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Math Puzzles and Free Play: Which is More Effective for Children's Spatial Development?

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ABSTRACT

This study aims to compare the effectiveness of learning using math puzzles (game-based learning) with free play (play-based learning) in developing spatial abilities of early childhood. This study uses a mixed methods approach with an explanatory sequential design. The sample of the study consisted of 30 students, 15 students at TK Inpres Mannurukki (experimental class) and 15 students at TK IT At-Tibyan (control class), with a purposive sampling technique. The instruments used were tests and interviews. Quantitative data were analyzed using descriptive and inferential statistics through SPSS 26, including normality tests, variance homogeneity tests, Mann-Whitney tests, Independent Samples t-tests, and N-Gain tests. Qualitative analysis was carried out using thematic analysis. The results showed that in the posttest, the average score of the experimental class (math puzzle) was 76.13, while the control class (free play) reached 84.20. Statistical tests showed a significant difference (p = 0.014), with the control class showing better results. However, the N-Gain test in the experimental class showed moderate effectiveness with an average N-Gain value of 0.599. Interviews with students showed that mathematical puzzle-based learning increased motivation and interest in learning, although some students had difficulty with the level of puzzle difficulty being too high. In contrast, students in the control class felt freer, but needed more guidance to link the game to mathematical concepts. This study concluded that although mathematical puzzles are interesting, free play-based learning is more effective in supporting the overall development of mathematical concepts in early childhood.

Keywords: Spatial Ability; Game Based Learning; Learning Effectiveness; Early Childhood Education.

INTRODUCTION

Spatial development is a key aspect of cognitive growth, enabling children to understand and navigate their environment (Eising & Karasinski, 2022). It involves recognizing space, shape, size, direction, position, and object relationships. From early motor experiences like crawling or playing, children build spatial awareness, helping them grasp everyday concepts such as "above," "below," or "inside." For instance, placing a toy in a box requires processing spatial cues, not just following verbal instructions showing how vital this skill is for interpreting commands and orientation. Spatial ability also supports shape recognition and categorization, laying the groundwork for logical thinking and early math and science learning. Children with strong spatial skills more easily grasp abstract ideas like geometry and measurement (Birgin & Topuz, 2021; Muhammad & Juandi, 2023; Sugandi et al., 2019; Wardani et al., 2023). They also develop an understanding of object relationships essential for activities like map reading, puzzle solving, and building. Mental rotation and visualizing spatial changes are more advanced abilities tied to executive function and problem-solving.

Moreover, spatial skills are linked to both fine and gross motor development. Activities like climbing or stacking objects enhance spatial perception and coordination. Visual-spatial ability is also crucial for precise tasks such as writing, drawing, and reading like aligning letters, tracking lines, or distinguishing between similar shapes. Through diverse environmental interactions, children expand their spatial experience. Parents and educators play a key role by offering enriching stimuli constructive play, picture books, guided exploration, or interactive tools that develop spatial perception. Strong spatial development equips children to better tackle academic and everyday challenges involving spatial reasoning.

Spatial development is more than recognizing shapes or object positions it is a fundamental aspect of cognition that supports children's learning and interaction with their environment. This ability evolves through hands-on experiences and requires appropriate stimulation to help children form accurate mental representations of space. According to Piaget, spatial understanding develops through direct interaction with the environment and sensorimotor activities (Hidayatulloh, 2021; Li & De Costa, 2023; Narpila, 2019). These abilities not only aid in math learning such as geometry and problem-solving (Al Ayyubi et al., 2018; Al Ayyubi, Bukhori, et al., 2024; Al Ayyubi, Hayati, et al., 2024; Al Ayyubi, Rohaendi, et al., 2024), but are also essential in everyday tasks like navigation, motor coordination, and action planning. Strong early spatial skills correlate with better academic performance in STEM fields later on (Blustein et al., 2022; Bunyamin, 2015; Felder & Brent, 2024; Pangesti et al., 2017; Yusuf & Ma'rufi, 2022).

Children learn spatial concepts through their surroundings, and every experience shapes how they process and use spatial information. Stimuli can be physical, visual, verbal, or emotional, and must be age-appropriate to provide the right level of challenge. Activities like block stacking, puzzles, mazes, and sorting by shape or size help train eye-hand coordination, concentration, and spatial awareness. Visual aids such as picture books also support imagination and visualization. Ensuring the activity aligns with the child's interests increases engagement and learning impact. Group play offers additional spatial stimuli, teaching children to navigate shared spaces, observe others' positions, and collaborate on tasks. A supportive environment at home and school is essential, with teachers and parents playing key roles in guiding and encouraging active exploration through meaningful learning experiences.

Through appropriate and continuous stimulation, children will become more skilled in recognizing and understanding the structure of space and the relationships between objects around them. This is not only useful in academic aspects such as mathematics and reading, but also in everyday life which requires children to be able to navigate, organize objects, or follow directions. Therefore, providing early stimulation is a very important part in supporting optimal spatial development, because childhood is a golden period where children's basic cognitive and sensorimotor abilities are developing rapidly and are very easily influenced by the environment and experiences they experience. In developing the spatial abilities of early childhood there are several approaches that are usually used such as learning using math puzzles and also free play which is more flexible. Both of these approaches certainly have their own advantages and disadvantages, so that there are several opinions regarding the effectiveness in optimizing spatial abilities in children.

Several previous studies have examined the relationship between play activities and early childhood spatial development. The study conducted by Safitri & Suryadi (2023) showed that mathematical puzzle-based games can improve children's spatial skills because they involve the manipulation of shapes, patterns, and systematic problem solving. The study found that children who played puzzles more often had better mental rotation skills and understanding of spatial relationships than those who were rarely exposed to such activities. Similar findings were also obtained by Abarua (2022) which states that children's interaction with puzzles from an early age is positively correlated with the development of their spatial skills at school age. On the other hand, research by Eising & Karasinski (2022) emphasizes that free play also plays an important role in children's spatial development. This study shows that free play activities, such as building with blocks, playing outdoors, or arranging objects independently, allow children to explore space in a more natural and flexible way. Free play provides opportunities for children to develop spatial skills through direct experience, without strict rules such as in math puzzle games. The study Bokingo et al. (2022) also support these findings, highlighting that free play contributes to the development of executive functions, creativity, and cognitive flexibility which also support spatial understanding.

Although math puzzles and free play have each been studied for their role in developing spatial skills, few studies directly compare their effectiveness. Math puzzles, as structured tasks, enhance skills like logical reasoning, pattern recognition, and spatial visualization. Children engaged in puzzles often show better organization of visual-spatial information. Conversely, free play being open-ended and self-directed fosters imagination, exploration, and spontaneous spatial learning through activities like block building or navigating space.

Despite their unique benefits, the lack of comparative research leaves key questions unanswered: which approach is more effective, and under what conditions? Structured activities may yield clearer outcomes in formal settings, while free play might better support holistic development. Without side-by-side studies, assessing their relative strengths remains difficult. This gap challenges educators and parents in choosing effective strategies. Ideally, both methods should complement each other. However, more evidence-based comparisons especially through experimental or longitudinal studies are needed to understand how factors like age, learning context, and individual preferences affect outcomes. Most current research focuses on one method, overlooking how child-specific variables influence effectiveness. To address this, researchers used VOSViewer to analyze relevant literature and identify connections between keywords such as "math puzzles," "free play," and "spatial development." The results reveal how little these intersections have been explored, highlighting the need for further study.

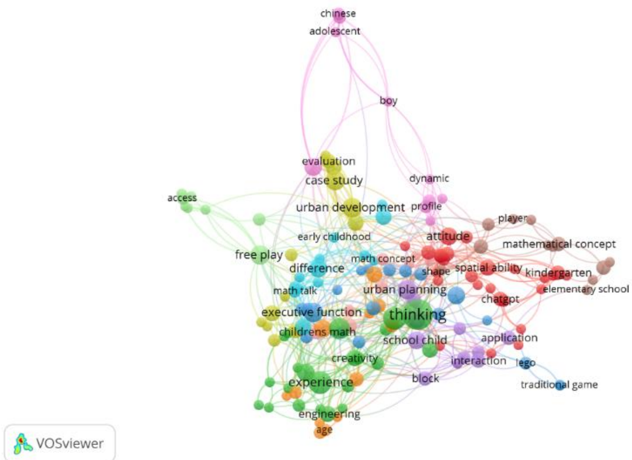


Figure 1. Bibliometric Analysis Results Regarding Mathematical Puzzles And Free Play: Which Is More Effective For Children's Spatial Development

Using bibliometric analysis with VOSViewer, researchers reviewed 513 articles indexed by SINTA and SCOPUS (2020–2025) on the topic math puzzles vs. free play: which is more effective for children's spatial development. Data from Publish or Perish ver. 8 (Figure 1) show that relevant research remains limited. Keywords such as puzzles, mathematics, free play, and spatial development rarely appear together, with only one network linking puzzles and spatial intelligence. This gap in the literature, supported by field observations, prompted deeper investigation into the comparative effectiveness of math puzzles and free play in enhancing children's spatial skills. This study seeks to fill that gap by directly analyzing both approaches in relation to spatial ability development. By considering activity types, cognitive engagement, and exploration levels, it aims to offer insights into optimal strategies for early childhood learning. The findings are expected to guide educators and parents in selecting effective methods to support children's cognitive, particularly spatial, growth.

Empirical, research-based findings hold high value in child education, serving as a foundation for designing relevant developmental approaches. Spatial ability is crucial for tasks such as reading, writing, problem-solving, and logical thinking. Understanding the most effective stimulation methods will help educators craft engaging strategies that deliver measurable improvements. For teachers in formal and non-formal settings, this research can inform decisions on instructional materials, tools, and activity types. Applying evidence-based methods enhances teaching efficiency by aligning with students' developmental stages. For instance, if exploratory play proves more effective, educators may emphasize physical and visual-spatial activities. If structured math puzzles show greater impact, they can be systematically integrated into the curriculum or daily classroom routines.

Meanwhile, for parents, the practical implications of the results of this study are very important in accompanying children at home. Parents often look for ways to be actively involved in their children's development, but do not always have enough information about what methods are most effective. With clear and directed research results, parents can have guidance in choosing play activities or learning aids that are in accordance with certain developmental goals, including in forming children's spatial skills. They can facilitate children through appropriate games, create a home environment rich in visual-spatial stimulation, or even involve children in daily activities that can support these skills indirectly.

In addition, the results of this study can also encourage better cooperation between educators and parents in supporting holistic child development. With the same understanding of the most appropriate approach, both parties can complement each other's roles in providing consistent and sustainable learning experiences for children. Therefore, the results of research that raise spatial aspects not only contribute to the development of science, but also have a real impact on daily educational and parenting practices. Thus, the practical implications of this study are very valuable as a foundation in creating a conducive, adaptive learning environment that supports optimal child growth and development in the cognitive domain.

METHOD

This study uses a mixed methods approach (Creswell, 2010), with explanatory sequential design to gain an understanding of children's spatial development in learning using mathematical puzzles and free play to see its effectiveness in mathematics learning at the early childhood level. This study was conducted at TK Inpres Mannurukki and TK IT At-Tibyan with a population of all students in the school with a sample of 15 students from each school with a sampling technique using purposive sampling. The research instruments used in this study were tests and interviews. The quantitative method used to compare two independent groups was the game-based learning approach using mathematical puzzles at TK Inpres

Mannurukki and the play-based learning approach using free play learning. While the qualitative method used to explore the learning outcomes through interviews and observations of the understanding of pluralism values.

Based on this, the data analysis technique used in the quantitative method (Sugiyono, 2021), uses descriptive statistics and inferential statistics assisted by SPSS version 26. This is used to describe how learning is done before and after learning and to test hypotheses in order to generalize. As for inferential statistics, it is first carried out to see the normality of the data based on Kolmogorov-Smirnov and the Homogeneity of Variance test using Levene's Test. If the data is normally distributed, it is continued with a parametric statistical test using Independent Samples, but if the data is not normally distributed, a non-parametric statistical test is carried out using the Mann-Whitney test. Then if the posttest results show a significant difference, the N-Gain test is continued to find out more about the effectiveness or improvement that occurs in the experimental class, namely the learning using mathematical puzzles.

Meanwhile, in the qualitative stage, thematic analysis is carried out to identify, analyze, and report patterns in the data (Susanty et al., 2023). This method helps to find the meaning contained in interviews, observations, and documentation by classifying information into certain themes. This method is often used in research to understand the experiences, perceptions, and meanings contained in a phenomenon such as the focus of this research, namely on mathematics learning outcomes that emphasize learning using mathematical puzzles and free play. The steps of thematic analysis in this study include (1) Familiarization with data; (2) Generating initial codes; (3) Searching for Themes; (4) Reviewing Themes; (5) Defining and Naming Themes; and (6) Writing a report on the results of the analysis. So by using this method, research can produce a deep understanding of how mathematics learning outcomes, especially at the kindergarten or early childhood level, are in learning using mathematical puzzles and free play.

RESULTS AND DISCUSSION
RESULT

In this section, the results of the research from all activities that have been carried out will be presented. The results of the research are in the form of data consisting of quantitative data in the form of pretest and posttest data in the experimental class and control class. Quantitative data processing uses SPSS software version 26. Based on the processing of Pretest data in the descriptive statistical test is presented in the following table.

Table 1. Group Statistics Pretest

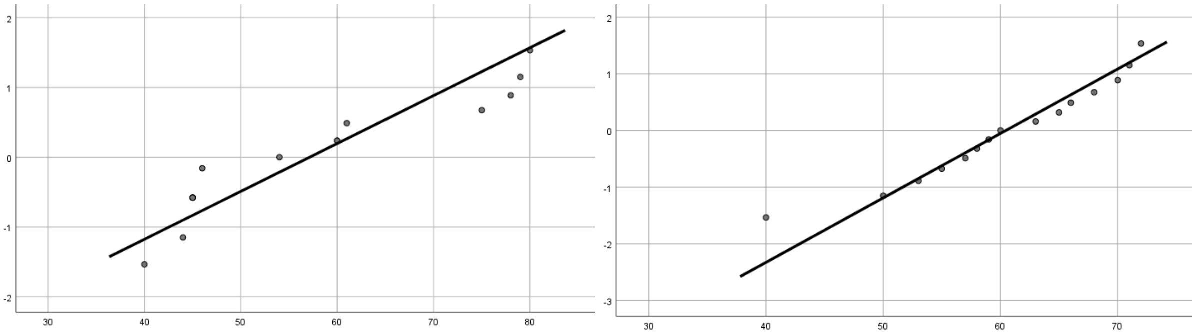
Class	Mean	Std. Deviasi	Std. Error Mean
Eksperiment	57.13	14.579	3.764
Control	60.47	8.798	2.272

Based on the table above, it can be seen that the average value of the experimental class and the control class is 57.13 and 60.47 with a standard deviation value of 14,579 and 8,798. The standard error of the average of the experimental class and the control class is 3,764 and 2,272. Furthermore, a normality test was carried out on the pretest scores of the two classes. To test the normality of the pretest scores in this study to see the generalization of the pretest data in the experimental class and the control class as follows.

Table 2. Tests of Normality Data Pretest

Class	Statistic	Sig.
Eksperiment	.244	.016
Control	.097	.200*

Based on the table above, it shows that the significance value for the experimental class and control class is 0.016 < 0.05 and 0.200 > 0.05. Based on the decision-making criteria, it can be concluded that the pre-test data for the experimental class and control class are not normally distributed because there is one class whose significance value is less than 0.05.



Picture 2. Normal Q-Q Plot of Pretest

Tabel 3. Tests of Homogeneity of Variance

	Levene Statistic	Sig.
Based on Mean	6.156	.019
Based on Trimmed Mean	5.999	.021

Based on Figure 2 above, it can be seen that the data or points in the pretest data of the experimental class and the control class are not spread around the diagonal line and are significantly far from the line, so this shows that the pretest data in the experimental class and the control class are not normally distributed.

Tabel 4. Test Statistics[a]

	Pretest
Mann-Whitney U	92.500
Z	-.831
Asymp. Sig. (2-tailed)	.406

Based on the table above, it shows that the significance value is 0.406. From the data, it is obtained that the significance value is > 0.05. This shows that there is no difference in the average initial ability of students in the experimental class with students in the control class in children's spatial development with a game-based learning approach using math puzzles at TK Inpres Mannurukki and a play-based learning approach using free play learning. Furthermore, Posttest data processing is carried out on the descriptive statistical test presented in the following table.

Table 5. Group Statistics Postest

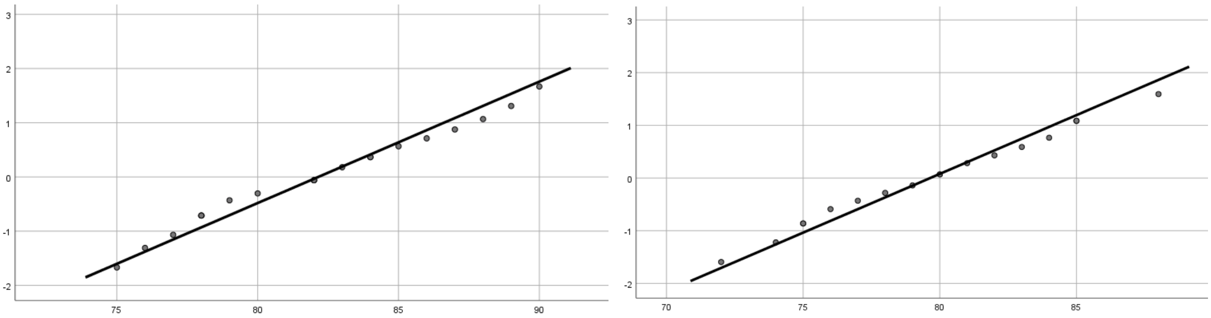
Class	Mean	Std. Deviasi	Std. Error Mean
Eksperiment	76.13	10.555	2.725
Control	84.20	5.596	1.445

Based on the table above, it can be seen that the average value of the experimental class and the control class is 76.13 and 84.20 with a standard deviation value of 10.555 and 5.596. The standard error of the average of the experimental class and the control class is 2.725 and 1.445. Furthermore, a normality test was carried out on the posttest scores presented in the following table.

Tabel 6. Tests of Normality Data Postest

Class	Statistic	Sig.
Eksperiment	.191	.148
Control	.159	.200*

Based on the table above, it shows that the significance value for the experimental class and the control class is 0.148 and 0.200. From the data, it is obtained that the significance value for the experimental class and the control class is greater than 0.05, so based on the decision-making criteria, it can be concluded that the post-test data for the experimental class and the control class are normally distributed.



Picture 3. Normal Q-Q Plot of Pretest

Based on Figure 3 above, it can be seen that the data or points on the posttest data of the experimental class and the control class are spread around the diagonal line and are significantly close to the line, so this indicates that the data is normally distributed. The next test carried out is by using the Levene test.

Table 7. Tests of Homogeneity of Variance

	Levene Statistic	Sig.
Based on Mean	1.523	.227
Based on Trimmed Mean	1.357	.254

Based on the table above, it shows that the significance value for Based on Mean is 0.227. From the data, it is obtained that the significance value is greater than 0.05, so based on the decision-making criteria, it can be concluded that the variance of the two classes is homogeneous. Furthermore, a parametric statistical test was carried out using the independent sample t test to determine the differences that occurred in the pretest data between the experimental class and the control class.

Table 8. Independent Samples Test

	t	Sig. (2-tailed)
Equal Variances Assumed	-2.615	.014

Based on the table above, it shows that the significance value is 0.014. From the data, it is obtained that the significance value is smaller than 0.05. This shows that the average posttest of the final ability of the experimental class in children's spatial development with a game-based learning approach using math puzzles is not better than the average of the control class with a play-based learning approach using free play learning significantly. Based on this, it is continued with the N-Gain test to see how much effectiveness occurs.

Table 9. Uji N-Gain

Mean	**Std. Deviasi**
.599	.119

Based on the table above, it can be seen that the average value of N-Gain is 0.599 with a standard deviation value of 0.119. This shows that the effectiveness that occurs in the experimental class on children's spatial development with a game-based learning approach using mathematical puzzles is classified as moderate.

Based on the results of quantitative research conducted at TK Inpres Mannurukki and TK IT At-Tibyan, there were significant differences between the two learning groups, namely the experimental group using math puzzles and the control group using the free play approach. Although the experimental group showed a significant increase in spatial skills based on the N-Gain test, the control group had better results in the overall math posttest. This shows that although math puzzles successfully attract students' attention, more flexible free play-based learning is more effective in supporting the development of overall math concepts for early childhood.

Interviews with students in the experimental class using math puzzles showed that most students felt more interested and motivated with this game-based learning. They expressed that math puzzles felt fun and challenging, so they were more focused on learning. One student said,

"This puzzle is like a game, but I learned a lot of things, like counting and arranging shapes."

The students felt that learning this way was much more fun than more conventional methods. They felt that by working on the puzzles, they were not only learning mathematics, but also felt like playing. However, some students also found it difficult when the puzzles given were too complicated. One student expressed,

"Sometimes I'm confused, the puzzle is really hard."

This shows that although math puzzles can increase students' interest, too high a level of difficulty can frustrate them and reduce their understanding of the material given. Students who complete puzzles faster tend to feel more confident and often share strategies with their friends. They feel happier because they can help friends who have difficulty solving puzzles. One student said,

"I love helping my friends solve puzzles, so we can learn together."

On the other hand, interviews with students in the control class using the free play approach showed that they felt freer and less bound by a strict learning structure. One student said,

"I like to learn while playing, I can play whatever I want."

They feel more comfortable and not burdened with overly complicated tasks. However, some students also feel that they are less able to connect the game with the mathematical concepts being studied.

"Sometimes I don't know how playing games can help me learn math,"

said one of the students. This shows that although free play provides freedom in exploration, students need more direction to relate the game to mathematics learning. In addition, there are students who feel that the free play approach is less structured and makes it difficult for them to focus on learning. One of the students said,

> *"Sometimes my friends prefer to chat and play around, so I join in too, forgetting to study math."*

This shows that although students feel happy with the freedom to play, the lack of guidance from the teacher can result in a lack of understanding of the mathematical concepts taught. Most students in the control class expressed that they needed more explanation and direction from the teacher to connect playing activities with relevant mathematical concepts. This is in accordance with the verbal statement of a student who stated :

> *"I think it would be great if someone could tell me how to play which could help me learn."*

Some students also expressed that they felt more comfortable with an approach that gave them time to explore and understand new things in their own way, although they sometimes felt confused if there was no clear direction. One student stated,

> *"Even though I am free to play, sometimes I am confused about where to start, and sometimes I don't know what I should learn."*

This suggests that while free play provides freedom, students who are not used to a more open learning structure need help to manage their focus and set clear learning goals. Overall, interviews with students in both groups showed differences in how they responded to the different types of learning. Students in the experimental class using math puzzles felt more focused and preferred the challenge, although they also acknowledged that puzzles that were too difficult could hinder their understanding. Meanwhile, students in the control class using the free play approach felt more free and creative in their play, but needed more direction to connect the game to the learning they were doing. The two groups had different experiences, and both expressed that teacher support and direction were essential to maximizing their learning.

In terms of observation, although students in the experimental class showed higher engagement in learning activities using math puzzles, they needed more time to complete more complex puzzles. In the control class, although there was more active social interaction, students often lost focus on the math tasks given. Based on the results of these interviews and observations, it can be concluded that although both approaches have their own advantages, a combination of the two can be a more optimal strategy. A more structured approach such as math puzzles can better support the development of spatial skills, while a more flexible free play approach can enhance creativity and social interaction, thus providing a more holistic learning experience.

It is important to note that the success of learning depends not only on the type of approach used, but also on how the teacher directs and manages the class. In the game-based learning approach, setting the right level of difficulty and sufficient guidance from the teacher can help students overcome difficulties in solving more complex puzzles. On the other hand, in the free play approach, although students are more free and creative, they need more structure and guidance from the teacher so that learning is more focused and effective. Therefore, combining elements of both approaches in one learning strategy can be a more optimal choice to support children's holistic development, both in terms of spatial skills and in terms of creativity and social interaction.

DISCUSSION

This study found that the chosen learning approach significantly affects students' conceptual understanding. It highlights that teaching strategies are not merely tools for delivering content but are central to how well students grasp, process, and master concepts. When tailored to student characteristics, learning styles, and content context, teaching becomes more meaningful, active, and constructive. The significant impact observed reflects an improvement in both the depth of understanding and the ability to apply concepts in new contexts. Conceptual understanding is a key indicator of learning success not just in recalling facts but in making connections between ideas, explaining them independently, and applying them in real situations.

Learning approaches that promote exploration, discussion, reflection, and hands-on application such as project-based, contextual, scientific, or game-based methods can enhance long-term retention and relevance. These results emphasize that learning strategies should not be chosen arbitrarily or out of habit. Effective methods must align with learning goals, student needs, and the nature of the material. Success is measured not only by outcomes but also by student engagement, motivation, and their ability to relate concepts to real life. Thus, this study reinforces the idea that educational success depends heavily on how learning is designed and how well it fosters critical thinking, creativity, and holistic understanding.

In addition to being a basis for developing more effective teaching methods, these findings can also be a reference for teachers, educators, and educational policy makers in evaluating and designing learning strategies that are more adaptive and responsive to the needs of students. The significant impact shown in the results of this study should encourage various parties to be more aware of the importance of innovation in learning practices, as well as the need for training and professional development for teachers to be able to master various approaches that have been proven effective in improving student understanding. Thus, the learning approach applied is not only a tool in delivering material, but truly a bridge that connects students with a deep, applicable, and relevant understanding of the concepts taught. This is in line with the theory put forward by Piaget (Suparno, 2001), which states that children's cognitive development occurs through stages that must be supported by learning approaches that are appropriate to their age and thinking abilities. Piaget emphasized that children learn through direct experience and interaction with their environment, so that learning methods that involve concrete activities can improve their understanding.

Recording to Sholehuddin et al. (2023), social interaction plays an important role in children's learning. He argues that learning occurs optimally when children receive support in their zone of proximal development through guidance from teachers or more competent peers. In the context of this study, the learning method used allows students to interact and build understanding together. Vygotsky also emphasized the importance of language as a tool for thinking, so that discussion and collaboration in learning can improve understanding of concepts more deeply. Furthermore, according to Huda & Susdarwono (2023) the concept of scaffolding is very relevant in helping students understand new concepts by providing appropriate assistance until they can master them independently. Bruner argues that learning should begin by providing support in the form of explicit guidance or instruction, which is then reduced as students' understanding increases. In this study, the application of learning strategies involving gradual guidance was proven to increase the effectiveness of students' understanding.

In addition, the constructivism theory developed by Dewey (Moss et al., 2019), also supports this finding, where learning must be based on experience and direct exploration so that students can connect new concepts with their previous experiences. Dewey emphasized that meaningful learning occurs when students are actively involved in the educational process and have the opportunity to experiment with the concepts they are learning. The results of this study indicate that the methods applied have provided opportunities for students to learn actively and build their own understanding. This finding reflects a learning approach that places students as the main subjects in the learning process, not just recipients of information from the teacher. In this approach, students are given space to be directly involved in learning activities, explore materials independently or in groups, and link new knowledge with experiences or knowledge they already have. Learning methods that encourage active student involvement allow for a more meaningful knowledge construction process, where students do not only memorize information, but truly understand concepts, principles, and their applications in real life.

Active learning activities encourage students to ask questions, investigate, discuss, experiment, solve problems, and express their opinions. These processes are very important in forming deep and lasting understanding, because students become the main actors in discovering and constructing meaning from the material they are learning. In this context, the methods applied may involve strategies such as project-based learning, contextual learning, collaborative learning, or the use of interactive media that encourage active and reflective student participation. When students are involved in learning activities that require them to think critically, make decisions, and reflect on what they are learning, they will find it easier to internalize the concepts taught and relate them to real situations.

The results of this study also suggest that the classroom atmosphere created through this method allows for an open dialogue process between teachers and students, as well as between students themselves. Such interactions provide opportunities for students to convey ideas, listen to other people's points of view, and revise their understanding based on the input received. In other words, active learning is not just a physical activity in the classroom, but includes a complex mental process in which students continuously build, test, and refine their understanding of a concept. The application of methods that provide opportunities for students to construct their own understanding also reflects the philosophy of constructivist education, which believes that knowledge cannot simply be transferred from teacher to student, but must be constructed by students themselves through their experiences and involvement in the learning process. Therefore, the success of this method shows that an approach that values student activeness in learning is much more effective than conventional methods that are one-way lectures and only emphasize passive absorption of information.

These findings provide a strong basis for educators to continue developing and evaluating their teaching methods to be more oriented towards active learning. Teachers are required to be facilitators who are able to design challenging, relevant, and meaningful learning activities, so that students do not only learn to pass exams, but also to understand and apply knowledge in real life. With the right method, students will feel in control of their own learning process, which will ultimately increase their motivation, self-confidence, and responsibility in achieving learning goals. Therefore, the results of this study are not only evidence of the success of the approach applied, but also an important foundation for building a more humanistic, reflective, and student-centered learning paradigm.

Recording to Pratama & Lestari (2023) cooperative learning has a positive impact on learning outcomes because it involves interaction between students in completing academic tasks. Cooperative learning provides opportunities for students to share ideas, discuss concepts, and help each other understand the subject matter. This is in line with research findings that show that students who study in groups have a better understanding of concepts compared to individual learning. Fauzi et al. (2025) also emphasizes that cooperation in groups can increase learning motivation and strengthen students' social skills. In addition, the experiential learning theory of Kolb also supports the approach applied in this study (Almalky & Alwahbi, 2023; Cilesiz, 2011; Fajrie, 2024; Heyneman, 2023; Jackson & Tomlinson, 2022). Kolb emphasized that effective learning occurs through a cycle of direct experience, reflection, conceptualization, and application. By using experiential and exploratory learning methods, students can better internalize concepts and relate them to real situations.

Based on expert opinions, the learning method in this study aligns with constructivist principles that emphasize social interaction, scaffolding, and direct experience. Thus, the study's implications can inform the development of more effective learning strategies and an adaptive curriculum tailored to student needs. The findings also serve as a reference for educators in applying innovative, research-based teaching methods. Educational research plays a key role in guiding curriculum development, ensuring its responsiveness to student growth and contemporary challenges. When proven methods enhance understanding, skills, or attitudes, these results become valuable references for shaping relevant content, goals, strategies, and assessments. An adaptive curriculum requires flexibility to accommodate diverse learning styles, interests, socio-cultural backgrounds, and academic readiness. Research helps identify real student needs and informs contextual, responsive policy decisions (Atmowidjoyo et al., 2022; Djubaedi et al., 2022; Puspita et al., 2024; Suhra et al., 2021). Curriculum should be seen as a dynamic framework, refined through credible field data.

Educators can also use the findings to design creative (Darling-Hammond et al., 2020; Indiyanti et al., 2023; Mertler, 2024), effective methods grounded in evidence (Bardach et al., 2022; Cheng, 2022; Mariska & Mustakim, 2024; Uz Bilgin & Gul, 2020; Zaenuri et al., 2020). Research-based approaches undergo trials and analysis, enhancing their reliability. This strengthens pedagogical practices, allowing teachers to confidently implement active, participatory strategies aligned with student realities. Moreover, research-driven methods promote an academic culture rooted in continuous improvement. Teachers and curriculum developers are encouraged to collaborate in creating programs focused on authentic, sustainable outcomes. Educational policies, in turn, can be designed with data-driven precision to elevate overall quality. In conclusion, this study offers both theoretical insight and practical value. The findings contribute to building a progressive education system where decisions by teachers, developers, and policymakers are grounded in student needs and proven approaches. Education, then, becomes a dynamic, reflective process shaped by ongoing research and innovation.

CONLUSION

Based on the results of the study conducted at TK Inpres Mannurukki and TK IT At-Tibyan, there was a significant difference between learning using mathematical puzzles and free play on the spatial development of early childhood. Quantitative data analysis showed that although the experimental class using mathematical puzzles experienced a significant increase in spatial skills, the posttest results showed that the control class implementing free play-based learning had a higher average score in overall mathematical understanding. This indicates that the free play approach, which is more flexible and allows for independent exploration, can be more effective in developing children's mathematical concepts broadly than the more structured puzzle-based approach. The results of interviews with students in the experimental class showed that they were more motivated and interested when learning using math puzzles. Most students considered this method as a fun and challenging game, thus increasing their focus on learning. However, there were some students who had difficulty when facing more complex puzzles, which could cause confusion and reduce the effectiveness of their learning. This shows that although the game-based learning approach with math puzzles has the potential to improve spatial skills, the difficulty factor of the task must be adjusted to the child's ability in order to continue to provide a positive learning experience. Overall, this study confirms that both learning methods have their respective advantages in supporting children's spatial development. The mathematical puzzle approach is effective in improving certain cognitive skills and learning motivation, while the free play approach provides greater flexibility in understanding mathematical concepts as a whole. Therefore, in mathematics learning at the early childhood level, a combination of these two methods should be used so that children can get optimal benefits from both, both in terms of spatial skills and understanding mathematical concepts holistically.

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