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Building spatial skills in a fun way: Exploring cube learning through a joyful approach

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Abstract

Spatial ability is a crucial component of learning geometry, particularly with cube materials that require students to visualize three-dimensional objects, perform mental rotation, and understand relationships among faces. This study aims to describe students' spatial abilities through the implementation of Joyful Learning in class IX.3 of SMP Negeri 17 Palembang. The research employed a descriptive design with a final sample of 34 students. Instruments included a spatial ability test based on five indicators (perception, orientation, rotation, relation, and visualization) and in-depth interviews with representatives from high-, medium-, and low-ability groups. Data were analyzed using quantitative (percentage scores) and qualitative techniques (data reduction, display, and conclusion drawing). The results show that the average spatial ability was 71.3% (moderate). Stronger performance was observed in rotation, orientation, and visualization indicators. At the same time, weaknesses were noted in relation and perception, especially in determining the surface area of composite solids and understanding hidden cube structures. The implementation of Joyful Learning through exploration, group discussions, concrete media (cube nets), and educational games enhanced student engagement and participation. Overall, the implementation of Joyful Learning is associated with increased students' enthusiasm, participation, and spatial understanding, and effectively supports students' understanding of the relationship between two-dimensional and three-dimensional representations.

Keywords: cube; geometry; joyful learning; spatial ability; spatial visualization

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INTRODUCTION

One subject that plays an important role in education is mathematics learning (Chintia et al., 2021). The National Education System states that mathematics is a compulsory subject in primary and secondary education (Satriani, 2024). Mathematics is one of the subjects that plays an important role in developing students' thinking skills. However, in reality, mathematics is often considered difficult and lacking in demand (Desanti et al., 2023). One of the materials considered challenging is building space, even though it plays an important role not only in academic settings but also in real-world applications such as architecture and engineering (Lutfi & Kusumastuti, 2024). In learning geometry, students need strong spatial reasoning skills to understand and solve problems (Fitriyani et al., 2025). Understanding of building space is closely related to spatial abilityv(Hendroanto, 2022). Spatial ability which is the ability to imagine, imagine, estimate, determine, construct, present, and find information from visual stimuli in the context of the room (Nuraeni et al., 2024). This ability allows a person to imagine changes in the shape of an object, such as rotation, translation, and reflection (Fitri & Ibrahim, 2019).

However, various studies show that most students have difficulty in understanding the concept of building space due to limitations in visualization and spatial imagination (Aini, 2022). One contributing factor is the lack of variety in the learning strategies teachers use (Nurwijaya, 2022). In mathematics learning activities, the main task of a teacher is not only to convey information, but also to motivate students and foster an attitude of cooperation and responsibility (Yanti, 2021). Therefore, this condition requires learning innovations that are fun and motivating, one of which is joyful learning (Abrori et al., 2025). Joyful learning is a learning approach designed to make learning fun and engage students' interest, thereby increasing students' concentration and participation in the material presented (Sutria et al., 2025). Implementing joyful learning in elementary schools has been shown to improve learning quality, both in academic outcomes and student motivation (Sutrina et al., 2025).

Several previous studies also support the application of this approach. Research by Ramadhani et al. (2024) shows that implementing joyful learning with flat building materials allows students to learn while playing, making learning feel more interactive and fun. The results of this study show that students' interest and learning outcomes in mathematics can increase in a more comfortable learning environment. Furthermore, research by Yuliana et al. (2025) found that the joyful learning model in flat building materials not only improves understanding of concepts but also encourages students' creativity. This is evidenced by the higher average posttest score in the experimental class than in the control class, as well as the significance level indicating the model's effectiveness. Other research by Yanti (2021) also shows that joyful learning can improve mathematics learning outcomes in algebra materials at the junior high school level, as evidenced by increases in grade point averages and the number of students who achieve learning completion.

Spatial abilities are closely related to geometry learning, especially space-building materials, as students are required to visualize three-dimensional objects in their minds (Herawati & Hariyani, 2024). Lee & Park stated that spatial ability is the ability to visualize, understand, and mentally organize the spatial relationships of objects (Suparmi et al., 2022). Low spatial ability is associated with students who still do not understand the concept of spatial construction, which impacts their problem-solving skills (Simamora et al., 2024). The importance of spatial thinking must be applied at all levels of the education system so that all individuals develop strong spatial skills (Adzani et al., 2023). Spatial skills are particularly well-suited for learning mathematics, especially in building materials (Putri & Yulia, 2024). However, most previous studies using the joyful learning framework have reported increased interest, motivation, and learning outcomes among students. There is still limited research examining how joyful learning can improve students' spatial abilities. In fact, joyful learning activities, which emphasize direct engagement, concrete media, and a fun atmosphere, have the potential to train students in mental rotation, imagining forms, and connecting two-dimensional representations to three-dimensional ones (Habeahan et al., 2023).

Although many studies have examined joyful learning, most focus on improving students' interest, motivation, and learning outcomes. However, studies specifically exploring the relationship between joyful learning and students' spatial ability, particularly in three-dimensional geometry, remain limited. In fact, spatial ability is an essential aspect in understanding geometric concepts. Therefore, it is necessary to conduct research that examines the relationship between joyful learning and students' spatial ability. The research problem in this study is how students' spatial ability appears through the implementation of joyful learning in three-dimensional geometry. The objective of this study is to describe students' spatial ability through joyful learning in the topic of solid figures. The novelty of this study lies in its focus on integrating joyful learning with students' spatial ability in three-dimensional geometry. This area has been less explored than in previous studies, which mainly emphasize motivation and learning outcomes. This study is expected to provide practical contributions as an alternative instructional strategy for teachers to help students overcome difficulties in understanding three-dimensional concepts, as well as theoretical contributions that enrich the literature on the relationship between joyful learning and spatial ability in mathematics learning (Liu et al., 2021).

METHODS

This study uses a descriptive research method to examine students' spatial abilities in joyful-based learning with flat-sided 3D shape materials in junior high school. The data collected in this study will be analyzed descriptively, with the results presented in a written sentence. The subjects in this study are 34 students in grade IX.3 of SMP NEGERI 17 Palembang in the odd semester of the 2025/2026 school year. The focus of this study is on 5 indicators of spatial ability, namely:

Table 1. Spatial Ability Indicators (Suparmi et al., 2022)

Indicator	Description
Spatial Orientation	Determining the position and direction of objects in the context of space
Spatial Relations	Imagining the state of an object from a different perspective
Spatial Visualization	Imagine, manipulate, or reverse an object.
Rotation Mental	Identify a building of space and its elements that have been rotated or rotated accurately and quickly.
Perception Spatial	Observing the shape of space or parts of space in a horizontal or vertical position, even after the object is manipulated

The collection technique used 5 test and interview questions. Two experts in mathematics education validated the instrument on its content, construct, and language. These five description questions were arranged according to learning objectives, indicators of spatial ability, and a joyful approach. The following are the test questions used in the research:

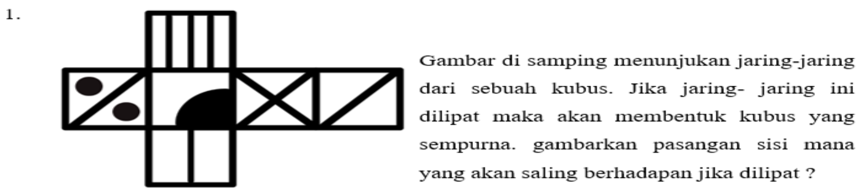
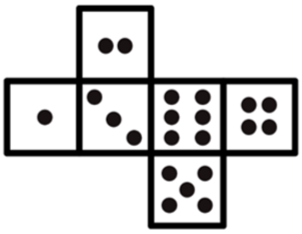


Figure 1. Instrument Question 1

In question 1, students were given a picture of a cube net. Students were asked to imagine how the nets would be folded to form a complete cube. After that, students must determine which sides face each other. This question trains the rotation of the mind, the ability to imagine the change in the shape of a building or space when folded or rotated.



2. Jika sisi [dice 6] berada di bagian bawah kubus, tentukan sisi sisi yang lain :

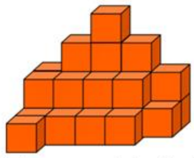
a) Di atasnya

b) Di sebalah kiri jika [dice 5] berada di kananya?

Figure 2. Instrument Question 2

In question 2, students are given cube nets that resemble dice. Students are asked to determine the location of the other side if one side is placed at the bottom. The step is to imagine the folds of the dice, then find the top and bottom sides according to the instructions. This question trains spatial orientation, the ability to determine the direction and position of an object in space.

Perhatikan gambar di bawah ini untuk menjawab soal no 3 dan 4!



3. Di atas terdapat beberapa susunan kubus. Gambarlah tampak kubus tersebut jika dilihat dari atas!

Figure 3. Instrument Question 3

In question 3, students see a picture of a multi-tiered cube arrangement. Students are asked to imagine what it would look like when viewed from above, then describe it. This question trains spatial visualization, the ability to imagine 3D shapes from different perspectives.

Jika susunan tersebut dibongkar menjadi satuan kubus, berapa jumlah seluruh kubus yang digunakan? Jelaskan caramu menghitungnya!

Figure 4. Instrument Question 4

In question 4, students see the arrangement of several cubes. Students are asked to count the number of cubes in the array, including those that are invisible because they are closed. This question trains spatial perception, namely the ability to understand the number and arrangement of cubes, both visible and hidden.

Jika setiap kubus pada susunan tersebut memiliki sisi 5 cm, tentukan luas permukaan seluruh bangun kubus yang terbentuk seperti gambar di atas!

Figure 5. Instrument Question 5

Question 5 trains spatial relations, namely the ability to understand the relationships between parts of a spatial building. Each item was scored on a rubric ranging from 1 to 4 based on the accuracy and completeness of the student's answers. After that, the test data were analyzed using descriptive statistics, including mean scores, percentages, and categorization of spatial ability levels.

$$Nilai = \frac{skor\ yang\ diperoleh}{skor\ maksimal} \times 100$$

Information:

Maximum score = maximum score of each question × many questions = 4 × 5=20

Furthermore, determine the research subject's spatial ability category based on the test scores obtained. The categorization of spatial abilities in this study is adapted from the research (Nugroho et al., 2025), as shown in Table 2.

Table 2. Categories of Spatial Abilities

Value	Categories Spatial Ability	Description
0 – 25	Very Low	Students' abilities to understand and apply spatial concepts are very limited.
26 – 50	Low	Students still have difficulties in understanding and applying several spatial concepts.
51 – 75	Medium	Students can understand spatial concepts, but they still need further development.
76 – 100	High	Students have good spatial thinking skills and can apply mapping concepts appropriately.

After determining the category of students' abilities, 5 students were selected based on their test results to represent high, medium, and low ability groups for in-depth interviews. The presentation of data in this study was carried out systematically to describe the results of data collection obtained through tests and interviews. The data is presented in a descriptive form, complemented by direct quotes from the interview results and tables or graphs that support understanding. Each piece of data displayed has undergone transcription, grouping, and interpretation according to the spatial ability category.

RESULTS AND DISCUSSION

Learning Outcomes

The research was conducted in two meetings using *the* joyful learning approach. Through joyful learning in mathematics, it is hoped that students will know that learning can also be fun. In joyful learning, there are also several stages. Here are the stages.

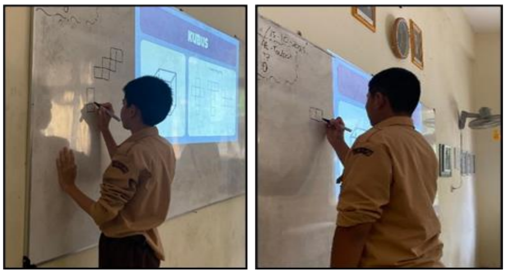
1) Preparation Stage

At this stage, the researcher begins the lesson with an introduction by greeting, praying, checking attendance, and conducting an ice-breaking activity called geometry gymnastics. Students form hand symbols based on the shapes mentioned: a cube (square gesture), a ball (circle), and a cone (triangle above the head), performing them quickly and accurately. The researcher then assesses students' readiness, explains the learning objectives, and links them to prior knowledge of cube nets. Next, guiding questions are posed about an open gift box, the formula for the area of a square, and the number of squares forming a cube. Students respond enthusiastically while recalling concepts of square shapes.

Figure 6. Situation During Ice Breaking

2) Delivery Stage

At this stage, the researcher presents a cube model to the students and asks questions about its faces, edges, and vertices. Students respond by raising their hands, and those who answer correctly receive small rewards. The researcher then displays various cube nets on a projector, asks about the number of net types, and invites two students to draw different cube nets on the board. A YouTube video showing cube net patterns is also played to strengthen students' understanding. Furthermore, the researcher introduces spatial ability tasks through descriptive questions as preparation for students' worksheets, using a real cube marked with symbols while guiding students to label and fold the nets.



(a) (b)

Figure 7. (a) Student a's Answer (b) Student b's Answer

In Figure 7a, students show another net pattern, namely the 2-2-2 pattern, whereas students in Figure 7b use the 1-4-1 pattern.

3) Training Stage

At this stage, the researcher divided the students into six groups of 5–6 members each. The researcher distributed the first meeting worksheet and net-shaped paper as learning media. Instructions for the tasks were given, and students listened carefully to the explanation.

(a) (b)

Figure 8. (a) The Group Forms the Net, (b) The Group Has a Discussion

Here, the researcher observed many students who could not fold the nets properly, and the researcher also helped the students in group discussions by going to each group one by one, asking where their problems were, and helping them. When the researcher went around asking the group of students about their difficulties, several groups did not respond because the students felt there were none. The researcher also encouraged students to be more active in discussions. In the presentation of group 3 that advanced earlier, there was still confusion in folding the cube and in determining its position.

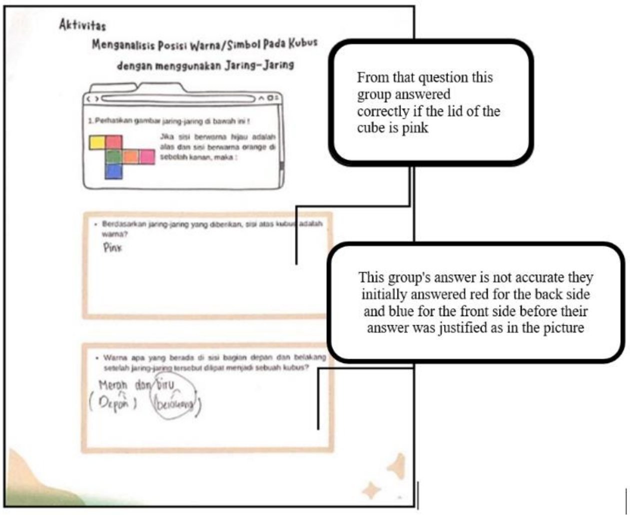


Figure 9. Student Worksheet Number 1

From question 1, part a, all groups answered correctly. However, in the next part, group 3 wrote only the colors red and blue, without explaining which side was the front and which was the back. After being asked to explain, they called red the back side and blue the front side, so the Answer was incorrect. When the researcher checked the other groups, all had different answers, so the researcher asked one of the students to state the Answer: the front side is red, and the back side is blue, which was agreed by the whole group. Thus, only group 3 is wrong on number 1.

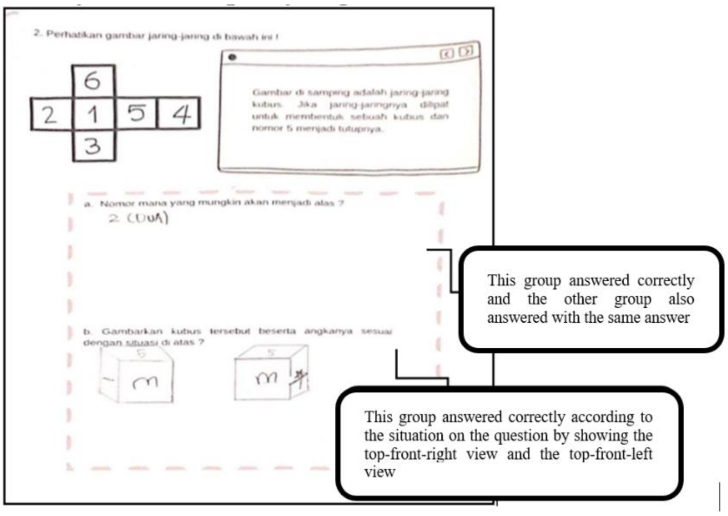


Figure 10. Student Worksheet Number 2

In question 2, part b, 4 groups answered with 2 cube images, and 2 groups answered with 1 cube image.

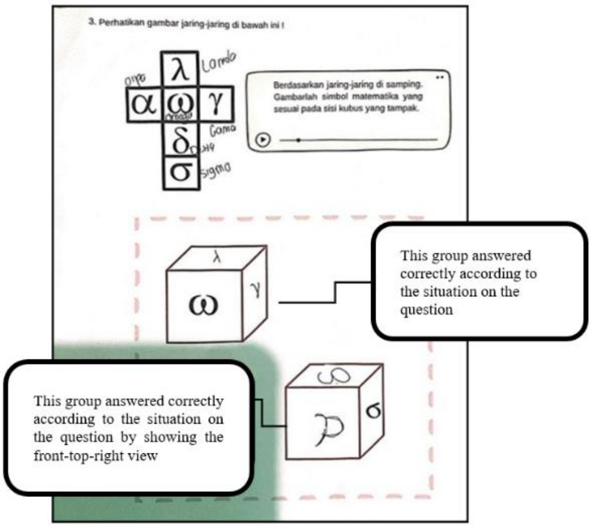


Figure 11. Student Worksheet Number 3

When the presentation group finished explaining answer number 3, the researcher asked the other group if they had a different answer. The other group also asked whether their answers were the same as those of the presenters' group.

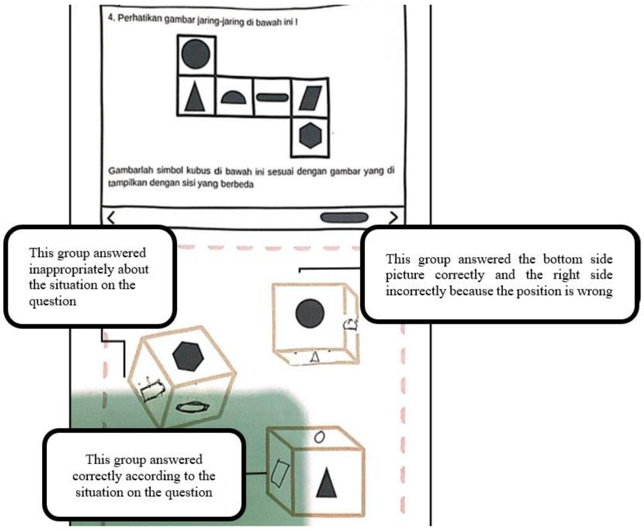


Figure 12. Student Worksheet Number 4

From this problem, many groups of students are still hesitant to determine the side of the hexagonal part of the cube, but some groups are correct.

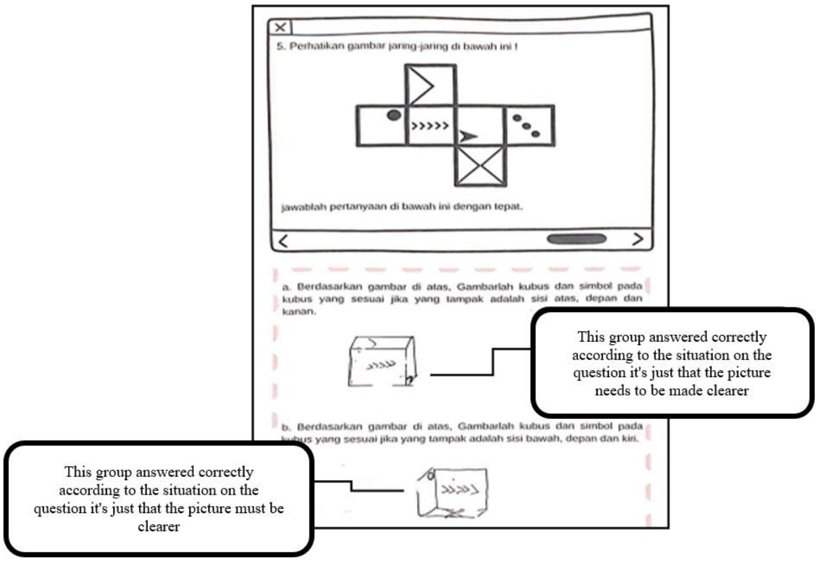


Figure 13. Student Worksheet Number 5

4) Closing Stage

At the closing stage, the researcher appreciated students who participated well and gave small rewards to those who presented. The researcher asked students for their opinions on using the net media, and they responded positively. One student was asked to conclude the lesson, but still needed guidance. Finally, the researcher informed the next topic and closed the session.

Test Results

In the third meeting, a spatial ability test was conducted to assess students' understanding after implementing Joyful Cube Learning on the cube material. The test consisted of five essay questions based on spatial ability indicators (perception, orientation, rotation, relation, and visualization) and had been validated by experts. The aim was to identify the most developed indicators and to obtain an overview of students' understanding of three-dimensional concepts. Following the test, five students representing high, medium, and low categories were selected for interviews to explore their spatial thinking processes. The results showed an average spatial ability of 71.3% (medium category). These findings indicate that concrete, activity-based learning, such as folding and manipulating cube models, contributes to students' understanding of two- and three-dimensional relationships.

Interview data further supported these findings. Students in the high category demonstrated strong mental visualization and rotation skills, as one student reported being able to imagine folding cube nets step by step. Students in the medium category showed partial understanding and still experienced confusion when cube positions changed. Meanwhile, difficulties remained in spatial relations and perception, as some students relied only on visible parts and struggled to identify hidden structures. Overall, these results indicate variation in students' spatial abilities across different indicators.

Table 1. Test Instrument Results

Category	Frequency	Percentage
High	4	11,76 %
Medium	30	88,24 %
Low	0	0,00
Very Low	0	0,00
Sum	34	100 %
Average	71,32 %	
Category	Medium	

High Category Students

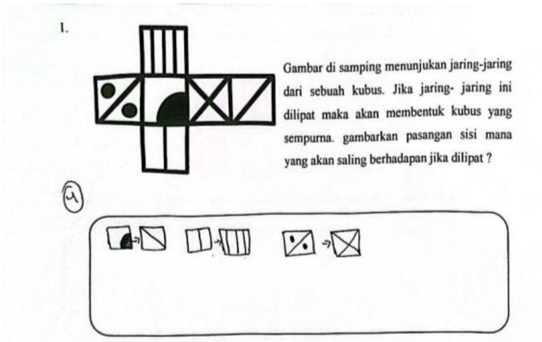


Figure 14. Student's Answer to Question 1

In question 1, the assessed ability is the rotation of the mind. This problem concerns cube nets, specifically determining which pairs of sides face each other after the nets are folded into cubes. In the first question, the results of CA's work showed that his mind-rotation ability was fulfilled very well. CA can imagine and determine the sides facing each other when the cube webs are folded into a three-dimensional spatial structure. The accuracy of his Answer, which scored 4, showed that the CA could visualize the correct folding of the net without conducting a direct experiment. Therefore, CA is categorized as having high capabilities in this indicator.

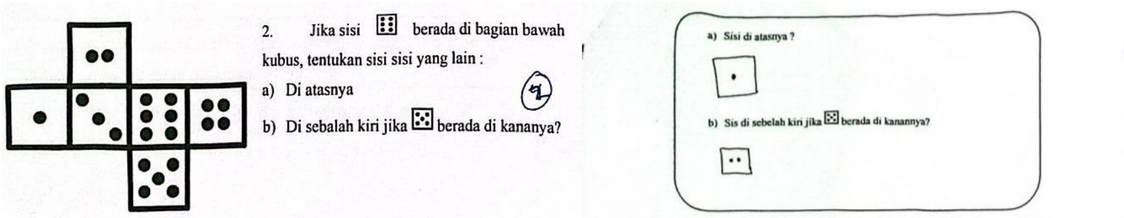


Figure 15. Student's Answer to Question 2

In question 2, the assessed ability indicator is spatial orientation. The PA can correctly indicate the side just above the reference side. However, when it comes to determining the left side after the position of one side moves to the right, the PA becomes hesitant. This difficulty indicates that the PA is not yet fully able to imagine the cube's position when rotated, so the relationship between the sides is inconsistent as the orientation changes. Based on this, PA received a score of 2, indicating that the spatial orientation indicator is only partially mastered.

Medium Category Students

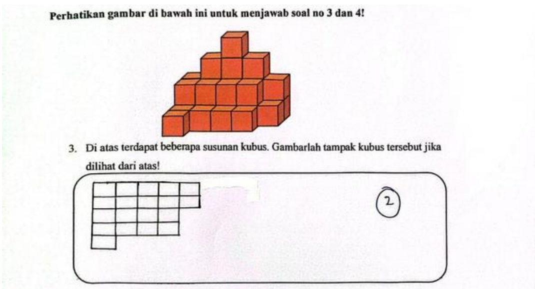


Figure 16. Student's Answer to Question 3

In question 3, the assessed ability indicator was spatial visualization. The PA can correctly indicate the side just above the reference side. However, when it comes to determining the left side after the position of one side moves to the right, the PA becomes hesitant. This difficulty indicates that the PA is not yet fully able to imagine the cube's position when rotated, so the relationship between the sides is inconsistent as the orientation changes. Based on this, PA received a score of 2, indicating that the spatial orientation indicator is only partially mastered.

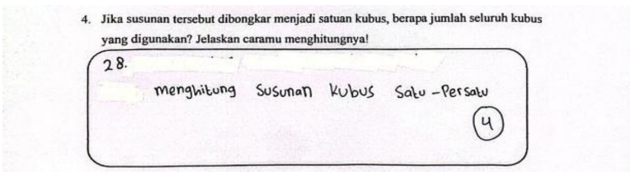


Figure 17. Student's Answer to Question 4

In question 4, the assessed ability is spatial perception. Based on the answers given, the PA correctly calculated the number of cubes (28) and explained the process by saying he counted them one by one. Although the explanation is simple, the steps taken demonstrate that the PA has good spatial perception, as it can understand the structure in its entirety and identify the number of units that make it up without error. Therefore, PA obtained a maximum score of 4.

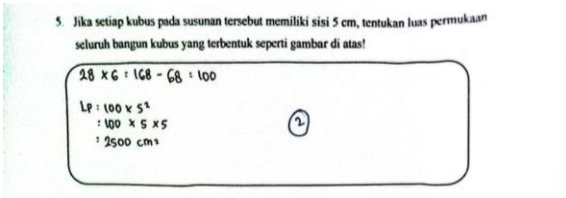


Figure 18. Student's Answer to Question 5

In question 5, the spatial ability indicator measured is spatial relations. Based on his work, PA wrote that there are 28 cubes in the arrangement. The PA then multiplies the number of cubes by 6 sides to get 168 sides in total. After that, the PA subtracts the 68 sides considered attached to estimate the number of visible sides, leaving 100. The PA then calculates the surface area using the area of one side of the cube ($5^2 = 25$) and produces a final answer of 2500 cm^2. Although the calculation is not yet accurate, the PA has recognized that the sides attached do not count as the outer surface. This shows that the PA is beginning to see the relationships among the cubes in the arrangement, although the overall calculation is not yet correct. Based on these results, PA scored 2, indicating that he has only mastered part of the spatial relationship indicator.

Discussion

The test results show that joyful cube learning contributes positively to spatial ability, with an average of 71.32% and a medium category rating. The distribution of categories showed that most students (88.24%) were in the medium category, while 11.76% were in the high category, and none were in the low or very low categories. These findings indicate that manipulative activities such as folding nets, arranging cube models, and manipulating concrete objects can improve students' spatial understanding. Recent research shows that learning with concrete media improves students' spatial abilities and learning activities (Khoiriyani & Suhendra, 2022).

The analysis of each indicator provides a deeper picture of the student's thinking process. On the mind rotation indicator, students in the high category, such as CA, can accurately imagine the rotation of three-dimensional objects without conducting physical experiments. This shows that learning from concrete models can build strong mental representations, enabling students to manipulate objects better mentally (Wathoni, 2024). On the Spatial orientation indicator, students like the PA begin to understand the relationship between the sides, but still experience confusion when the cube changes position. The inconsistency in determining the left and right sides after rotation is consistent with previous research, which confirms that spatial orientation is a complex spatial aspect because it demands an understanding of relative position and simultaneous changes (Khoiriyani & Suhendra, 2022). In the visualization indicator, some students can visualize the cube arrangement, but sometimes still hesitate when the perspective changes. In addition, the spatial perception indicator showed better results, as students were able to understand the arrangement's structure and calculate the number of cubes precisely. The indicator of spatial relations is the most challenging; it is evident in students' mistakes when determining the surface area of a compound cube, even though they have understood that the sides attached are not counted as the outer surface.

Overall, joyful cube learning is effective at strengthening spatial abilities, especially in perception and rotation, although orientation, visualization, and relationships still require more advanced training and visual support.

CONCLUSION

This study shows that students' spatial ability falls in the medium range, with an average of 71.32%, indicating that joyful learning supported by concrete media and interactive activities positively contributes to students' spatial understanding, especially in the indicators of rotation, orientation, and visualization. However, students still experience difficulties in indicators of spatial relationships and perception, especially in identifying hidden structures and solving the problem of building a combined space. These findings imply that the use of concrete media and interactive activities can be considered as alternative strategies to support students' spatial learning.

This research has limitations due to the limited learning time, so not all students have the optimal opportunity to explore and complete the task. This means there are still some students who have difficulty with spatial skills questions as a whole. Given these limitations, further research is recommended over a longer period to optimize the learning process. In addition, the research can examine the application of similar approaches to other mathematics materials or to different educational levels to gain a broader understanding of the development of students' spatial abilities.

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