

The Effect of Teaching Two-Dimensional Shapes Using the Collaborative Learning Method on Students' Spatial Ability

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ABSTRACT

This study aims to analyze the effect of implementing collaborative learning methods on flat-sided three-dimensional shapes on the improvement of students' spatial abilities. The study used a quantitative approach with a quasi-experimental design and a Non-Equivalent Posttest-Only Control Group Design, with a population of eighth-grade students at MTsN 2 Kerinci and an instrument in the form of a spatial ability essay test. The analysis results indicate that the data from both classes are normally distributed, with a P-value of 0.323 for the experimental class and 0.218 for the control class (both > 0.05), and exhibit homogeneous variance based on Levene's test with a P-value of 0.665. A two-tailed t-test revealed a mean difference of 21.73 with a 95% confidence interval ranging from 17.19 to 39.73 and a P-value of 0.000, indicating a significant difference between the two groups. Thus, it can be concluded that collaborative learning on flat-sided three-dimensional shapes is more effective in improving students' spatial abilities compared to direct instruction.

Keywords : Teaching Two-Dimensional, mathematics, collaborative, spatial ability

ABSTRAK

Penelitian ini bertujuan untuk menganalisis pengaruh penerapan metode pembelajaran kolaboratif pada bentuk tiga dimensi sisi datar terhadap peningkatan kemampuan spasial siswa. Penelitian ini menggunakan pendekatan kuantitatif dengan desain kuasi-eksperimental dan Desain Kelompok Kontrol Non-Ekuivalen Pasca-Tes Saja, dengan populasi siswa kelas delapan di MTsN 2 Kerinci dan instrumen berupa tes esai kemampuan spasial. Hasil analisis menunjukkan bahwa data dari kedua kelas terdistribusi normal, dengan nilai P 0,323 untuk kelas eksperimen dan 0,218 untuk kelas kontrol (keduanya > 0,05), dan menunjukkan varians homogen berdasarkan uji Levene dengan nilai P 0,665. Uji t dua arah mengungkapkan perbedaan rata-rata 21,73 dengan interval kepercayaan 95% berkisar antara 17,19 hingga 39,73 dan nilai P 0,000, menunjukkan perbedaan signifikan antara kedua kelompok. Dengan demikian, dapat disimpulkan bahwa pembelajaran kolaboratif pada bangun ruang tiga dimensi dengan sisi datar lebih efektif dalam meningkatkan kemampuan spasial siswa dibandingkan dengan pengajaran langsung.

Kata kunci: Pengajaran Dua Dimensi, matematika, kolaboratif, kemampuan spasial

INTRODUCTION

Mathematics education plays a crucial role in developing students' cognitive and affective abilities (Sari and Oktafia 2024). Mathematics is a required subject at all levels of education, from elementary school through high school and college. Fundamentally, the purpose of mathematics is to help develop students' problem-solving skills, whether in tackling mathematical problems or everyday challenges (Fatimah et al. 2024). The concepts within mathematics have strong and clear interconnections, enabling anyone who studies them to think rationally (Ulandari et al. 2019). One of the main branches of mathematics is geometry, which not only sharpens logical thinking but also plays a role in developing students' spatial reasoning skills (Sundayana and Maryati 2024). One subtopic discussed in geometry is flat-sided three-dimensional shapes, which include cubes, rectangular prisms, prisms, and pyramids. Understanding the concept of flat-sided three-dimensional shapes is not only academically beneficial but

also useful in daily life, such as in design, planning, and problem-solving related to space. However, the reality is that many students still struggle to understand the concept of flat-sided three-dimensional shapes due to limited spatial abilities.

Spatial ability is a fundamental skill that is essential for studying geometry and various other fields involving spatial analysis, such as art, architecture, and engineering (Susilo and Sutarto 2023). Students with strong spatial skills can more easily identify and describe three-dimensional shapes in various positions and orientations, as well as calculate volume and surface area more effectively. However, these spatial skills do not develop automatically; an appropriate teaching approach is needed to enhance them.

Students' difficulties in understanding flat-sided three-dimensional shapes are generally closely related to spatial ability, which is the ability to visualize, manipulate, and understand three-dimensional objects in space (Pratiwi and Budiman 2024). Various studies in

several regions of Indonesia indicate that students' spatial abilities remain relatively low, which impacts their understanding of geometry. Putri (2017) study in East Java revealed that spatial ability has a significant influence on the geometry skills of junior high school students, where students with low spatial ability tend to struggle with solving solid geometry problems. In line with this, Pratiwi and Budiman (2024) in West Java found that students still face challenges in visualizing three-dimensional shapes such as cuboids and cubes, particularly when considering differences in learning styles, which ultimately affect their learning outcomes. Similar findings were also reported by Destiani et al. (2023) in West Sumatra, who stated that students' spatial abilities—among both boys and girls—still need improvement, as many students make errors when solving geometry problems that require spatial visualization and manipulation skills. Furthermore, Farisdianto and Budiarto (2014) in East Java explain that students with low mathematical ability have very limited spatial skills, particularly in performing mental rotations and understanding changes in the positions of three-dimensional shapes, and experience difficulty in viewing objects from different perspectives. This is supported by research by Khofifah, Risalah, and Sandie (2022) in West Kalimantan, which found that students' spatial abilities still vary and tend to be low, particularly among students with low mathematical ability, making it difficult for them to accurately understand relationships between shapes and visual representations. Additionally, Kustiawati, Azzahra, and Satriawati (2023) in Jakarta reported that the average score for students' spatial abilities remains below the proficiency standard, and many students are still unable to understand the relationships between objects and geometric concepts effectively. Based on these findings, it can be concluded that students' spatial abilities in understanding flat-sided three-dimensional shapes remain low, necessitating more effective learning strategies, such as the implementation of collaborative learning methods that actively engage students in the learning process.

Students' low spatial abilities are also evident at MTsN 2 Kerinci. This is evident from observations in the eighth-grade class at MTsN 2 Kerinci, which revealed that most students have not yet been able to fully develop their spatial abilities. This is evident from the students' difficulty when asked to imagine shapes in space, visualize relationships between sides and angles, or reproduce a shape in another form. In addition, many students face obstacles when they have to

explain differences in shapes or determine relationships between elements in three-dimensional figures. These conditions indicate that students' spatial skills remain low, which results in suboptimal conceptual understanding and learning outcomes.

Students' spatial abilities are influenced by various factors, both internal and external. Internal factors include interests, motivation, and learning styles, while external factors include the learning environment and the teaching strategies employed by educators (Afriani, Oktaviana, and Haryadi 2025). One of the most influential external factors is the instructional model used. An instructional model that does not align with the characteristics of the students can hinder the process of understanding spatial concepts and result in low learning outcomes (Sukmarini, Wulandari, and Anjani 2023). (Safari and Aidah 2023) It also states that the selection of an inappropriate learning model results in students becoming passive, less engaged, and struggling to understand the material in depth. Therefore, the implementation of a learning model that aligns with students' needs is essential for improving the quality of instruction and learning outcomes, particularly in mathematics.

To address the issue of students' low spatial abilities at MTsN 2 Kerinci, it is necessary to implement a learning model that aligns with the students' characteristics—one that can enhance student engagement, participation, and collaboration. The learning strategies employed must foster an interactive learning environment and encourage students to help one another and share responsibility in understanding geometric concepts.

One learning model that can address these needs is the collaborative learning model. The collaborative learning model is a method that encourages students to work together in groups, engage in discussions, and provide feedback to one another as they solve problems (Handayani and Sulistiawati 2019). Collaborative learning methods can be applied to the study of flat-sided three-dimensional shapes by giving students the opportunity to work in groups to solve various problems related to these shapes (Azka 2024). In each group, students can discuss ways to visualize three-dimensional shapes, identify their properties, and calculate their volume and surface area. By working together, students can exchange ideas, clarify each other's understanding, and correct any mistakes that may occur. This type of learning is expected to help students develop their spatial skills, as they are directly involved in the process of

understanding and manipulating geometric objects.

In mathematics education, this approach is grounded in the theory of social constructivism proposed by Lev Vygotsky, which emphasizes that knowledge is constructed through social interaction among students. Therefore, in collaborative learning, students do not merely receive information from the teacher but are also actively engaged in discussions, exchanging ideas, and building shared understanding through group work. This approach fosters the development of critical thinking skills, creativity, and deeper mathematical discourse, ensuring that conceptual understanding is not merely rote memorization but the result of meaningful knowledge construction (Khoiriyah 2013). Through the implementation of collaborative learning, students at MTsN 2 Kerinci are expected to become more actively involved in the learning process, support one another, and become better equipped to develop their spatial skills, particularly in understanding the concepts of two-dimensional shapes. Consequently, students' mathematics learning outcomes are expected to improve in line with the learning objectives.

Collaborative learning on the topic of flat-sided three-dimensional shapes is an effective way to improve students' spatial skills. This is because, during the collaborative process, students not only learn individually but also actively interact with their group members to build a shared understanding (Yanuarto and Setyaningsih 2016). Activities such as discussing, drawing models of three-dimensional shapes, and presenting group work can help students develop visual thinking skills and gain a deeper understanding of the relationships between the elements of three-dimensional shapes. As a result, collaboration among students can create a more dynamic and constructive learning environment for developing spatial skills (Haryanti 2022).

Based on an analysis of previous research, collaborative learning generally focuses more on improving learning outcomes, critical thinking skills, and understanding of mathematical concepts, while studies specifically linking it to students' spatial abilities remain limited, particularly regarding flat-sided three-dimensional shapes. Furthermore, research on spatial abilities more frequently employs other approaches, such as problem-based or realistic learning. Therefore, this study offers a novel perspective by directly examining the application of collaborative learning in flat-sided three-dimensional shapes to assess its impact on students' spatial abilities, with an

emphasis on student interaction and the process of constructing understanding.

In line with this, this study aims to examine the effect of learning flat-sided three-dimensional shapes using the collaborative learning method on the improvement of students' spatial abilities. Through this study, it is hoped that a contribution can be made toward improving students' spatial abilities in mathematics, particularly regarding flat-sided three-dimensional shapes, in Grade VIII at MTsN 2 Kerinci.

METHOD

This study employs a quantitative approach using a quasi-experimental design. According to (Sugiyono 2017) Quasi-experimental methods are used when researchers are unable to strictly control all external variables that influence the course of the experiment, allowing the study to still reveal cause-and-effect relationships even though it does not fully meet the criteria of a pure experiment. The research design used is the Non-Equivalent Posttest-Only Control Group Design, which involves two groups: an experimental group that receives instruction using collaborative learning methods, and a control group that participates in traditional classroom instruction. In line with this (Sundayana 2020) explains that this design is suitable for use in an educational context because it allows researchers to compare learning outcomes between two groups without having to conduct a full randomization, while still providing an indication of the effectiveness of the intervention. To assess mathematics learning outcomes, both groups were given a posttest. The research design is shown in Table 1.

Table 1. Non-Equivalent Posttest-Only Control Group Design

Class	Treatment	Post Test
Experimen	X	O
Control	-	O

Sumber : (Sugiyono 2017)

Explanation:

- X : Collaborative learning method
- : Direct instruction model
- O : Final test (Posttest)

The study population comprised all eighth-grade students at MTsN 2 Kerinci for the 2024/2025 academic year, consisting of five parallel classes, namely classes VIII A through VIII E. Sampling was conducted using simple random sampling, which involves selecting samples at random from the population without considering specific strata, ensuring that each class had an equal chance of being selected.

Prior to sampling, data prerequisite tests were conducted, including a normality test, a test of homogeneity of variance, and a test of equality of means to ensure that the population met the basic assumptions of the analysis. The normality test was performed using the Anderson-Darling test with the assistance of Minitab software. The analysis results showed that all population classes had P-values greater than 0.05, indicating that the data were normally distributed. Next, a test of homogeneity of variance was performed using Bartlett's test, yielding a P-value of 0.665—which is greater than the significance level of 0.05. This indicates that the population variances are homogeneous. Subsequently, a test for equality of means was performed using the t-test, yielding a P-value of 0.000, which is also greater than 0.05. Thus, it can be concluded that the populations have equal means, are normally distributed, and are homogeneous. Therefore, sampling was conducted using simple random sampling, and based on the results of the draw, Class VIII B was selected as the experimental group and Class VIII C as the control group. The experimental group received instruction using the collaborative learning method, while the control group participated in direct instruction without any special approach.

The instrument used in this study was a spatial ability test in the form of a written test consisting of 5 questions on the topic of flat-sided three-dimensional shapes. This spatial ability test was administered as a posttest to both the experimental and control classes to determine differences in students' spatial abilities between the class taught using the collaborative learning method and the class taught using the direct instruction model. After the learning process was completed and the data collected, prerequisite tests for analysis were conducted, including tests of normality, homogeneity, and equality of means, to ensure the data met the requirements for statistical analysis. The test instrument was developed by the researcher and tailored to the research objectives to measure students' spatial abilities. Subsequently, the instrument was pilot-tested in one class to assess the quality of the test items. The pilot test results were analyzed through validity, reliability, difficulty level, and item discrimination tests, thereby confirming that the instrument used was appropriate and relevant.

Item validity analysis was conducted by correlating the score of each item with the total score. This correlation was used to determine the extent to which each item was able to measure the same ability as the test as a whole.

In this study, validity testing was conducted using Pearson's product-moment correlation (Masullah, Zuhry, and Usman 2024). Next, the distribution of the table r-value is determined at a significance level of $\alpha = 5$ with degrees of freedom ($df = n - 2$). The decision criterion is that if $r_{calc} \geq r_{table}$, the item is deemed valid; conversely, if $r_{calc} < r_{table}$, the item is deemed invalid.

Based on the results of the item validity test, all test items were found to be valid. This is indicated by the calculated r values for each item, which meet the validity criteria with a table r of 2.13. Specifically, Item 1 has a calculated r value of 0.65, Item 2 of 0.66, Item 3 of 0.85, Item 4 of 0.65, and Item 5 of 0.58. Thus, all five items meet the established criteria and are suitable for use as research instruments.

Next, after all test items were deemed valid, a reliability test was conducted to determine the instrument's level of consistency. The reliability test was conducted to determine whether the test is reliable and provides consistent results in measuring the same ability. In this study, the reliability coefficient was calculated using the Alpha formula proposed by Arikunto (2014), which involves the number of test items, the variance of each item, and the total variance. The results of the reliability coefficient calculation were then interpreted based on specific criteria: if the value of r_{11} falls within the range $0.80 < r_{11} \leq 1.00$, it is categorized as very high; $0.60 < r_{11} \leq 0.80$ is high, $0.40 < r_{11} \leq 0.60$ is moderate, $0.20 < r_{11} \leq 0.40$ is low, and $0.00 < r_{11} \leq 0.20$ is very low (Sundayana 2020).

Based on the results of the reliability test conducted, a reliability coefficient of 0.69 was obtained, classified as high. This value indicates that the test instrument used in this study has a good level of consistency. This means that the instrument is sufficiently reliable in measuring the ability under study and can provide relatively consistent results when used under similar conditions. Thus, the test instrument is suitable for use as a data collection tool in this study.

After the instrument was declared valid and reliable, a difficulty index analysis was conducted to determine the difficulty level of each test item. The difficulty level indicates whether a question is classified as easy, moderate, or difficult, thereby determining the suitability of the question in measuring students' abilities.

The difficulty index results were then interpreted based on the following criteria: values where $0.00 < I_k \leq 0.30$ were classified as difficult, $0.30 < I_k \leq 0.70$ as moderate, and $0.70 < I_k \leq 1.00$ as easy (Masullah et al. 2024)

Good test items generally fall into the moderate difficulty category because they are able to measure students' abilities more effectively. Consequently, this analysis serves as a benchmark for evaluating the quality of test items.

Based on the results of the item difficulty level test, it was found that most test items fall into the moderate category. Item 1 has a difficulty index of 0.65 with a moderate criterion, item 3 of 0.41 with a moderate criterion, item 4 of 0.59 with a moderate criterion, and item 5 of 0.43 with a moderate criterion. Meanwhile, Item 2 has a difficulty index of 0.24, meeting the difficult criterion. These results indicate that, overall, the test items used in this study have a proportional difficulty level, with a predominance of the moderate category, making them suitable for measuring students' abilities.

After conducting the difficulty index analysis, the next step is to analyze the discriminative power to determine the ability of the test items to distinguish between high- and low-ability students. Discriminative power indicates the extent to which a question can identify differences in student ability. This analysis was conducted by dividing the students into two groups, namely the high-performing group and the low-performing group, and then comparing the results of these two groups.

The results of the discrimination index calculations were then interpreted based on the following criteria: a discrimination index (DP) ≤

0 was categorized as very poor, $0.00 < DP \leq 0.20$ as poor, $0.20 < DP \leq 0.40$ as adequate, $0.40 < DP \leq 0.70$ as good, and $0.70 < DP \leq 1.00$ as very good. Thus, the discriminant power analysis was used as a reference in determining the quality of test items in the study.

Based on the results of the item discrimination index test, it was found that the test items vary in their ability to distinguish between high- and low-ability students. Item 1 has a discrimination index of 0.33, interpreted as adequate; Item 2 has an index of 0.29, interpreted as adequate; and Item 4 has an index of 0.25, interpreted as adequate. Meanwhile, Item 3 had a discrimination index of 0.50, interpreted as good, and Item 5 had an index of 0.42, also interpreted as good. These results indicate that most test items fall into the adequate to good categories, meaning that, in general, these items are capable of distinguishing students' abilities and are suitable for use in the study.

RESULT AND DISCUSSION

Data on students' spatial ability test scores were obtained through the administration of a final test to both sample groups. The test was an essay-type assessment consisting of 5 items. A total of 36 students took the test, including 19 students from the experimental class and 17 students from the control class. The results of the final test for both groups are presented in the following table.

Tabel 2. Daftar Populasi dan Sampel Penelitian

Class	N	\bar{X}	S	X_{max}	X_{min}	P-Value
Experimen	19	74,7	15,8	100	46,7	0,323
Control	17	46,3	17,2	80	26,7	0,218

Based on the data in Table 2, the mean spatial ability test score for students in the experimental class was 74.7 with a standard deviation of 15.8. The highest score obtained by students in the experimental class was 100, while the lowest was 46.7. Meanwhile, in the control class, the average spatial ability of students was 46.3 with a standard deviation of 17.2, the highest score was 80, and the lowest score was 26.7. These results indicate a difference in spatial ability between students who participated in collaborative learning in the experimental class and students in the control class.

The normality test yielded a P-value of 0.323 for the experimental group and 0.218 for the control group. Since the P-value is greater than 0.05, it can be concluded that the data

from both groups are normally distributed. The results of the test for homogeneity of variances (Levene's Test) showed a P-value of 0.665, indicating that the two groups have homogeneous variances. These conditions meet the requirements for conducting a t-test.

The results of the two-tailed t-test indicate a mean difference of 21.73 with a 95% confidence interval ranging from 17.19 to 39.73. The P-value is 0.000, indicating a significant difference between the experimental and control classes. Thus, the

Implementation of flat-sided three-dimensional shape learning using the collaborative learning method has a significant effect on improving students' spatial abilities. This difference indicates that collaborative

learning provides opportunities for students to discuss, help one another, and build a shared understanding of flat-sided three-dimensional shape concepts, thereby positively impacting student learning outcomes. The following is a breakdown of the spatial ability test results by indicator:

a. Describing the relationships between the elements of a three-dimensional shape.

The first indicator measures students' ability to describe the relationships between the elements of a three-dimensional shape. Assessment is conducted through questions that ask students to observe a diagram of a three-dimensional shape and identify the relationships between points, lines, and planes. Students' spatial skills are assessed based on their accuracy in describing the positions and relationships between elements, such as parallel, intersecting, or perpendicular.

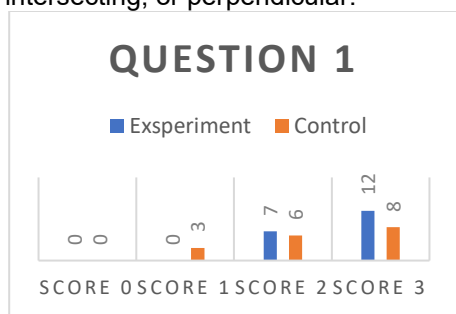


Figure 1. Distribution of scores for Indicator 1

Based on Figure 1, most students in both groups scored a 3. There were 12 students in the experimental group and 8 students in the control group. A score of 2 was obtained by 7 students in the experimental group and 6 students in the control group, while a score of 1 was found only in the control group, with 3 students. No students scored 0. These results indicate that the students' ability to describe the relationships between the elements of three-dimensional shapes is relatively good, with the experimental group performing better, suggesting that collaborative learning has a positive impact.

b. Visualizing and describing the shape or position of a geometric object as seen from a specific viewpoint.

The second indicator assesses students' ability to visualize and describe the shape and position of geometric objects

from a specific perspective. Assessment is conducted through contextual problems that require students to visualize modified three-dimensional shapes and then represent them in the form of drawings and mathematical models. Spatial ability is assessed based on students' accuracy in visualizing changes in shape and determining the precise positions of the shape's parts.

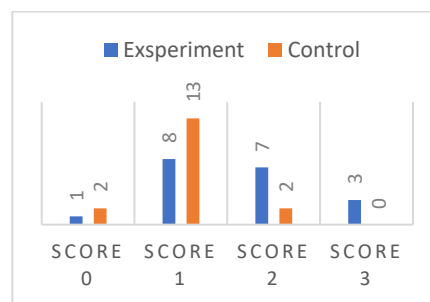


Figure 2. Distribution of scores for Indicator 2, Question 2

Based on Figure 2, three students in the experimental group achieved a score of 3, while none in the control group did. For a score of 2, there were seven students in the experimental group and two in the control group. These results indicate that students in the experimental group were better able to accurately determine the positions and relationships between the elements of three-dimensional shapes. These findings indicate that collaborative learning has a positive impact on improving spatial ability through discussion and the exchange of ideas.

c. Explain and present geometric models drawn on a flat surface in a spatial context.

The third indicator focuses on students' ability to construct and present geometric models on a flat surface within a spatial context. Assessment is conducted through contextual problems that require students to understand the relationship between real-world measurements and models, and to represent them in mathematical calculations. Spatial ability is assessed based on students' accuracy in presenting shapes and sizes proportionally through the concepts of scale and volume.

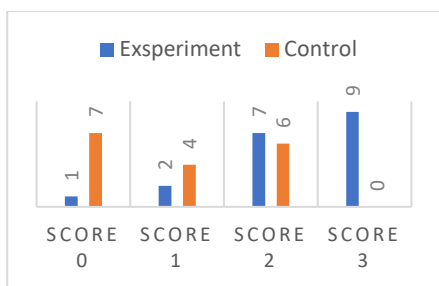


Figure 3. Distribution of scores for Indicator 3

Based on Figure 3, nine students in the experimental group achieved a score of 3, while none in the control group did. For a score of 2, there were seven students in the experimental group and six in the control group. These results indicate that students in the experimental group demonstrated better ability to visualize the shape and position of three-dimensional figures from a specific perspective. This finding suggests that.

collaborative learning has a positive impact on enhancing spatial visualization skills through group discussions.

d. Investigating the actual size of the visual stimulus of a geometric object.

The fourth indicator assesses students' ability to determine the actual size of a geometric object based on visual cues. Assessment is conducted through contextual problems that require students to interpret two-dimensional representations, such as sketches and nets, and then relate them to three-dimensional shapes. Spatial ability is assessed based on students' accuracy in determining the size and relationships between elements of three-dimensional shapes in a logical and systematic manner

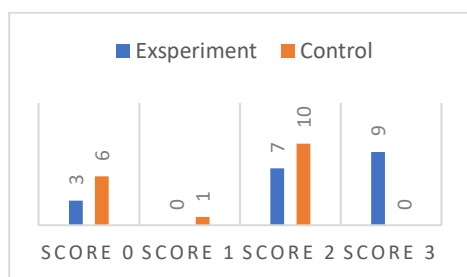


Figure 4. Distribution of scores for Indicator 4, Question 4

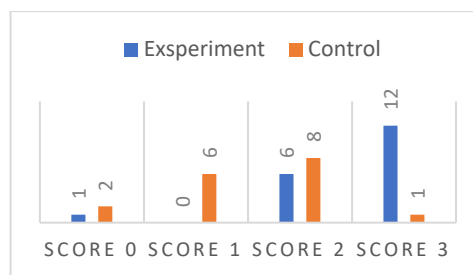


Figure 5. Distribution of Scores for Indicator 4, Question 5

Referring to Figures 4 and 5, students in the experimental group tended to score higher than those in the control group on questions 4 and 5. On question 4, 9 students in the experimental group scored a 3, whereas none in the control group did, and most scored a 2. On question 5, the experimental group again showed better results with 12 students achieving a score of 3, while in the control group only 1 student achieved that score and the majority scored 2 and 1. These results indicate that students in the experimental group have better abilities in constructing and presenting geometric models. These findings indicate that collaborative learning has a positive impact on improving the ability to visualize and present concepts systematically.

The results of data analysis using a two-tailed t-test indicate that there is a difference in spatial ability between eighth-grade students at MTsN 2 Kerinci in the 2024/2025 academic year who learned using the collaborative learning method and those who used the direct instruction model. The test was conducted with the hypotheses $H_0: \mu_1 = \mu_2$ and $H_1: \mu_1 \neq \mu_2$. Based on the calculation results, a P-value of $0.000 < 0.05$ was obtained, so H_0 was rejected. The average spatial ability of students learning through the collaborative learning method was higher by a margin of 21.73 compared to those in the direct instruction group. These findings indicate that the collaborative learning method has a significant effect on students' spatial ability.

These differences in outcomes are influenced by the characteristics of collaborative learning, which positions students as active participants in the learning process. Through group discussions, the exchange of ideas, and collaborative problem-solving activities, students not only receive information from the teacher but also build understanding through interaction and cooperation. This process allows students to help one another visualize three-dimensional shapes, connect concepts to real-world experiences, and correct

misunderstandings through feedback from their peers. Thus, this participatory learning fosters a deeper conceptual understanding while enhancing students' spatial visualization skills.

This aligns with Jerome Bruner's theory, which states that learning is an active process in which students construct their own knowledge through interaction with their environment and others. Bruner also emphasizes the importance of discovery learning as well as the enactive, iconic, and symbolic stages in understanding concepts (Fauziati 2021). In relation to spatial ability, these stages of representation—particularly the iconic and symbolic stages—play a crucial role because they involve the use of visualization, images, and abstract representations that help students understand spatial concepts more deeply (Soraya, Utami, and Nirawati 2021). Therefore, learning that involves visual activities and interaction, such as collaborative learning, holds great potential for enhancing students' spatial abilities.

Furthermore, through discussions and group work, students can share visual representations with one another, build a shared understanding, and develop the ability to visualize spatial objects more effectively. In contrast, in the control class, which used a direct instruction model, the learning process tended to be teacher-centered, resulting in students becoming more passive and facing limitations in constructing knowledge independently. Consequently, student learning outcomes in the experimental class, which implemented collaborative learning, were higher than those in the control class.

The improvement in spatial ability among the experimental group can also be explained by the key characteristics of collaborative learning itself. In this method, students do not merely passively receive material but actively participate in group discussions, exchange ideas, and help one another understand spatial concepts. This social interaction process enables students to construct knowledge collaboratively and develop visualization and manipulation skills for three-dimensional shapes, thereby making the learning process more effective, meaningful, and student-centered.

Furthermore, this study employs indicators of students' spatial abilities that focus on several key aspects: the ability to describe the relative positions of elements within a three-dimensional figure; to visualize and describe the shape or position of a geometric object as viewed from a specific perspective; to investigate the actual dimensions of a geometric object's visual stimulus; and to

construct and present geometric models drawn on a flat surface within a spatial context (Harahap 2020). Through the application of these indicators, students are encouraged to be more active in observing, visualizing, and representing geometric objects both mentally and in writing, enabling them to gain a deeper understanding of three-dimensional shapes. Thus, the implementation of collaborative learning not only improves mathematics learning outcomes but also develops visualization, representation, and spatial understanding skills, which form the core of students' overall spatial abilities.

Thus, the results of this study reinforce previous theories and findings that the implementation of collaborative learning methods has a significant effect on students' spatial abilities. Collaboration among students facilitates the exchange of information, enhances visual thinking skills, and fosters a deeper conceptual understanding. Therefore, the implementation of collaborative learning methods in the Flat-Sided Three-Dimensional Shapes curriculum has proven effective in helping students better understand the shape, size, and position of objects in space compared to direct instruction models, which tend to be one-sided.

This finding is consistent with the view that Salam (2010) which states that discussion is a form of exchanging information and opinions to achieve a shared understanding. In the context of learning about flat-sided three-dimensional shapes, collaborative discussion activities help students connect the concepts of three-dimensional shapes, surface area, and volume through group interaction and cooperation. Through the process of exchanging ideas and solving problems together, students become more active in building conceptual understanding and improving their spatial skills.

In line with that Marlina (2013) explains that collaborative learning can improve learning outcomes because each group member has a positive interdependence and a sense of responsibility toward shared achievements. This encourages students to help one another and ensure that all members understand the material being studied. Thus, the cooperation fostered within the group not only strengthens social skills but also fosters students' motivation to learn and their cognitive engagement in understanding the concepts of plane figures.

Furthermore, the results of this study are also supported by the findings Putri and Fauzi (2025) which shows that students' spatial abilities improve significantly when they learn through collaborative activities that involve the

concrete visualization of geometric shapes. These activities enable students to build stronger mental representations of shapes and the relationships between the elements of three-dimensional figures. In other words, the combination of group collaboration, active discussion, and visual learning experiences makes collaborative learning methods effective in improving students' spatial abilities and mathematics learning outcomes.

CONCLUSION

Based on the research findings, it can be concluded that the implementation of collaborative learning methods in the study of flat-sided three-dimensional shapes has a significant effect on improving the spatial abilities of eighth-grade students at MTsN 2 Kerinci; thus, the research objective of determining the effect of collaborative learning on students' spatial abilities has been achieved. This is evident from the difference in learning outcomes between the experimental and control classes, where students who learned through collaboration demonstrated better visualization skills, conceptual understanding, and spatial representation compared to students who learned through direct instruction. Nevertheless, this study has several limitations, including a sample size limited to a single school, the use of a quasi-experimental design without full randomization, and the measurement of spatial ability using only one type of test instrument, so the research results cannot yet be generalized widely. Therefore, it is recommended that future researchers expand the number and variety of samples, use a stronger research design, and develop more diverse instruments to obtain more comprehensive results.

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