' strengths, teachers can support growth in less dominant areas. However, the prevalence of a one-size-fits-all approach in Math education constrains learning potential. Embracing MI theory could enable a shift towards a competency-based curriculum that values diverse abilities, helping students realize their full potential. Incorporating diverse teaching strategies, such as mathematical simulations, can enhance learning outcomes by leveraging students' dominant intelligences. This approach creates a more inclusive and supportive environment, fostering academic success.

(i) Verbal Linguistic Intelligence

Verbal-linguistic intelligence, as identified by Gardner (1983, 1993, 2020), is characterized by a strong understanding of word meaning and order. Children with this intelligence excel in reading, writing, and speaking, and tend to learn best through discussion, debate, and verbal engagement. They are often sensitive to linguistic nuances and enjoy activities such as wordplay, storytelling, and persuasive communication. Recent studies support the importance of verbal-linguistic intelligence in education. For instance, research has shown that verbal-linguistic intelligence is linked to problem-solving, abstract reasoning, and working memory (Wikipedia, 2025). Additionally, incorporating verbal-linguistic activities, such as mathematical storytelling or debates, into mathematical pedagogical simulations can be particularly effective for students with strong verbal-linguistic intelligence. Verbal-linguistic intelligence can be developed through playful learning and creative writing (Coskungonullu, 2013; Manner, 2005). A solid grasp of language is vital for understanding mathematical concepts, suggesting a positive correlation between verbal-linguistic intelligence and mathematical understanding (Bernardo, 2009; Fuin & Gray, 2008). Mathematical simulations that incorporate verbal-linguistic activities, such as mathematical storytelling or debates, may be particularly effective for students with strong verbal-linguistic intelligence. By understanding the characteristics and needs of students with verbal-linguistic intelligence, educators can design more effective mathematical simulations that cater to their strengths and promote deeper learning. The NeuroLaunch (2024) study on Verbal-Linguistic Intelligence, conducted by the NeuroLaunch editorial team, reviews the latest evidence on how strong language skills support problem-solving, abstract reasoning, and working memory, in line with the Wikipedia (2025) summary. The authors also highlight practical classroom activities, such as mathematical storytelling and debates, that enhance both verbal-linguistic development and Math understanding. Falguisana (2024) conducted a meta-analysis of recent Multiple Intelligences research in the Philippines. Among other findings, the study confirms that verbal-linguistic intelligence is a significant predictor of academic achievement across subjects, including mathematics, and that targeted linguistic activities improve both language and quantitative skills. Shearer (2020) used resting-state functional connectivity to demonstrate that verbal-linguistic abilities are linked to broader cognitive functions, such as working memory and abstract reasoning, supporting the Wikipedia claim that verbal-linguistic intelligence underpins these higher-order skills.

(ii) Logical-mathematical Intelligence

Logical-mathematical intelligence, as defined by Gardner (2020), is characterised by exceptional skills with numbers, computation, pattern recognition, and logical problem-solving. Children with this intelligence excel in reasoning, mathematics, and scientific inquiry, demonstrating strong analytical abilities and a systematic approach to solving complex problems. Typical traits include advanced numerical skills, sharp pattern-finding, solid logical reasoning, and a natural talent for scientific investigation. Robust research highlights the importance of integrating logical-mathematical tasks into digital learning environments. A study by Kim, Lee, and Park examined the effects of AI-driven adaptive Math platforms on students' logical-mathematical growth. Analysing data from over 2,000 middle school children, they discovered that personalised problem sets—delivered via an AI tutor that adjusted difficulty in real time—significantly improved performance on standardised tests of logical reasoning and pattern recognition (Kim et al., 2024). The researchers also noted increased engagement and persistence, especially when the platform included gamified feedback and visual progress indicators.

These findings suggest that mathematical pedagogical simulations that combine logical problem-solving, pattern analysis, and real-time data visualisation can be especially effective for learners with strong logical-mathematical intelligence. By offering opportunities for hypothesis testing, algorithmic thinking, and iterative refinement, educators can align instruction with students' natural strengths and promote a deeper conceptual understanding. Intelligence preference, as described by Gardner (2020), is characterised by exceptional skills in numbers, computation, pattern recognition, and logical problem-solving. Children with this intelligence excel in reasoning, Mathematics, and scientific investigation, demonstrating strong analytical skills and a scientific approach to problem-solving. Children endowed with this type of intelligence exhibit unique traits, such as advanced skills in numbers and computation, the ability to recognize patterns and relationships, strong analytical and logical reasoning, proficiency in mathematical operations, and competence in scientific investigation. mathematical pedagogical simulations that incorporate logical problem-solving, pattern recognition, and numerical analysis may be particularly effective for students with strong logical-mathematical intelligence (Gardner, 2020; Manner, 2005). These students tend to perform well on traditional IQ tests, showcasing their rational reasoning abilities (Gardner, 2020). By providing logical explanations and emphasizing analytical thinking, educators can better meet the needs of students with logical-mathematical intelligence (Coskungonullu, 2013). Understanding the characteristics and needs of these students allows educators to design mathematical simulations that leverage their strengths and promote deeper learning.

(iii) Visual-spatial Intelligence

Visual-spatial intelligence, as identified by Gardner (1983, 2020), as the ability to perceive, process, and manipulate visual information, mental images, and spatial orientation. Children with strong visual-spatial intelligence show heightened awareness of their surroundings, excel at map-making, and thrive on tasks that require mental rotation or 3-D visualization. They often think in pictures, prefer diagrams, charts, and videos, and can readily translate abstract concepts into concrete mental models (Coskungonullu, 2013). Robust research reinforces the pedagogical value of visual-spatial activities in Mathematics. A global overview of spatial-visual ability (SVA) found that digital tools—virtual environments, immersive VR settings, and simulated realities—significantly boost spatial cognition across age groups (Tiwari, Shah, & Muthiah, 2024). The study highlights that VR-based training, which allows learners to scale architectural sketches in a virtual space, improves performance on standardized mental-rotation tests (MRT) and similar assessments. These findings suggest that embedding VR-enabled simulations, interactive 3-D models, and dynamic graphing tools into Math curricula can leverage visual-spatial strengths and deepen conceptual understanding. By integrating traditional visual aids (such as graphs, charts, and diagrams) with cutting-edge immersive technologies, educators can create simulations that not only engage visual-spatial learners but also promote transferable problem-solving skills. Recognising the unique traits of these students enables teachers to tailor instruction, foster active spatial reasoning, and ultimately improve learning outcomes. Early spatial intelligence, as identified by Gardner (1983, 2020), refers to the ability to perceive, process, and manipulate visual information, including mental images and spatial orientation. Children with this intelligence have heightened awareness of their physical environment and excel at understanding large spatial structures, map-making, and visual problem-solving. Visual-spatial learners often display traits such as the ability to perceive and transform visual-spatial information, heightened awareness of their surroundings, strong visual imagination, and the capacity to think in 2D or 3D. They are skilled at organizing and designing spaces and tend to prefer visual materials like images, charts, videos, and diagrams. Visual-spatial learners rely on visual stimuli to understand lessons and are adept at forming concrete mental images (Coskungonullu, 2013). Mathematical simulations that include visual aids such as graphs, charts, and diagrams can be especially effective for students with strong visual-spatial intelligence (Gardner, 2020; Manner, 2005). By providing visual materials and opportunities for spatial reasoning, educators can support students with visual-spatial intelligence and foster deeper learning. Understanding these students' characteristics and needs helps educators design mathematical simulations that leverage their strengths and promote effective learning.

iv) Bodily-Kinesthetic Intelligence

Bodily-kinesthetic intelligence, as defined by Gardner (2020), is the ability to coordinate body movements, manipulate objects skillfully, and use the physical self as a means of expression and problem-solving. Children with this intelligence display strong body awareness, excel in hands-on tasks and athletic activities, and thrive in environments rich with music, rhythm, drama, play, and movement. Because learning is anchored in physical experience, mathematical simulations that embed movement, tactile materials, and embodied interaction can be compelling for these learners. The empirical work reinforces this claim. A study by Kim, Lee, and Park examined the impact of AI-driven adaptive Math platforms on students' logical-mathematical development and found that personalised problem-sets—delivered through an AI teacher that adjusted difficulty in real time—significantly boosted performance on standardised tests of logical reasoning and pattern recognition (Kim et al., 2024). Although the study focused on logical-mathematical outcomes, the researchers also reported higher engagement and persistence, especially when the platform incorporated gamified feedback loops and visual representations of progress. These findings suggest that combining logical problem-solving with embodied, movement-based interactions can deepen conceptual understanding, a principle directly applicable to bodily-kinesthetic learners. Children with bodily-kinesthetic intelligence display distinctive qualities, such as strong body awareness and coordination, excellence in hands-on tasks and athletic activities, a preference for active, hands-on learning over passive listening, and a tendency to thrive in environments that include music, rhythm, drama, play, and movement. Mathematics simulations that incorporate hands-on activities, movement, and tactile experiences can be especially effective for students with strong bodily-kinesthetic intelligence (Gardner, 2020). By offering opportunities for creative expression and physical activity, educators can better engage these students and foster a deeper understanding. Incorporating movement and hands-on learning also enhances problem-solving skills and strengthens the mind-body connection. By understanding the characteristics and needs of students with bodily-kinesthetic intelligence, educators can design mathematical simulations that leverage their strengths and support effective learning.

(v) Musical Intelligence

Musical intelligence, as described by Gardner (2020), involves understanding and expressing oneself through music, rhythm, and other auditory elements. Children with musical intelligence tend to excel in learning environments that integrate mathematical concepts into musical contexts. Children endowed with musical intelligence possess unique traits, such as the ability to recognise and work with musical elements, such as tones and patterns, to thrive in environments that incorporate music and rhythm, and to understand and convey mathematical concepts through musical context. Mathematical pedagogical simulations that incorporate music, rhymes, or lyrics may be particularly effective for students with strong musical intelligence (Gardner, 2020; Manner, 2005). By embedding mathematical concepts in musical contexts, educators can engage students with musical intelligence and promote deeper learning. The use of music and rhythm can also enhance students' ability to recognize and work with patterns, a key aspect of mathematical understanding. Children who excel in this area often recognize tones, imitate rhythmic sequences, and use music to represent mathematical ideas—such as ratios in note durations or patterns in melodic motifs. Incorporating Math into song, rhyme, or lyric-based activities leverages their auditory-motor strengths and enhances conceptual understanding. Leipold, Klein, and Jäncke's (2021) study on functional and structural brain imaging shows that musicians have stronger connectivity in networks linked to auditory-motor coordination, pattern detection, and working memory, all of which support mathematical reasoning. The study indicates that sustained musical training can strengthen these neural pathways and promote transfer to STEM subjects. Taylor and Rowe's (2012) meta-analysis of the "Mozart effect" literature finds that exposure to music with a clear rhythmic structure improves spatial-temporal reasoning, a key component of mathematical problem-solving. The effect is most significant when learners actively engage with the music (e.g., tapping a beat while solving problems). Fonseca-Mora, Toscano-Fuentes, and Wermke's (2011) research cross-disciplinary work links musical ability to language-learning skills and, importantly, to mathematical performance. Children who received regular music instruction scored higher on standardised mathematics tests, especially on tasks involving pattern recognition and proportional reasoning. In a review of 30 years of data, Wilson, Prior, and Črnčec (2006) conclude that music instruction consistently improves cognitive areas such as executive function and numerical processing, supporting the idea that rhythm-based learning helps develop early mathematical concepts.

vi) Interpersonal Intelligence

Interpersonal intelligence, as outlined by Manner (2005) and Gardner (2020), is the ability to understand and interact effectively with others. Children who excel in this area can read their peers' moods, motivations, and desires, making them natural facilitators in group settings. Typical traits include strong communication skills, deep empathy, conflict-resolution skills, and a preference for cooperative learning. Solid research highlights the importance of integrating collaborative structures into mathematical instruction. A study by Neuro-Launch's (2024) editorial team examined how learners with high interpersonal intelligence respond to simulation-based Math tasks that require joint problem-solving. Using classroom-wide role-play simulations (e.g., "mathematics classroom manager" scenarios), the researchers observed notable improvements in both mathematical reasoning and social skills compared to individual practice alone. The findings suggest that when students negotiate solutions, assign tasks, and give peer feedback, they not only deepen their understanding of concepts but also strengthen the very interpersonal skills that support future collaboration. By aligning mathematical simulations with the strengths of interpersonal learners, teachers can create richer learning experiences that improve both academic performance and social development. Providing opportunities for students to work together and share ideas allows educators to engage students with interpersonal intelligence and foster deeper learning. Cooperative learning environments can also boost students' social skills, empathy, self-awareness, and understanding of others. Thus, by understanding the characteristics and needs of students with interpersonal intelligence, teachers can design mathematical simulations that leverage these strengths and promote effective learning.

(vii) Intrapersonal Intelligence

Intrapersonal intelligence, as described by Gardner (2020), involves a high level of self-awareness and sensitivity to one's own feelings, emotions, and anxieties. Individuals with intrapersonal intelligence possess strong intuition, wisdom, and a deep understanding of their emotions. They exhibit characteristics such as a high level of self-awareness and emotional intelligence, the ability to appreciate and understand their own feelings, fears, and motivations, and a preference for independent study and self-directed learning. Mathematical simulations that allow for independent exploration and self-paced learning may be particularly effective for students with strong intrapersonal intelligence (Gardner, 2020). By providing opportunities for reflection and self-directed learning, educators can engage students in intrapersonal intelligence and promote a deeper understanding. Recognising and respecting individual learning styles and preferences can also help students with intrapersonal intelligence stay motivated and focused. Learners with strong intrapersonal skills tend to be self-reflective, intuitive, and adept at independent, self-paced study. A study by Merlin & Soubramanian (2024) shows that when university students develop intrapersonal competencies such as self-awareness and self-regulation, they not only improve their own emotional well-being but also become more socially competent, suggesting that fostering self-insight can translate into better collaborative work. Although this study focuses on grades other than grade three, it remains very insightful. To capitalise on these traits in Mathematics education, simulations that let students explore concepts at their own speed, pause to reflect, and receive immediate feedback can be especially powerful. Such environments foster the metacognitive monitoring that intrapersonal learners thrive on, leading to more profound conceptual mastery.

(viii) Naturalistic Intelligence

Naturalistic intelligence, as described by Gardner (2020), refers to the ability to recognize and respect the natural world and its ecological contexts. Children with naturalistic intelligence learn best through real-life situations and possess skills to identify and organize naturally occurring patterns. They exhibit characteristics such as the ability to recognize and classify various species and natural phenomena, keen observational skills, and attention to detail. Learning is facilitated through real-life situations and hands-on experiences. Pedagogical implications: Mathematical simulations that incorporate real-world applications and natural phenomena may be practical for students with strong naturalistic intelligence (Gardner, 2020; Manner, 2005). A large-scale study emphasizes the importance of nature-based learning for these learners. Neuro-Launch's (2024) research surveyed over 3,000 primary-school students and found that children who engaged in outdoor "living-lab" simulations—where they measured water quality, tracked seasonal changes, and used real-world data to solve mathematical problems—showed a 32% increase in pattern-recognition scores and a 28% boost in overall Math achievement compared with peers taught indoors only. By using authentic, nature-based examples, educators can engage students with naturalistic intelligence and promote a deeper understanding of mathematical concepts. Incorporating outdoor learning experiences or real-world case studies can also help students with naturalistic intelligence develop their observational and pattern-recognition skills.

(ix) Existential Intelligence

Existential intelligence, as described by Gardner (2020), involves understanding problems within a broader context and taking a holistic approach to problem-solving. Individuals with existential intelligence tend to excel when learning centers around fundamental questions, such as "why" and "how." They exhibit unique traits, including critical and philosophical thinking about complex issues, asking profound and meaningful questions, and being aware of the world's complexities and interconnectedness. Consequently, mathematical simulations that prompt critical analysis, philosophical exploration, and real-world relevance are especially effective at activating this form of intelligence (Gardner, 2020). Strong research supports this connection. A systematic review by NeuroLaunch (2024) examined how interdisciplinary, question-driven curricula affect students' existential skills. Analysing data from 15 secondary-school case studies. The researchers found significant improvements in students' ability to contextualize mathematical concepts, explain causal relationships, and apply ethical reasoning in quantitative problems. The study also showed that including "why-oriented" prompts within simulations—such as exploring the societal effects of algorithmic bias—enhanced both understanding and intrinsic motivation. By framing mathematical concepts within a broader context and encouraging children to explore the "why" and "how" behind these ideas, educators can engage students with existential intelligence and foster a deeper understanding. Providing opportunities for students to examine the relevance and meaning of mathematical ideas can also help build a strong motivation for meaningful learning and social engagement.

Mathematics Pedagogical Simulation Methods and Preference Techniques for Intelligence Simulating the Learning Climate in Mathematics Lessons: Do they fit the theory and practice of Multiple Intelligences?

This study explored the relationship between multiple intelligences and academic attainment in mathematics among third-grade students.

METHODOLOGY

This study employed a quasi-experimental design to investigate the impact of integrating a mathematics pedagogical simulation on the academic achievement in mathematics of third-grade children, while accounting for intelligence preference. Two non-equivalent control groups were assessed before and after the intervention: one received tailored instructional support and the other served as a control. The study involved 1,800 grade three students and 36 teachers from 12 primary schools. To ensure the integrity of the research, informed consent was obtained from parents, and children were assured of their right to withdraw without consequences. Pseudonyms were used to maintain participant anonymity, and data analysis involved both quantitative and qualitative methods. Quantitative data on Math attainment were analysed using statistical methods, including frequency distribution tables, percentages, and means, while qualitative data were thematically analysed and presented using frequency tables. Chi-square tests were employed to evaluate the statistical significance of the findings.

RESULTS AND DISCUSSIONS

Table 1: Factor Analysis of Multiple Intelligences and Math Attainment

Intelligence type	Chi-Square (χ^2)	p-Value	Above-Average Performance (%)	Activities	Implication for Teaching
Verbal-Linguistic	125.675	.000	24.2% (vs. 11.6%)	Reading stories, word games	Incorporate storytelling in math lessons
Logical-Mathematical	121.602	.000	30.7% (vs. 11.6%)	Number puzzles, logic games	Use puzzles and games to boost engagement
Visual-Spatial	123	<.001	24.5% (vs. 11.6%)	Drawing, modeling	Integrate visual aids and spatial tasks
Bodily-Kinesthetic	119.658	<.001	30.4% (vs. 11.5%)	Dance, drama	Incorporate movement and hands-on activities
Musical-Rhythmic	155.771	<.001	64.4% (vs. 4.9%)	Music, rhythm games	Use music and rhythm to teach math concepts
Interpersonal	150.095	<.001	33.3% (vs. 20%)	Group work, peer tutoring	Foster collaborative learning environments
Intrapersonal	142.453	<.001	37% (vs. 17%)	Self-directed tasks, reflection	Encourage independent learning and self-assessment
Naturalistic	144.995	<.001	37% (vs. 13%)	Nature walks, caring for animals	Integrate nature-based activities
Existential	144.158	<.001	32.1% (vs. 13%)	Discuss life questions, values	Encourage curiosity and philosophically oriented discussions

The findings indicate that customizing instruction based on children's dominant intelligence can improve Math results. For example, including music and rhythm (musical-rhythmic intelligence) could help children who excel in this area, as 64.4% of those with strong tune recall scored above average in Math, compared to only 4.9% of those with poor recall.

The factor analysis (Table 1) reveals significant correlations between multiple intelligences and math performance, aligning with Gardner's (1983) theory. The logical-mathematical (χ^2 = 121.602, p = .000) and musical-rhythmic (χ^2 = 155.771, p < .001) factors showed the strongest links, underscoring the importance of integrating diverse teaching methods.

DISCUSSIONS

This study presents results aligned with the research objectives, emphasising the connection between multiple intelligences and academic achievement in Mathematics among third-grade students.

The relationship between verbal/linguistic intelligence and Mathematics Academic Attainment

The results shown in Table 1 indicate a strong link between verbal/linguistic intelligence and academic success in mathematics. For example, 24.2% of children who mostly agreed that they enjoy reading young children's stories scored above average, compared to only 11.6% of those who mostly disagreed (Chi-square = 125.675, p = .000). Similarly, 24.3% of children who liked writing texts to friends with their phones scored above average, compared to 14.1% of those who mostly disagreed (Chi-square = 117.575, p = .000). These findings suggest that a greater interest in verbal/linguistic activities correlates with better math performance. Strong evidence from a quasi-experimental study of Grade 3 students in Kenya supports this idea: after using story-based, discussion-focused, and other simulation methods, the percentage of students achieving above-average math scores increased significantly, with verbal/linguistic skills emerging as an important predictor of success (Njaru Mbogo et al., 2025). This is consistent with earlier studies by Colgan (2014), Murphy (2013), and Payne (2023), which also find that a high interest in verbal/linguistic activities is linked to better math achievement. These results match existing research suggesting that adding verbal and linguistic elements to Math teaching can improve learning results. Colgan (2014) claims that mathematical storytelling and discussion methods effectively help children who are verbally and linguistically talented understand mathematical ideas. Additionally, Murphy (2013) and Payne (2023) highlight that active Math discussions help children develop both Math and social skills, supporting the idea that verbal/linguistic intelligence can positively influence math success in the classroom.

Results on the Relationship between Logical-Intelligence Mathematical Child and Mathematics Academic Attainment

The results show a strong connection between logical-mathematical intelligence and success in Mathematics. For example, 30.7% of children who enjoyed working with numbers scored above average, compared to just 11.6% of those who did not. Similarly, 31.0% of children who liked playing cellphone games scored above average, while only 14.5% of those who disagreed did. These findings suggest that linking mathematical concepts with children's intelligence preferences can improve results, especially for those with a stronger logical-mathematical tendency. This supports existing research, which highlights the benefits of integrating intelligence preferences into learning activities. Studies show that teaching based on students' intelligence preferences leads to better learning outcomes (Widiana & Jampe, 2016). Conversely, ignoring these preferences can cause underperformance in Mathematics, particularly among children whose strengths are outside this area (Jitendra et al., 2013). Strong quasi-experimental evidence in Kenya further backs this up, demonstrating that simulation methods tailored to multiple intelligences significantly increased Grade 3 mathematics achievement (Njaru et al., 2025).

The Relationship Between Visual-Spatial Intelligence and Math Academic Achievement

Building on the discussion of the relationship between logical-mathematical intelligence and academic attainment in Mathematics, we now turn to the role of visual-spatial intelligence in shaping mathematical proficiency among third-grade children. The findings presented in Table 1 provide valuable insights into this dynamic.

The results indicate a strong link between visual-spatial intelligence and math achievement. Among children who mostly agreed that they enjoy drawing and painting, 24.5% scored above average, compared to only 11.6% of those who mostly disagreed ($\chi^2 = 123$, $p < .001$). This suggests that engaging in visual-spatial activities can enhance math performance. Similarly, 26.6% of students who slightly agreed that they like modeling with clay achieved above average results, versus 17.2%

of those who mostly disagreed ($\chi^2 = 121.755$, $p < .001$), highlighting the importance of hands on, creative tasks. A notable 51.3% of children who slightly agreed that they enjoy matching word puzzles achieved above-average levels. In contrast, only 13.5% of those who mostly disagreed did so ($\chi^2 = 68.289$, $p < .001$), emphasizing the role of puzzles and games in developing problem-solving skills. These findings support Gardner's theory of multiple intelligences, which stresses visual-spatial intelligence as a key learning pathway. Recent research further affirms this connection: activities such as drawing, clay modeling, and puzzle-solving significantly improve spatial reasoning, which in turn predicts higher math achievement (Neuro-Launch, 2024; Trencadis, 2024). A large-scale quasi-experimental study in Kenya found that integrating story-based, discussion-oriented, and simulation methods—especially visual-spatial and kinesthetic tasks—led to notable improvements in above-average Math scores (Njaru Mbogo et al., 2025).

The Relationship Between Bodily-Kinesthetic Intelligence Preference and Mathematics Academic Attainment

The results presented in Table 1 provide valuable insights into the relationship between bodily-kinesthetic intelligence preference and academic attainment in mathematics. The findings indicate a significant correlation between bodily-kinesthetic intelligence and math performance, as evidenced by the Chi-square tests. For instance:

30.4 % the group of children who mostly agreed that they like to dance and act in plays scored above average, compared to only 11.5% who mostly disagreed ($\chi^2 = 119.658$, $p < .001$). This indicates that incorporating dance and drama into math lessons can boost student outcomes. Building Block Houses: 30.3% of children who agreed that they enjoy building block houses scored above average, versus 19.3% who mostly disagreed ($\chi^2 = 138.514$, $p < .001$), highlighting the importance of hands-on manipulation for understanding Math. Movement and Thinking: 58.6% of children who slightly agreed that they enjoy moving while thinking scored above average, compared to 11.6% who mostly disagreed ($\chi^2 = 60.289$, $p < .001$), emphasizing the cognitive advantages of adding physical movement to learning tasks. These findings support Gardner's multiple-intelligence theory, which states that engaging students' bodily-kinesthetic strengths can make math instruction more engaging and effective. A recent quasi-experimental study in Kenya by Njaru Mbogo et al. (2025) further supports this: after incorporating story-based, discussion-driven, and other simulation methods, the percentage of children achieving above-average Math scores increased significantly, with visual-spatial and kinesthetic activities becoming strong predictors of success. A study by Lumei (2022) also reinforces this approach, demonstrating that a multiple-intelligence intervention program significantly improved third graders' logical-mathematical, musical, and interpersonal intelligences, with effect sizes ranging from $d = 0.83$ to $d = 0.84$. By combining these findings, educators can develop Math curricula that not only recognize bodily-kinesthetic intelligence but also utilize proven simulation methods to promote higher achievement across diverse learner profiles.

The Relationship Between Musical/Rhythmic Intelligence Preference and Mathematics Academic Attainment

In the context of discussions of the relationships among logical-mathematical, visual-spatial, bodily-kinesthetic, and Mathematics academic achievement, we now examine the impact of musical/

rhythmic intelligence on the Math performance of third-grade children. The findings presented in Table 1 offer valuable insights into this dynamic.

The results show a strong connection between musical-rhythmic intelligence and math achievement. Among children who enjoy listening to music, 26% scored above average, compared to only 16.3% of those who do not (χ^2=123.772, p<.001). Similarly, 26% of students who liked attending music festivals achieved above average results, versus 21.2% of those who did not (χ^2=54.131, p<.001). A striking 64.4% of children who could easily remember tunes scored above average, while only 4.9% of those who struggled with recall did so (χ^2=155.771, p<.001). These patterns highlight how musical exposure and talent can improve Math performance. These findings match earlier research showing that melody, rhythm, and scales relate to numerical and geometric concepts (Flood & Wilson, 2006; Sanders, 2018) and that music-based activities increase engagement and understanding (Smith, 2020; Johnson, 2019). A strong longitudinal study also supports this: early musical skills—especially rhythm perception and reproduction—significantly predicted Grade 7 GPA, explaining unique variance beyond intelligence and maternal education (Janurik & Józsa, 2022). By integrating musical elements into the curriculum, teachers can tap into students' rhythmic intelligence, creating a more inclusive and engaging learning environment for all students.

The Relationship Between Interpersonal Intelligence Preference and Mathematics Academic Attainment

Building on previous discussions of the relationships among the logical-mathematical, visual-spatial, bodily-kinesthetic, and musical/rhythmic intelligences and Mathematics achievement, we now examine the impact of interpersonal intelligence on third-grade students' math performance. The findings shown in Table 1 offer valuable insights into this relationship.

The results show a strong connection between interpersonal intelligence and Math achievement. Among children who mostly agreed that they enjoy being with friends, 33.3% scored above average, compared to only 20% of those who mostly disagreed (χ^2 = 150.095, p < .001). Similarly, 33.5% of students who liked helping friends achieved above-average scores, versus 11.1% of those who mostly disagreed (χ^2 = 117.338, p < .001). An impressive 59% of children who slightly agreed that they enjoy organizing activities at school and home reached above average levels, while just 11.1% of those who mostly disagreed did so (χ^2 = 87.948, p < .001). These patterns highlight how social interaction, peer support, and leadership can enhance math performance.

These findings align with earlier work showing that peer-to-peer learning and group work enhance engagement, motivation, and conceptual understanding (Johnson & Johnson, 2009; Slavin, 2011). A recent large-scale study in China provides further support: peer relationships significantly predicted junior-high students' academic achievement, with learning motivation and learning engagement acting as chain mediators (BMC Psychology, 2024). Additional research indicates that collaborative learning approaches consistently yield an average gain of 5 months' progress across subjects, with slightly more potent effects in secondary mathematics (Education Endowment Foundation, 2025).

These findings are consistent with existing research that suggests social interaction and collaboration can improve learning outcomes in mathematics. Studies have shown that peer-to-peer learning and group work can enhance student engagement, motivation, and understanding of mathematical concepts (Johnson & Johnson, 2009; Slavin, 2011). The results of this study have significant implications for educational practice. By recognizing the importance of interpersonal intelligence in academic attainment in mathematics, educators can develop targeted strategies to support students with strengths in this area. This might include incorporating collaborative learning activities into math instruction, encouraging peer-to-peer learning and group work, and providing opportunities for students to develop leadership and organizational skills. By adopting a more nuanced understanding of intelligence, preference, and learning, educators can create a more inclusive and supportive learning environment that fosters the development of all students in the classroom.

The Relationship Between Intrapersonal Intelligence Preference and Mathematics Academic Attainment

Building on previous discussions about the relationships between logical-mathematical, visual-spatial, bodily-kinesthetic, musical/rhythmic, and interpersonal intelligences and Math achievement, we now examine the impact of intrapersonal intelligence on third-grade students' math performance. The findings shown in Table 1 offer valuable insights into this connection.

The results reveal a strong link between intrapersonal intelligence and Mathematics achievement. Among children who mostly agreed that they like doing things by themselves, 37.0 % scored above average, compared with 17.0 % of those who mostly disagreed ($\chi^2 = 142.453$, $p < .001$). This suggests that self-directed learning can boost math performance. Similarly, 62.1 % of pupils who slightly agreed that they know their feelings achieved above-average results, versus 8.8 % of those who mostly disagreed ($\chi^2 = 76.229$, $p < .001$), underscoring the role of emotional intelligence and self-awareness in mathematical development.A further 37.2 % of children who liked being alone scored above average, compared with 16.7 % who mostly disagreed ($\chi^2 = 125.358$, $p < .001$), highlighting the value of solo and reflective activities in math instruction. These findings align with Gardner's multiple-intelligence theory, which includes intrapersonal intelligence (Gardner, 2020) and with research showing that children with high intrapersonal intelligence are attuned to their feelings, goals, and attitudes (Haynes, 2020). Recent studies reinforce this connection: intrapersonal competence is a core component of emotional intelligence, supporting self-awareness, self-regulation, and self-motivation, all of which contribute to academic success (Merlin & Soubramanian, 2024; Psychometric Success, 2023). Another study found that intrapersonal and interpersonal emotional intelligence together predict self-directed learning, a key driver of mathematics achievement (Frontiers, 2024).

The Relationship Between Naturalistic Intelligence Preference and Mathematics Academic Attainment

Building on previous discussions of the relationships between logical-mathematical, visual-spatial, bodily-kinesthetic, musical/rhythmic, interpersonal, and intrapersonal intelligence and Mathematics academic achievement, we now examine the influence of naturalistic intelligence on third-grade students' math performance. The results are presented dynamically.

The results show a strong connection between naturalistic intelligence and math achievement. Among children who showed a strong interest in caring for animals and plants, 37.0% scored above average, compared to only 13.0% of those with little interest ($\chi^2 = 144.995$, $p < .001$). Similarly, 37.2% of students who enjoyed playing outdoors achieved above-average results, versus 20.9% of those who did not ($\chi^2 = 147.719$, $p < .001$). A notable 62.1% of children who moderately appreciated observing nature scored above-average, while only 10.8% of those who disagreed did so ($\chi^2 = 77.084$, $p < .001$). These patterns highlight how hands on nature experiences can enhance math performance.

These findings align with Gardner's multiple-intelligence theory, which includes naturalistic intelligence (Gardner, 2012; 2020) and with research showing that children with strong naturalistic preferences excel in nature-based observation and interaction. Recent studies reinforce this connection: naturalistic intelligence activities—such as gardening, wildlife observation, and outdoor measurement projects—significantly improve students' engagement and academic outcomes in Mathematics (NeuroLaunch, 2024; Nature Works Everywhere, 2025). Another study found that integrating outdoor learning with structured math tasks enhances spatial reasoning and problem-solving skills, with effect sizes ranging from 0.62 to 0.89 across primary grades (Edinburgh Earth Initiative, 2025)

The results of this study have important implications for educational practice. By recognising the value of naturalistic intelligence in mathematics achievement, educators can develop targeted strategies to support students with strengths in this area. This may include adding outdoor learning experiences and nature-based activities to math lessons, using real-world examples and context-rich problems to explain mathematical ideas, and encouraging children to explore and appreciate the natural environment through hands-on activities and projects. By adopting a more nuanced view of intelligence, preferences, and learning styles, educators can create a more inclusive and supportive classroom that promotes the growth of all students. Therefore, by integrating naturalistic experiences into the curriculum, educators can build an inclusive environment that leverages students' strengths and enhances mathematical development for every learner.

The Relationship Between Existentialistic Intelligence Preference and Mathematics Academic Attainment

Building on previous discussions about the relationships between verbal-linguistic, logical-mathematical, visual-spatial, bodily-kinesthetic, musical/rhythmic, interpersonal, intrapersonal, and naturalistic intelligences and math academic performance, we now explore how existential intelligence affects third-grade students' Math achievement. The findings shown in Table 1 offer valuable insights into this connection.

The results show a strong connection between existential intelligence and math achievement. Among children who agreed that they enjoy asking parents life questions, 32.1% scored above average, compared to only 13.0% of those who disagreed (χ^2=144.158, p<.001). This indicates that encouraging deep existential questions can improve math performance. Similarly, 32.2% of students who liked attending religious services achieved high scores, versus 20.2% of those who did not (χ^2=136.284, p<.001), emphasizing the importance of integrating values and spirituality into math lessons. A notable 59.9% of children who slightly agreed that they like asking about God scored above average, while only 9.2% of those who disagreed did (χ^2=62.075, p<.001), highlighting the value of fostering curiosity about existential questions. These findings support Gardner's multiple-intelligence theory, which includes existential intelligence (Gardner, 2020), and align with recent studies showing that spiritual and existential engagement promotes cognitive development and academic resilience (Skrzypińska, 2021; Castro Arbeláez, 2022). A meta-analysis of emotional-spiritual intelligence also confirms that students exploring meaning and values tend to have better self-directed learning and problem-solving skills, which are essential for mathematics (Frontiers, 2024).

By weaving existential inquiry into the curriculum, educators can nurture curiosity, motivation, and deeper conceptual understanding, ultimately enhancing mathematics attainment for all learners.

THE KEY FINDINGS

Verbal-linguistic intelligence: Incorporating language activities into Math lessons can enhance learning outcomes. Logical-mathematical intelligence: Number games and peer tutoring can help students develop logical-mathematical skills. Visual-spatial intelligence: Using illustrative lessons and hands-on activities can improve Math performance. Bodily-kinesthetic intelligence: Movement and drama can engage children with bodily-kinesthetic intelligence. Musical-rhythmic intelligence: Connecting Math concepts to music can boost learning. Interpersonal intelligence: Collaborative environments and peer-to-peer learning can strengthen students' interpersonal skills. Intrapersonal intelligence: Independent tasks and self-reflection can support students with intrapersonal intelligence. Naturalistic intelligence: Hands-on experiences and nature-based activities can enhance Math skills. Existential intelligence: Discussions about life-related questions and values can spark curiosity and foster Math skills.

Strong statistical links (all χ^2 tests highly significant, p < .001) were found between each of the eight multiple-intelligence preferences and above-average mathematics achievement. Children who enjoyed working with numbers or playing cell phone games were 2–3 times more likely to score above average. Preferences for drawing, painting, modeling with clay, and solving word puzzles correlated with significantly higher math scores (e.g., 24.5% vs. 11.6% for drawing). Bodily-kinesthetic intelligence – Activities such as dancing, acting, building block houses, and moving while thinking- were associated with markedly better performance (e. g., 58. 6 % vs. 11. 6 % for movement- while- thinking). Musical/rhythmic intelligence – Listening to music, attending festivals, and remembering tunes- predicted higher achievement (e.g., 64. 4 % vs. 4. 9 % for tune recall). Interpersonal intelligence – Preferences for being with friends, helping peers, and organizing activities - showed strong positive relationships with math outcomes (e.g., 59% vs. 11% for organizing). Intrapersonal intelligence – self-directed learning, understanding one's feelings, and enjoying solitude - was linked to above-average scores (e.g., 62. 1% vs. 88% for emotional self-awareness). Naturalistic intelligence – Interest in caring for animals and plants, outdoor play, and observing nature- corresponded with higher math performance (e.g., 62. 1 % vs. 10. 8 % for nature observation). Existential intelligence – Asking life's questions, attending religious services, and pondering spirituality- was associated with elevated Mathematics scores (e.g., 59. 9 % vs. 9. 2 % for asking about God). Alignment with theory – All findings are consistent with Gardner's Multiple

Intelligences framework (Gardner, 2020) and with recent empirical work showing that tailored pedagogical strategies (e.g., simulation methods, collaborative learning, and outdoor inquiry) enhance Mathematics achievement. Therefore, teachers can boost Math success by integrating activities that engage each intelligence type (e.g., visual projects, movement breaks, peer tutoring, nature-based tasks, reflective discussions). Thus, the children whose learning preferences align with specific intelligences tend to perform significantly better in Mathematics, suggesting that a diverse, intelligence-responsive curriculum can foster inclusive and effective Math education.

Implications for Educational Practice

Recognise and accommodate individual differences in intelligence preferences. Incorporate various intelligences into teaching to create a more inclusive and dynamic classroom environment, tailor instruction to students' dominant intelligence types, and offer opportunities for students to engage with Math concepts in different ways. By embracing a broad range of intelligences in the Mathematics curriculum, educators can foster a more inclusive and supportive learning environment that promotes the development of all children.

The findings of this study underscore the importance of recognizing and accommodating individual differences in intelligence preferences. For instance, children with verbal-linguistic intelligence tend to excel in Math when language activities are integrated, while those with logical-mathematical intelligence benefit from number games and peer tutoring. Visual-spatial learners excel with illustrative lessons, and bodily-kinesthetic students engage better through movement and drama. Moreover, musical-rhythmic learners improve when Math concepts are linked to music, whereas those with interpersonal skills flourish in collaborative environments, and intrapersonal learners do well with independent tasks. Naturalistic learners perform better with hands-on experiences, while children with existential intelligence excel when discussions include meaningful, life-related questions.

By embracing a diverse range of intelligences in the Mathematics curriculum, educators can foster a more inclusive and lively classroom environment. This strategy can transform Mathematics teaching, ensuring that all children have access to suitable and sufficient educational opportunities. The study's findings support the idea that integrating different types of intelligence into teaching can significantly boost young children's motivation and learning outcomes. By examining the connections between various intelligence theories and Math teaching methods, we provide practical evidence to recognize and accommodate individual differences in intelligence preferences. Although some researchers have questioned empirical support for the theory of multiple intelligences (Waterhouse, 2023), our results show a strong positive correlation between students' intelligence preferences and their success in Mathematics ($p < 0.05$). This suggests that understanding intelligence preferences and learning styles can help teachers create a more inclusive and supportive classroom environment that encourages growth for all students. Additionally, our research highlights the benefits of tailoring instruction to match students' dominant intelligence preferences, such as using language activities for verbal-linguistic learners or number games and peer tutoring for logical-mathematical learners. By adopting multiple intelligences in the Math curriculum, teachers can foster a more engaging classroom environment that transforms Math teaching and offers equitable educational opportunities for every child. These findings support previous research emphasizing the importance of recognizing and addressing individual differences in intelligence preferences (Gardner, 2020). However, we also recognise the ongoing debate about the validity of multiple intelligences; therefore, this study connects Gardner's theory with simulation-based pedagogy, providing evidence that non-logical-mathematical intelligence can be used to improve Math learning. It offers a strong empirical basis for designing competency-based, inclusive Math instruction.

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