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The Geometry of Play: Assessing Spatial Reasoning Skills Through Traditional Local Games Versus Digital Construction Apps

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ABSTRACT
This study assessed the spatial reasoning skills of elementary learners through traditional local games and digital construction apps. Using a descriptive-comparative research design, data were collected from 44 Grade 4 pupils through a survey questionnaire and a standardized spatial reasoning assessment. Descriptive statistics, including frequency, percentage, and weighted mean, were used to analyze the data. Findings revealed that learners demonstrated a high level of spatial reasoning, with spatial orientation obtaining the highest mean, followed by mental rotation and spatial visualization. Results also indicated that regular participation in both traditional games and digital construction apps contributed to the development of spatial skills. Based on the findings, a "Geometry of Play" integration module was proposed to combine traditional and digital play in supporting learners' cognitive development.

INTRODUCTION

Childhood development is changing as traditional physical play is increasingly replaced by digital technologies. Spatial reasoning, which involves understanding and manipulating two- and three-dimensional objects, is an essential skill for STEM education and has traditionally been developed through hands-on play.

The "Geometry of Play" explains how children naturally learn mathematical and spatial concepts while interacting with their physical environment. As digital technology becomes more common in education, researchers have become interested in how different forms of play influence cognitive development.

Traditional local games, such as Piko and marbles, develop spatial reasoning through physical movement, sensory experiences, and real-world problem-solving. These activities improve mental rotation, spatial awareness, and coordination by allowing children to interact directly with objects and their surroundings.

In contrast, digital construction apps like Minecraft provide opportunities for abstract thinking, virtual building, and architectural design. They encourage children to create complex structures and strengthen visualization skills, although they may not fully replicate the physical experiences gained through traditional play.

Despite existing studies on spatial reasoning, there is limited research directly comparing traditional local games and digital construction apps. There is also insufficient evidence on whether spatial skills developed in digital environments transfer effectively to real-world situations.

This study aims to compare the effectiveness of traditional local games and digital construction apps in developing spatial reasoning among young learners. Specifically, it examines mental rotation, spatial visualization, and spatial orientation to determine how both play modalities can be integrated to support children's cognitive development and improve educational practices.

LITERATURE REVIEW

The Evolution of Spatial Cognition in Childhood

Spatial cognition consists of skills such as mental rotation, spatial perception, and spatial visualization, which are essential for success in STEM fields (Newcombe, 2018). During early childhood, these abilities develop rapidly through interaction with the environment. Traditionally, children enhanced spatial reasoning by manipulating physical objects and navigating real-world spaces, helping them create cognitive maps and strengthen their understanding of movement and spatial relationships.

Traditional Local Games and Physical Embodiment

Traditional local games, such as Patintero, Piko, Luksong Baka, and Agawan Base, provide embodied learning experiences that promote proprioception, balance, distance estimation, and spatial awareness (Pellegrini, 2009). These games require children to calculate positions, trajectories, and boundaries while interacting with real physical environments. The combination of movement, tactile materials, and environmental interaction strengthens sensorimotor integration and long-term spatial understanding (Smith & Gasser, 2005).

Digital Construction Apps and Virtual Manipulation

Digital construction applications like Minecraft, Roblox, and Toca Builders offer a different approach to developing spatial skills by allowing children to manipulate three-dimensional structures in virtual environments (Caldera et al., 2019). These platforms encourage mental rotation, visualization, architectural design, and experimentation through features such as instant feedback and undo functions. Although digital play enhances abstract thinking and symbolic representation, it lacks the rich haptic feedback and physical interaction found in traditional play.

Comparative Analysis of Learning Outcomes

Studies comparing traditional and digital play suggest that both improve spatial cognition but emphasize different abilities (Verdine et al., 2017). Traditional games strengthen executive function, physical coordination, and real-world problem-solving through embodied experiences, while digital applications improve precise visualization and exploration of complex geometric structures. According to Newcombe (2018), spatial reasoning is a flexible skill that can be enhanced through play-based learning. Overall, combining traditional local games with digital construction apps may provide the most comprehensive development of children's spatial cognition and support future learning in mathematics and STEM disciplines.

METHODOLOGY

This study employed a descriptive-comparative research design to assess and compare the spatial reasoning skills of elementary learners who engage in traditional local games and digital construction apps. The respondents consisted of 44 Grade 4 pupils from a selected elementary school during the Academic Year 2025–2026, chosen through stratified random sampling to ensure balanced representation based on their initial characteristics. Data were collected using a researcher-made survey questionnaire and a standardized spatial reasoning assessment measuring mental rotation, spatial visualization, and spatial orientation. The questionnaire also gathered the respondents' demographic profile, frequency of participation in traditional local games, and average daily time spent using digital construction applications.

Prior to data collection, permission was secured from the school administration, and informed consent was obtained from the parents or guardians of the participants. The survey questionnaire and spatial reasoning assessment were administered in a controlled classroom setting, after which the responses were collected, organized, and tabulated for analysis. Descriptive statistical tools, including frequency, percentage, and weighted mean, were used to summarize the respondents' profiles and determine their level of spatial reasoning skills. The findings served as the basis for comparing the two play modalities and for developing a proposed "Geometry of Play" integration module that combines traditional and digital play to support learners' cognitive and spatial development.

RESULTS AND DISCUSSION

This chapter presents, analyzes and interprets the data gathered from questionnaires, interviews and documentary analysis in connection with the objectives of the study – The Geometry of Play: Assessing Spatial Reasoning Skills through Traditional Local Games versus Digital Construction Apps.

The presentation is composed of two parts which is the profile of the respondents and information proper.

For clearer understanding, the data were presented in table forms and were treated comprehensively.

Profile of the Respondents

Table 1
Distribution of Respondents by Age

Particulars	Frequency (f)	Percentage (%)
10 years old	12	27.27
9 years old	18	40.91
8 years old	14	31.82
Total	**44**	**100.00**

Table 1 presents the demographic profile of the respondents in terms of age. Out of the 44 total participants surveyed, the majority belong to the 9-year-old age group with a frequency of 18, representing 40.91% of the sample. This is followed by the 8-year-old category, which constitutes 14 respondents or 31.82%. Lastly, the 10-year-old cohort represents the smallest portion of the sample, with a frequency of 12 or 27.27%.

The age distribution reveals that the sample is composed entirely of children in their middle-to-late childhood stage (ages 8 to 10). In the context of the study, "The Geometry of Play: Assessing Spatial Reasoning Skills through Traditional Local Games versus Digital Construction Apps," this age group is highly appropriate. According to cognitive development frameworks (such as Piaget's stages of development), children within this 8-to-10 age bracket are firmly inside the concrete operational stage, a critical developmental period where spatial awareness, mental rotation, and geometric visualization skills transform rapidly.

The heavy concentration of 9-year-olds (40.91%) ensures that the study captures data from students who are actively transitioning from concrete, physical manipulations to more abstract representations. Furthermore, having a distributed spread across 8-year-olds (31.82%) and 10-year-olds (27.27%) allows the study to explore micro-developmental differences. This breakdown helps evaluate whether traditional local games (which rely on physical, multi-sensory, and real-world 3D spaces) or digital construction apps (which rely on 2D screens and virtual 3D transformations) are more effective at specific age milestones during these formative elementary school years.

Table 2
Distribution of Respondents by Sex

Particulars	**Frequency (f)**	**Percentage (%)**
Male	24	54.55
Female	20	45.45
Total	**44**	**100.00**

Table 2 illustrates the demographic profile of the respondents categorized by sex. Of the 44 total participants involved in the study, males comprise the slightly larger portion of the sample with a frequency of 24, translating to 54.55%. On the other hand, female respondents account for 20 out of the total sample size, representing 45.45%. The data shows a relatively even and balanced distribution between both sexes among the research participants.

The near-equal distribution of male (54.55%) and female (45.45%) respondents is a highly favorable characteristic for this specific study, titled "The Geometry of Play: Assessing Spatial Reasoning Skills through Traditional Local Games versus Digital Construction Apps." In cognitive psychology and educational research, "sex" is a historically significant and heavily debated variable concerning spatial reasoning skills. Numerous studies suggest that males often show early advantages in specific spatial tasks, such as mental rotation and tracking objects in 3D environments, which are frequently reinforced by traditional physical play or action-oriented digital games. Conversely, females often demonstrate strong capabilities in spatial memory and object location tasks, which can be heightened through creative construction and structured play.

By achieving a balanced representation of both sexes, this study minimizes gender bias and avoids skewed results. This equilibrium allows the researchers to fairly assess whether traditional local games (which often involve gross motor skills and physical bounding, like Patintero or Luksong Baka) versus digital construction apps (which rely on fine motor controls and virtual manipulation, like Minecraft or block-building software) impact the spatial development of boys and girls differently, or if both mediums bridge traditional gender-based spatial gaps equally.

Table 3
Frequency Of Time Playing Traditional Local Games (E.G., Piko, Luksong Baka, Building With Blocks/Stones)

Particulars	Frequency (f)	Percentage (%)
Daily	8	18.18
3–4 times a week	15	34.09
1–2 times a week	14	31.82
Rarely / Never	7	15.91
Total	44	100.00

Table 3 details how often the 44 respondents engage in playing traditional local games (such as Piko, Luksong Baka, and building with blocks or stones). The data indicates that the largest segment of participants plays these games 3–4 times a week, comprising 15 respondents or 34.09%. This is closely followed by those who play 1–2 times a week, accounting for 14 respondents (31.82%). Meanwhile, 8 respondents (18.18%) engage in traditional play on a daily basis, and the remaining 7 respondents (15.91%) report that they rarely or never participate in these activities.

The data reveals that the vast majority of the respondents (65.91%), combining "3–4 times" and "1–2 times") have a moderate, consistent exposure to traditional local games, while a smaller, near-equal minority sit on the extreme ends of the spectrum (either playing "Daily" or "Rarely/Never").In relation to the research topic, "The Geometry of Play: Assessing Spatial Reasoning Skills through Traditional Local Games versus Digital Construction Apps," this baseline exposure profile is highly informative. Traditional games like Piko involve estimating spatial distances, grid layouts, and motor-sensory coordination. Games like Luksong Baka and block/stone building require immediate, dynamic spatial calculations of height, depth, and structural stability in a physical 3D environment.

Because over 84% of the children have regular exposure to these physical activities (from at least 1–2 times a week up to daily), the sample possesses a strong experiential foundation in real-world spatial positioning. When the study subsequently compares these results to digital construction apps, this specific data table will serve as a vital baseline to analyze whether a child's familiarity with physical, tactile geometry directly influences or correlates with their digital spatial reasoning performance

Table 4
Average daily time spent on Digital Construction Apps (e.g., Minecraft, Roblox, SimCity)

Particulars	**Frequency (f)**	**Percentage (%)**
None	5	11.36
Less than 1 hour	16	36.36
1 to 2 hours	15	34.09
More than 2 hours	8	18.18
Total	**44**	**100.00**

Table 4 displays the average daily duration that the 44 respondents spend engaging with digital construction applications like Minecraft, Roblox, or SimCity. The largest proportion of the sample spends less than 1 hour daily on these apps, representing 16 respondents or 36.36%. This is closely followed by those who play for 1 to 2 hours daily, accounting for 15 respondents (34.09%). Meanwhile, 8 children (18.18%) engage with these apps heavily for more than 2 hours a day, and a small minority of 5 respondents (11.36%) do not use digital construction apps at all.

The data reveals that digital construction apps are a highly prevalent fixture in the daily lives of the participants, with 88.64% of the children having some degree of daily exposure to them. However, the vast majority (70.45%) exhibit controlled usage patterns, playing for under 2 hours a day. In the context of the study, "The Geometry of Play: Assessing Spatial Reasoning Skills through Traditional Local Games versus Digital Construction Apps," this table is crucial for identifying a child's familiarity with virtual spatial manipulation. Digital construction environments like Minecraft or Roblox require players to read digital blueprints, execute mental transformations, understand perspective scaling, and manipulate isometric 3D blocks on a 2D interface. The high percentage of daily engagement implies that most respondents are highly comfortable with digital spatial syntax. By contrasting this table with Table 3 (Traditional Games), the researchers can cross-analyze whether heavy digital exposure correlates with superior abstract mental rotation skills, or if the tactile, physical calculations of traditional games provide a more robust foundation for early geometric reasoning.

Table 5
Spatial Reasoning Self-Assessment

Particulars	WM	QD
A. Mental Rotation (Turning objects in the mind)		
1. I can easily imagine what a toy looks like if I turn it upside down.	3.25	Agree

2. I can visualize how a shape looks from a different side without moving it.	3.10	Agree
Sub-Composite Mean	*3.18*	***Agree***
B. Spatial Visualization (Manipulating complex patterns)		
3. I can imagine how a piece of paper will look after it is folded.	2.85	Agree
4. I am good at solving puzzles and fitting complex shapes together.	3.40	Agree
Sub-Composite Mean	*3.13*	***Agree***
C. Spatial Orientation (Understanding position in space)		
5. I can easily find my way around a playground or a new building.	3.55	Strongly Agree
6. I can describe exactly where an object is located in relation to me.	3.35	Agree
Sub-Composite Mean	*3.45*	***Agree***
Average Weighted Mean	**3.25**	**Agree**

3.50–4.00,Strongly Agree,Very High Spatial Capability
2.50–3.49,Agree,High/Moderate Spatial Capability
1.50–2.49,Disagree,Low/Developing Spatial Capability
1.00–1.49,Strongly Disagree,Very Low Spatial Capability

Table 5 shows the self-assessment of the 44 respondents across three core pillars of spatial reasoning. The overall average weighted mean is 3.25, which maps to a qualitative description of "Agree". Among the categories, Spatial Orientation registered the highest sub-composite mean of 3.45 ("Agree"), powered by Item 5 (finding one's way around a playground), which achieved the highest individual mean of 3.55 ("Strongly Agree"). Mental Rotation followed with a sub-composite mean of 3.18 ("Agree"). Meanwhile, Spatial Visualization scored the lowest sub-composite mean of 3.13 ("Agree"), influenced heavily by Item 3 (imagining folded paper), which drew the lowest single score in the entire matrix at 2.85 ("Agree").

The overall average weighted mean (3.25) indicates that the children perceive themselves as having highly competent, functional spatial reasoning abilities. Breaking down the specific indicators reveals an analytical goldmine for the research title, "The Geometry of Play: Assessing Spatial Reasoning Skills through Traditional Local Games versus Digital Construction Apps."

The Dominance of Spatial Orientation (3.45): The exceptionally high score in navigating physical playgrounds (Item 5 = 3.55) strongly aligns with the group's high exposure to traditional local outdoor games, as established in Table 3. Physical games like Piko and Luksong Baka demand an embodied awareness of boundaries, self-localization, and navigating real-world barriers. This direct interaction with physical topology creates a highly developed internal compass.

The Strength in Puzzle Solving (3.40): The high agreement with being good at solving puzzles and fitting complex shapes together matches the daily digital construction app exposure discovered in Table 4. Apps like Minecraft and Roblox act as infinite digital LEGO sets. They reinforce structural building mechanics, block alignment, and the consolidation of complex pieces into unified patterns, boosting self-efficacy in spatial visualization.

The Struggle with Paper Folding (2.85): The noticeably lower mean for visualizing folded paper points to a critical developmental bottleneck. Abstract paper folding requires complex 2D-to-3D-to-2D cognitive transformations without any real-time tactile or automated physics engine assistance. While digital construction apps auto-render structural transformations instantly and traditional games deal with static macro-spaces, neither medium cleanly targets fine-motor, purely abstract paper geometry.

Conclusively, the profile suggests that while the children exhibit robust macro-environmental awareness (likely from physical local games) and component-assembly confidence (likely from digital construction apps), purely abstract, unassisted spatial visualization remains their primary area for cognitive growth.

CONCLUSIONS AND RECOMMENDATIONS

Age-Appropriate Development of Spatial Reasoning. The study's sample is predominantly composed of 9-year-olds (40.91%) and 8-year-olds (31.82%), with 10-year-olds forming the smallest cohort (27.27%). This specific age distribution indicates that the participants are in a crucial developmental stage where concrete operational thoughts transition into more abstract reasoning. Consequently, the findings on spatial reasoning are highly reflective of early middle childhood, a peak period for formal geometric concept acquisition. This developmental window makes the sample ideal for assessing how different play mediums impact foundational spatial skills.

Gender-Inconclusive Baseline for Play-Based Spatial Analysis. The demographic distribution by sex is relatively balanced, with males comprising 54.55% and females comprising 45.45% of the 44 total participants. This equitable representation minimizes gender bias within the baseline data, allowing for a fairer assessment of how local games and digital applications affect spatial skills across sexes. Because the sample is evenly split, any observed strengths in spatial orientation, mental rotation, or visualization can be attributed more accurately to play habits rather than gender-skewed preferences. Ultimately, this balance strengthens the validity of comparing traditional and digital play outcomes.

Robust Continuity of Traditional Local Play Habits. Despite the rise of digital entertainment, traditional local games remain a frequent fixture in the children's routine, with 65.91% of respondents playing them between 1 to 4 times a week. Furthermore, 18.18% engage in these physical activities daily, highlighting that tactile, real-world play is far from obsolete for this demographic. In the context of geometric reasoning, this consistent engagement ensures that the majority of the children are regularly calculating physical distances, bodily orientation, and 3D space. This strong baseline of traditional play provides a solid foundation for researchers to measure the impact of physical, real-world spatial manipulation.

Prevalent but Regulated Engagement with Digital Spatial Environments. Digital construction applications like Minecraft and Roblox are highly integrated into the participants' lives, with an overwhelming 88.64% reporting regular exposure to these platforms. However, this digital engagement is largely disciplined, as 70.45% of the children restrict their screen time to under two hours per day. This prevalent yet controlled usage pattern means that while the children are highly literate in virtual spatial syntax, they are not entirely consumed by screen-based play. This controlled exposure allows researchers to analyze the positive cognitive benefits of digital structural manipulation without the confounding negative variables of extreme screen addiction.

Strong Self-Perception of Functional Spatial Competency. The respondents demonstrate a high level of confidence in their spatial capabilities, yielding an overall average weighted mean of 3.25, which corresponds to a qualitative description of "Agree." This positive self-assessment indicates that the children perceive themselves as highly competent in navigating and manipulating their environments. Because the sample group regularly interfaces with both physical blocks/stones and digital building apps, their high self-efficacy likely stems from their dual-exposure to both play mediums. This strong self-perception serves as a subjective indicator that play-based learning actively fosters a child's confidence in handling geometric concepts.

Divergence Between Real-World Orientation and Abstract Visualization. A clear disparity exists among the pillars of spatial reasoning, where real-world Spatial Orientation scored the highest (sub-composite mean of 3.45), while abstract Spatial Visualization scored the lowest (sub-composite mean of 3.13). The children excelled at navigating physical spaces—such as playgrounds (3.55)—but struggled with complex mental transformations, like imagining folded paper (2.85). This divergence suggests that while frequent physical play and digital block building reinforce immediate environmental awareness, they may not fully bridge the gap to advanced, abstract mental rotation. Therefore, while both traditional and digital games build functional spatial skills, targeted pedagogical interventions may still be required to master abstract geometric visualization.

Recommendation

Designing Age-Targeted Play Curriculums. Educators and curriculum designers should capitalize on the critical developmental window of 8-to-10-year-olds by integrating targeted spatial games into early elementary mathematics. Since children in this age group are transitioning from concrete to abstract thinking, schools should introduce structured play-based modules that explicitly bridge physical and digital manipulation. Lessons could involve transitioning from building physical block structures to replicating those exact models inside digital applications. This intentional scaffolding will maximize geometric concept acquisition during a peak period of cognitive growth.

Promoting Gender-Inclusive Spatial Interventions. Since the baseline data demonstrates that both boys and girls are actively engaging in play-based environments, educators and parents should continue to foster gender-neutral access to both traditional local games and digital construction apps. Schools should avoid gender-stereotyping certain play mediums, ensuring that female students are equally encouraged to engage in 3D digital design, while male students actively participate in collaborative physical local games. Future researchers should leverage this balanced baseline to conduct longitudinal studies tracking whether these play habits help close historical gender gaps in STEM fields.

Preservation and Integration of Traditional Local Games. Local communities and school administrators should actively preserve and promote traditional local games like Piko and Luksong Baka as essential, budget-friendly tools for physical spatial development. Physical education programs should formally incorporate these games into their weekly schedules to ensure the 15.91% of children who rarely play them are given opportunities to develop real-world spatial calculations. Additionally, parents should maintain spaces and times for tactile, physical play to ensure children build a robust, kinesthetic foundation of geometric reasoning before moving entirely to virtual spaces.

Maintaining Balanced Screen Rules and Selecting Quality Apps. Parents and guardians should continue to enforce the observed "under 2 hours" daily screen limit to prevent screen addiction while still reaping the cognitive rewards of digital construction environments. Instead of outright banning video games, caregivers should curate digital play by prioritizing spatial syntax-rich applications like Minecraft or SimCity over mindless scrolling or non-constructive media. Schools can also mirror this regulated exposure by utilizing short, 30-minute digital drafting or building sessions as rewards or supplementary math activities, keeping digital engagement highly focused and productive.

Translating High Spatial Self-Efficacy into Academic Confidence. Teachers should leverage the children’s strong self-perception of spatial competency (mean of 3.25) to boost their confidence in formal, abstract mathematics and geometry classes. By explicitly connecting classroom geometric terms—such as symmetry, vertices, and coordinate planes—to the structures children build in local games or digital apps, educators can validate and reinforce this high self-efficacy. This pedagogical strategy transforms a student's intuitive, play-based confidence into academic motivation, reducing math anxiety in the classroom.

Developing Targeted Interventions for Abstract Spatial Visualization. To bridge the gap between strong environmental orientation and weak abstract visualization, educators must design specific exercises that target mental transformation skills. Lessons should move beyond simple navigation and introduce explicit activities like origami (paper folding), tangrams, and mental rotation puzzles that challenge students to manipulate 3D shapes purely in their minds. Furthermore, digital game creators could develop specialized game modes that require players to predict the outcomes of folded blueprints or rotated objects before building them, directly targeting the study's lowest-scoring indicators.

FURTHER STUDY

Future studies should further investigate the development of spatial reasoning skills through traditional local games and digital construction applications by involving larger and more diverse groups of learners from different age levels, educational backgrounds, and cultural contexts. Longitudinal and experimental studies are also recommended to examine whether repeated engagement with traditional games or digital construction apps produces sustained improvements in spatial visualization, mental rotation, spatial orientation, and problem-solving abilities.

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