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Mathematical Problem-Solving Cooperative Learning (MPSCL): Enhancing Geometry Problem-Solving Ability among Santri in an Islamic Boarding School

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ABSTRACT: This study examined the effectiveness of Mathematical Problem-Solving Cooperative Learning (MPSCL) in enhancing the geometry problem-solving ability of santri in an Islamic boarding school, particularly on the topics of circle circumference and circle area. A quantitative approach was employed using a one-group pretest-posttest pre-experimental design. The participants were 15 ninth-grade santri from MTs Darul Hikmah Mumbulsari, an Islamic junior secondary school, selected through purposive sampling. The research instruments consisted of a geometry problem-solving test, a santri response questionnaire, and observation sheets assessing learning implementation and santri activities. Data were analyzed using descriptive and inferential statistics, including the Shapiro–Wilk normality test, paired-samples t-test, N-gain analysis, and effect size analysis (Cohen's d). The findings revealed a significant improvement in the geometry problem-solving ability of the santri following the implementation of MPSCL. The paired-samples t-test yielded a significance value of 0.000 ($p < .05$), indicating a statistically significant difference between the pretest and posttest scores. The average N-gain scores were 0.466 for circle circumference and 0.552 for circle area, both categorized as moderate. Furthermore, Cohen's d values of 2.541 and 4.445 indicated strong practical effects. The santri also demonstrated highly positive responses toward the learning process, while the implementation of learning activities and santri participation were categorized as very good. These findings suggest that MPSCL is an effective instructional approach for enhancing geometry problem-solving ability among santri and supporting meaningful mathematics learning in Islamic boarding school settings.

KEYWORDS: Cooperative Learning, Geometry Problem-Solving Ability, Mathematical Problem-Solving Cooperative Learning (MPSCL), Santri, Islamic Boarding School.

INTRODUCTION

Mathematics is a fundamental discipline that plays an important role in developing students' thinking abilities, including reasoning, communication, and problem-solving skills. Among these competencies, problem-solving ability occupies a central position because it enables learners to apply their knowledge to address a wide range of problems in both academic and real-life contexts. Therefore, the development of problem-solving ability has become one of the primary goals of mathematics education.

The National Council of Teachers of Mathematics (NCTM) identifies problem solving as one of the five process standards that should be developed in mathematics learning, alongside communication, reasoning, connections, and representation (Hafriani, 2021). Conceptually, mathematical problem-solving ability involves a series of activities, including understanding a problem, determining goals, planning solution strategies, implementing strategies, adapting strategies to changing situations, and reviewing the obtained solution (Annizar et al., 2025; Arta et al., 2020). These abilities contribute to the development of students' critical, analytical, and reflective thinking skills (Susino et al., 2024).

Despite its importance, the mathematical problem-solving ability of Indonesian students remains relatively low. Results from the Programme for International Student Assessment (PISA) 2022 indicate that most Indonesian students are still performing at basic proficiency levels and have not yet demonstrated an optimal ability to solve complex mathematical problems. Indonesia's mathematics literacy score of 379 also remains below the international average score of 400 (OECD, 2023). These findings suggest that many students continue to experience difficulties in solving non-routine problems that require diverse reasoning processes and solution strategies.

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One area of mathematics that requires strong problem-solving ability is geometry. Geometry demands not only conceptual understanding but also visualization, reasoning, and the application of concepts in various situations. In practice, many students encounter difficulties in understanding geometric concepts, selecting appropriate solution strategies, and solving contextual problems involving both plane and solid geometric figures.

These difficulties are influenced by various factors related to both learners and instructional practices. Hanan and Alim (2023) argued that students' limited abilities and the instructional methods employed by teachers significantly affect success in learning geometry. Furthermore, Novainda and Turmudi (2021) identified ontogenic, didactic, and epistemological learning obstacles as major barriers that hinder students' understanding and application of geometric concepts.

The problem is further exacerbated by instructional practices that remain predominantly teacher-centered. In such learning environments, students often function as passive recipients of information, limiting opportunities to develop critical thinking and problem-solving abilities. According to Slavin (2015), active student engagement is a crucial factor in improving both conceptual understanding and learning outcomes.

Various instructional models have been developed to improve mathematical problem-solving ability, including Problem-Based Learning (PBL), Jigsaw cooperative learning, Think-Pair-Share (TPS), and other problem-solving approaches. Previous studies have shown that these models can enhance problem-solving ability through active student participation and collaborative learning activities.

However, most previous studies have examined cooperative learning and problem-solving approaches separately. Empirical evidence regarding instructional models that systematically integrate individual and collaborative problem-solving activities within a single instructional framework remains limited. In addition, studies specifically examining the effectiveness of Mathematical Problem-Solving Cooperative Learning (MPSCL) in geometry learning within Islamic school settings are still scarce. Given that geometry requires substantial reasoning and problem-solving skills, it provides an appropriate context for examining the effectiveness of this model.

In the Indonesian educational context, santri refers to students who study in an Islamic boarding school (pesantren). MPSCL is an instructional model that integrates problem-solving and cooperative learning approaches. The model was developed to facilitate students in constructing solution strategies individually while simultaneously developing understanding through social interaction and group discussion. MPSCL consists of nine instructional stages: (1) communicating objectives, motivating students, and presenting the material; (2) providing information about the problem-solving process; (3) presenting a problem; (4) conducting individual problem solving; (5) forming groups; (6) conducting group problem solving; (7) evaluating solutions; (8) reporting solutions; and (9) providing recognition or rewards (Annizar, 2026).

Furthermore, MPSCL accommodates six major problem-solving activities: understanding the problem, determining goals based on the required conditions, planning a solution, implementing the plan, adapting the plan to changing situations, and reviewing the obtained solution (Annizar et al., 2025). Through the integration of individual and collaborative activities, students are expected to develop their problem-solving ability in a more systematic and meaningful manner.

Based on the foregoing discussion, further empirical evidence is needed regarding the effectiveness of MPSCL in enhancing students' geometry problem-solving ability. Therefore, this study aimed to examine the effectiveness of MPSCL in enhancing the geometry problem-solving ability of santri on the topics of circle circumference and circle area.

RESEARCH METHODS

This study employed a quantitative approach using a pre-experimental research design. Specifically, a one-group pretest-posttest design was used, involving a single group of participants who completed a pretest before the intervention and a posttest after the intervention. This design was intended to identify changes in the geometry problem-solving ability of santri following the implementation of MPSCL.

The study was conducted at MTs Darul Hikmah Mumbulsari, Jember Regency, Indonesia. The participants consisted of 15 ninth-grade santri selected through purposive sampling based on their suitability to the objectives of the study. The research instruments included: (1) a geometry problem-solving test, (2) a santri response questionnaire regarding the implementation of MPSCL, (3) a learning implementation observation sheet, and (4) a santri activity observation sheet. The problem-solving test was developed based on the six problem-solving indicators proposed by Annizar et al. (2025): (1) understanding the problem, (2)

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determining goals based on required conditions, (3) planning a solution, (4) implementing the plan, (5) adapting the plan to changing situations, and (6) reviewing the obtained solution.

Prior to data collection, all instruments were validated by experts. Instrument validity was determined using the average score assigned by the validators and classified according to the criteria presented in Table 1. Instruments were considered suitable for use when they achieved at least the valid category.

The practicality of MPSCL was evaluated through observations of learning implementation and santri activities. Practicality percentages were calculated by comparing the obtained scores with the maximum possible scores and subsequently classified according to the criteria presented in Table 2. The model was considered practical when it achieved at least the good category.

Santri responses to the implementation of MPSCL were analyzed using questionnaire data collected after the completion of all learning activities. The responses were converted into percentages and classified according to the criteria presented in Table 3. Responses were considered positive when they achieved at least the positive category.

The effectiveness of MPSCL was evaluated through improvements in santri's geometry problem-solving ability using N-gain and effect size analyses. N-gain analysis was used to determine the level of improvement based on pretest and posttest scores according to the criteria presented in Table 4. Subsequently, effect size was calculated using Cohen's d to determine the magnitude of the effect of MPSCL on santri's geometry problem-solving ability. The interpretation of Cohen's d values followed the criteria presented in Table 5.

Data analysis was conducted using IBM SPSS Statistics 26. Descriptive statistics were used to summarize the data, including the mean, median, standard deviation, minimum score, and maximum score. Prior to hypothesis testing, the data were examined for normality using the Shapiro–Wilk test with a significance level of .05. Once the normality assumption was satisfied, hypothesis testing was conducted using a paired-samples t-test to determine whether there were significant differences in santri's geometry problem-solving ability before and after the implementation of MPSCL.

The hypotheses tested in this study were as follows:
H_0: There is no significant difference in santri's geometry problem-solving ability before and after the implementation of MPSCL.
H_1: There is a significant difference in santri's geometry problem-solving ability before and after the implementation of MPSCL.

The decision was based on the significance value (Sig. 2-tailed). H_0 was rejected when the significance value was less than .05 and accepted when the significance value was greater than .05.

1. Instrument Validity Analysis

Instrument validity analysis was conducted based on the average scores assigned by expert validators to each research instrument. The obtained validity scores were then classified according to the instrument validity criteria presented in Table 1. An instrument was considered suitable for use in the study if it achieved at least the valid category.

Table 1. Instrument Validity Criteria

Validity Score (Va)	Validity Level
$1 \leq V_a < 2$	Invalid
$2 \leq V_a < 3$	Less Valid
$3 \leq V_a < 4$	Valid
$V_a = 4$	Highly Valid

2. Analysis of the Practicality of the Instructional Model

The practicality of MPSCL was analyzed based on observations of learning implementation and santri activities throughout the learning process. The practicality level was determined by calculating the percentage of the obtained score relative to the maximum possible score. The criteria for the practicality percentage of the instructional model are presented in Table 2. The instructional model was considered practical if it achieved at least the good category.

Table 2. Practicality Percentage Criteria of the Instructional Model

Score	Criteria
$90\% \leq P_s < 100\%$	Very Good
$80\% \leq P_s < 90\%$	Good
$65\% \leq P_s < 80\%$	Fair
$40\% \leq P_s < 60\ \%$	Poor
$0\% \leq P_s < 40\ \%$	Very Poor

3. Analysis of Santri Responses

The analysis of santri responses was conducted to identify their perceptions of the implementation of the MPSCL model during the learning process. The data were collected through a response questionnaire administered after all learning activities had been completed. The categories of santri responses are presented in Table 3. Santri responses were considered positive if they achieved at least the positive category.

Table 3. Categories of Santri Responses

Percentage Score (RS)	Category
$85\% \leq$ RS	Very Positive
$70\% \leq$ RS $< 85\%$	Positive
$50\% \leq$ RS $< 70\%$	Less Positive
RS $< 50\%$	Not Positive

4. N-Gain Analysis

N-Gain analysis was conducted to determine the level of improvement in santri's geometry problem-solving ability after participating in learning activities using the MPSCL model. The N-Gain score was calculated based on the difference between the pretest and posttest scores. The classification criteria used in this study are presented in Table 4.

Table 4. Categories of Improvement in Problem-Solving Ability

N-Gain Score (g)	Category
$g > 0{,}7$	High
$0{,}3 < g \leq 0{,}7$	Moderate
$g \leq 0{,}3$	Low

5. Effect Size Analysis

In addition to measuring the level of improvement through N-Gain analysis, this study employed effect size analysis to determine the magnitude of the effect of the MPSCL model on santri's geometry problem-solving ability. The effect size was calculated using Cohen's *d* and interpreted according to the criteria presented in Table 5.

Table 5. Categories of Cohen's *d* Values

Cohen's *d* Score	Category
$g > 0{,}8$	Large
$0{,}5 < d \leq 0{,}8$	Moderate
$d \leq 0{,}5$	Small

All data were analyzed using IBM SPSS Statistics 26 with a significance level of 0.05. Descriptive statistics were used to summarize the data, including the mean, median, standard deviation, minimum score, and maximum score. Prior to hypothesis testing, the normality of the data was examined using the Shapiro–Wilk test. If the data met the normality assumption, hypothesis

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testing was conducted using a paired-samples *t*-test to determine whether there was a significant difference in santri's geometry problem-solving ability before and after the implementation of the MPSCL model.

The hypotheses tested in this study were as follows:

H_0: There is no significant difference in santri's geometry problem-solving ability before and after the implementation of the MPSCL model.

H_1: There is a significant difference in santri's geometry problem-solving ability before and after the implementation of the MPSCL model.

The decision criterion was based on the significance value (*p*-value, two-tailed). H_0 was rejected if the significance value was less than 0.05, whereas H_0 was accepted if the significance value was greater than or equal to 0.05.

RESULTS AND DISCUSSION

Results

This section presents the findings of the study on the effect of the MPSCL model on santri's geometry problem-solving ability in the topics of circle circumference and circle area. The data were analyzed using both descriptive and inferential statistics. Descriptive statistics were employed to describe the characteristics of the data, whereas inferential statistics were used to test the research hypotheses.

Descriptive Statistical Analysis

Descriptive statistical analysis was conducted to describe the characteristics of the pretest and posttest scores of santri's geometry problem-solving ability on the topics of circle circumference and circle area. The statistics analyzed included the number of participants, mean, median, maximum score, minimum score, and standard deviation. The results for the circle circumference topic are presented in Table 6.

Table 6. Pretest and Posttest Scores on Circle Circumference

No.	Statistic	Pretest	Posttest
1	N	15	15
2	Mean	52,13	74,00
3	Median	53	72
4	Maximum Score	58	94
5	Minimum Score	47	56
6	Standard Deviation	3,16	11,75

Table 6 shows that the mean pretest score on the circle circumference topic was 52.13, with a minimum score of 47 and a maximum score of 58. Following the implementation of the MPSCL model, the mean posttest score increased to 74.00, while the minimum and maximum scores increased to 56 and 94, respectively. These findings indicate an improvement in santri's geometry problem-solving ability on the circle circumference topic after participating in learning activities using the MPSCL model.

Table 7. Pretest and Posttest Scores on Circle Area

No.	Statistic	Pretest	Posttest
1	N	15	15
2	Mean	40.00	73,27
3	Median	39	75
4	Maximum Score	53	89
5	Minimum Score	33	55
6	Standard Deviation	5,57	8,97

The descriptive statistics presented in Tables 6 and 7 indicate a consistent improvement in santri's geometry problem-solving ability following the implementation of the MPSCL model. For the circle circumference topic, the mean score increased from 52.13 on the pretest to 74.00 on the posttest, while the minimum and maximum scores increased from 47 and 58 to 56 and 94, respectively. Similarly, for the circle area topic, the mean score increased substantially from 40.00 to 73.27, accompanied by an increase in the minimum score from 33 to 55 and the maximum score from 53 to 89. These findings suggest that santri demonstrated better performance across both topics after participating in learning activities based on the MPSCL model.

The observed improvement was not limited to average achievement but was also reflected in the broader distribution of scores. The increase in both minimum and maximum scores indicates that gains were experienced by santri with different initial ability levels. Although the posttest standard deviations were higher than those of the pretest, suggesting greater variation in performance after the intervention, the overall pattern of results demonstrates a positive shift in geometry problem-solving ability. This trend implies that most santri benefited from the learning process, although the magnitude of improvement varied among individuals.

The descriptive findings provide preliminary evidence that the MPSCL model contributed positively to the development of geometry problem-solving ability. Through the integration of individual problem-solving activities and collaborative discussions, santri were encouraged to actively engage with mathematical ideas, evaluate alternative solution strategies, and refine their understanding of geometric concepts. To complement these findings, additional data were collected through santri response questionnaires, classroom implementation observations, and activity observations to provide a more comprehensive evaluation of the effectiveness of the MPSCL model.

Analysis of Santri Responses

Santri responses to the implementation of the MPSCL model were collected through a questionnaire administered after all learning activities had been completed. The results of the response analysis are presented in Table 8.

Table 8. Santri Responses to the Implementation of the MPSCL Model

No.	Statistic	Value
1	Number of Respondents	15
2	Number of Items	17
3	Mean Score	3,42
4	Mean Percentage	85,49
5	Category	Very Positive

Based on Table 8, the mean santri response score was 3.42, with a mean percentage of 85.49%, which falls within the very positive category. These findings indicate that santri responded favorably to the implementation of the MPSCL model during mathematics learning activities. The high response score suggests that the learning experiences provided through the model were perceived as beneficial, engaging, and relevant to the learning needs of the participants.

The positive responses further indicate that the MPSCL model was able to create a learning environment that encouraged active participation throughout the problem-solving process. Through individual problem-solving activities followed by collaborative group discussions, santri were given opportunities to exchange ideas, compare solution strategies, and clarify mathematical concepts. Such learning experiences may contribute not only to improved understanding of geometry concepts but also to increased confidence in solving mathematical problems.

In addition, the favorable perception of the model suggests that the integration of problem-solving and cooperative learning was well accepted by santri in the context of an Islamic boarding school. Santri reported that the learning activities helped them understand mathematical concepts more effectively, engage productively with their peers, and develop problem-solving strategies in a more systematic manner. These findings indicate that the MPSCL model not only supports the development of geometry problem-solving ability but also promotes a positive learning experience that may enhance student motivation and participation in mathematics learning.

Analysis of Learning Implementation

The implementation of the MPSCL model was observed by two observers to evaluate the extent to which the learning activities were carried out in accordance with the planned instructional syntax. The results of the classroom implementation observations are presented in Table 9.

Table 9. Observation Results of MPSCL Implementation

No.	Meeting	Mean Score	Mean Percentage
1	Meeting 1: Circle Circumference	3,75	94
2	Meeting 2: Circle Area	3,93	98

As shown in Table 9, the mean implementation score in the first meeting was 3.75, corresponding to 94%, while the second meeting achieved a mean score of 3.93, corresponding to 98%. Both results fall within the very good category. The increase in the implementation score from the first to the second meeting suggests that the instructional procedures were carried out consistently and became more effective as the learning process progressed.

These findings indicate that all stages of the MPSCL model were implemented effectively and in accordance with the planned instructional procedures. The high implementation scores demonstrate strong implementation fidelity, indicating that the learning activities closely followed the intended instructional design. This is important because the effectiveness of an instructional model is often influenced by the extent to which its key components are implemented as designed.

Furthermore, the successful implementation of all instructional stages provided santri with opportunities to engage in both individual and collaborative problem-solving activities. The consistency of implementation across meetings suggests that the observed improvements in geometry problem-solving ability were likely associated with the systematic application of the MPSCL model rather than incidental classroom factors. Therefore, the implementation results provide additional support for the feasibility and effectiveness of MPSCL in teaching geometry topics such as circle circumference and circle area.

Analysis of Santri Activities

Santri activities during the learning process were observed to examine the level of participation and engagement throughout the implementation of the MPSCL model. The results of the observation are presented in Table 10.

Table 10. Observation Results of Santri Activities

Meeting	Mean Score	Mean Percentage
Meeting 1: Circle Circumference	3,76	94
Meeting 2: Circle Area	3,89	97

Based on Table 10, the mean activity score during the first meeting was 3.76, with a percentage of 94%, whereas the second meeting achieved a mean score of 3.89, with a percentage of 97%. Both results are classified as **very good**. The increase in activity scores from the first to the second meeting suggests that santri became increasingly engaged and comfortable with the learning process as they gained experience with the instructional procedures of the MPSCL model.

The high level of santri activity indicates that participants were actively involved throughout the learning process, both during individual problem-solving tasks and collaborative group discussions. Rather than acting as passive recipients of information, santri were encouraged to explore mathematical ideas, communicate their reasoning, and evaluate alternative solution strategies. Such active involvement is an important component of meaningful mathematics learning because it promotes deeper conceptual understanding and sustained cognitive engagement.

These findings suggest that the MPSCL model effectively facilitates active participation while simultaneously supporting the development of geometry problem-solving ability. The strong level of engagement observed throughout the lessons provides additional evidence that the integration of individual and collaborative problem-solving activities can create productive learning experiences for santri in an Islamic boarding school setting. Moreover, the consistently high activity scores indicate that the instructional model was successful in maintaining student involvement across different learning sessions and geometry topics.

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Inferential Statistical Analysis

Inferential statistical analysis was conducted to examine the effect of the MPSCL model on santri's geometry problem-solving ability. Prior to hypothesis testing, the data were tested for normality using the Shapiro–Wilk test. After the assumption of normality was satisfied, hypothesis testing was performed using a paired-samples *t*-test. In addition, N-Gain and effect size analyses were conducted to determine the level of improvement and the magnitude of the effect of the MPSCL model on santri's geometry problem-solving ability.

Normality Test

The normality test was conducted to determine whether the differences between the pretest and posttest scores were normally distributed. The results of the Shapiro–Wilk test are presented in Table 11.

Table 11. Results of the Shapiro–Wilk Normality Test

Variable	Shapiro–Wilk Statistic	df	Sig.
Difference between Pretest and Posttest Scores (Circle Circumference)	0.972	15	0.886
Difference between Pretest and Posttest Scores (Circle Area)	0.955	15	0.606

Based on Table 11, the significance value for the difference between the pretest and posttest scores on the circle circumference topic was 0.886, while the significance value for the circle area topic was 0.606. Since both values were greater than 0.05, the data can be considered normally distributed. Therefore, the assumption of normality was satisfied, and further analysis could proceed using the paired-samples *t*-test.

Paired-Samples* t*-Test

The paired-samples *t*-test was conducted to determine whether there were significant differences in santri's geometry problem-solving ability before and after the implementation of the MPSCL model. The results of the analysis are presented in Table 12.

Table 12. Results of the Paired-Samples *t*-Test

Paired Comparison	Mean Difference	Std. Deviation	Std. Error Mean	95% CI Lower	95% CI Upper	*t*	df	Sig. (2-tailed)
Pretest Circle Circumference – Posttest Circle Circumference	-21.867	9.576	2.472	-27.170	-16.564	-8.844	14	0.000
Pretest Circle Area – Posttest Circle Area	-33.200	10.241	2.644	-38.871	-27.529	-12.555	14	0.000

As shown in Table 12, the significance value (*p*-value, two-tailed) for both the circle circumference and circle area topics was 0.000. Since these values were lower than the significance level of 0.05, the null hypothesis (H_0) was rejected and the alternative hypothesis (H_1) was accepted. These findings indicate a statistically significant difference between the pretest and posttest scores, suggesting that the implementation of the MPSCL model contributed to improvements in santri's geometry problem-solving ability.

Furthermore, the mean difference between the pretest and posttest scores was −21.867 for the circle circumference topic and −33.200 for the circle area topic. The negative mean differences indicate that the posttest scores were substantially higher than the pretest scores. This pattern demonstrates that santri achieved better performance after participating in learning activities based on the MPSCL model and suggests that meaningful learning gains occurred across both geometry topics.

The larger mean difference observed for the circle area topic may indicate that the model provided greater support for learning tasks requiring deeper conceptual understanding and more complex reasoning processes. Because the circle area topic involves multiple conceptual relationships and procedural decisions, santri may have benefited more from opportunities to discuss, compare, and refine solution strategies during collaborative learning activities.

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Overall, the results of the paired-samples *t*-test provide strong evidence that the implementation of the MPSCL model positively influenced santri's geometry problem-solving ability. The significant differences between pretest and posttest scores suggest that the integration of individual problem solving and cooperative learning created learning experiences that supported both conceptual understanding and mathematical reasoning. These findings also provide preliminary empirical support for the use of MPSCL as an instructional approach for teaching geometry in Islamic boarding school settings.

N-Gain Analysis

N-Gain analysis was conducted to determine the level of improvement in santri's geometry problem-solving ability after participating in learning activities using the MPSCL model. The results of the N-Gain analysis are presented in Table 13.

Table 13. Results of the N-Gain Analysis

Topic	Mean N-Gain	N-Gain Category	Description
Circle Circumference	0.466	Moderate	Moderate Improvement
Circle Area	0.552	Moderate	Moderate Improvement

Based on Table 13, the mean N-Gain score was 0.466 for the circle circumference topic and 0.552 for the circle area topic. Both values are categorized as moderate, indicating a moderate improvement in santri's geometry problem-solving ability following the implementation of the MPSCL model.

The circle area topic obtained a higher N-Gain score than the circle circumference topic. This result indicates that santri experienced greater improvement when solving circle area problems. Nevertheless, both topics showed positive gains, suggesting that the MPSCL model supported the development of geometry problem-solving ability.

Effect Size Analysis

In addition to testing statistical significance, this study employed effect size analysis to determine the magnitude of the effect of the MPSCL model on santri's geometry problem-solving ability. Cohen's *d* was used to calculate the effect size, and the results are presented in Table 14.

Table 14. Results of the Effect Size Analysis

Topic	Mean Pretest	Mean Posttest	Pretest SD	Posttest SD	Pooled SD	Cohen's *d*
Circle Circumference	52.133	74.000	3.159	11.753	8.606	2.541
Circle Area	40.067	73.267	5.574	8.972	7.469	4.445

Based on Table 14, Cohen's d was 2.541 for the circle circumference topic and 4.445 for the circle area topic. Both values are classified as large effect sizes, indicating that the implementation of the MPSCL model had a strong impact on improving santri's geometry problem-solving ability.

The large effect sizes indicate that the improvement in problem-solving ability was not only statistically significant but also educationally meaningful. These findings suggest that the MPSCL model has substantial practical value in mathematics learning. Therefore, the MPSCL model can be considered an effective instructional alternative for supporting the development of geometry problem-solving ability among santri in an Islamic boarding school setting.

DISCUSSION

The findings of this study indicate that the implementation of MPSCL significantly improved santri's geometry problem-solving ability in the topics of circle circumference and circle area. This improvement is evidenced by higher posttest scores compared with pretest scores, moderate N-Gain values, and large effect sizes. These results suggest that integrating problem-solving activities with cooperative learning creates a learning environment that supports the development of mathematical problem-solving ability.

The improvement in geometry problem-solving ability can be explained by the characteristics of the MPSCL model, which combines individual and collaborative problem-solving activities. During the individual problem-solving phase, santri are encouraged to understand the problem, identify goals, plan solution strategies, and construct solutions independently. Subsequently, during group discussions, santri compare strategies, clarify concepts, and evaluate alternative solutions. These interactions facilitate cognitive elaboration and meaning negotiation, which strengthen conceptual understanding and improve the quality of problem-solving processes.

The findings are consistent with the meta-analysis conducted by Talkhan et al. (2025), which reported that cooperative learning has a moderate to high positive effect on students' mathematics achievement. Their study emphasized that well-structured cooperative learning models enhance student engagement, academic interaction, and learning outcomes. In the present study, the systematic structure of MPSCL enabled santri to actively participate in thinking processes and collaborative discussions, thereby supporting the development of geometry problem-solving ability.

The findings are also consistent with previous studies emphasizing the benefits of integrating cooperative learning and problem solving. Wakjira et al. (2026) reported that combining cooperative learning with problem-solving activities improved students' mathematical problem-solving skills, while Klang et al. (2021) highlighted the importance of peer interaction in generating alternative solution strategies. Similar patterns were observed in the present study, where santri discussed, compared, and evaluated multiple approaches to solving geometry problems, thereby strengthening both conceptual understanding and problem-solving performance.

The findings can also be interpreted from the perspective of conceptual understanding in geometry learning. Miranda and Saliceto (2024) found that exploratory activities involving discussion and idea exchange strengthen conceptual understanding and theoretical thinking in geometry. In the present study, the sequence of individual problem solving followed by group discussion allowed santri to reconstruct their understanding of circle circumference and area concepts through reflection and conceptual clarification. This process helped them connect procedures with underlying geometric concepts, resulting in more meaningful learning.

In addition to improving conceptual understanding, the implementation of MPSCL appears to enhance student engagement. Classroom observations revealed that santri's learning activities were categorized as very good throughout the instructional process. This finding aligns with Utami et al. (2025), who emphasized that cognitive, behavioral, emotional, and contextual engagement are essential factors in successful mathematics learning. Through the integration of problem-solving tasks and collaborative discussions, MPSCL provided santri with opportunities to actively participate, express ideas, and engage in decision-making processes, thereby promoting greater learning engagement.

The results also support the conclusions of Ayari et al. (2025), who found that problem-centered learning improves problem-solving ability, academic achievement, and student engagement in mathematics. These similarities suggest that the effectiveness of MPSCL is not solely attributable to cooperative group work but also to the presence of challenging mathematical problems that encourage learners to explore and evaluate different solution strategies. Therefore, the integration of problem solving and cooperative learning represents a key factor contributing to the improvement of santri's geometry problem-solving ability.

Although the N-Gain values were classified as moderate, the findings nevertheless demonstrate that MPSCL effectively improved santri's geometry problem-solving ability. The moderate level of improvement may be attributed to the fact that many santri were still adapting to problem-solving-oriented learning, which requires higher-order thinking, strategic reasoning, and active participation throughout the learning process. Moreover, the intervention was implemented over a relatively short period, which may have limited the extent to which santri could fully internalize the problem-solving procedures embedded in the MPSCL model. A longer implementation period may provide greater opportunities for sustained practice and potentially lead to higher learning gains.

Interestingly, the N-Gain value for the circle area topic was higher than that for circle circumference. This finding suggests that MPSCL may provide greater benefits for topics requiring deeper conceptual reasoning and more complex solution strategies. This interpretation is consistent with the findings of Supriadi et al. (2024), who reported a strong relationship between mathematical problem solving and mathematical reasoning. As the reasoning demands of a topic increase, problem-solving-oriented instruction is more likely to produce meaningful learning gains.

The large effect sizes indicate that the impact of MPSCL was not only statistically significant but also educationally meaningful. This finding suggests that the observed improvement was substantial enough to have practical value in classroom instruction rather than merely reflecting a statistical difference between pretest and posttest scores. The result is consistent with the problem-solving framework proposed by Annizar et al. (2025), which emphasizes understanding problems, identifying goals, planning strategies, implementing solutions, adapting strategies when necessary, and verifying solutions. Because these processes are explicitly embedded within the instructional stages of MPSCL, santri were able to engage in problem solving in a more structured, reflective, and systematic manner.

The successful implementation of MPSCL was further supported by highly positive responses from santri, excellent instructional implementation, and high levels of classroom participation. These findings suggest that MPSCL is effective not only in improving learning outcomes but also in creating a learning environment that promotes active participation. This result is consistent with Ceballos et al. (2026), who argued that collaborative problem solving can enhance student engagement and foster higher-order thinking when supported by clearly structured interactions.

From a theoretical perspective, the findings support the constructivist views of Piaget (1970) and Vygotsky (1978), which emphasize that knowledge is constructed through individual activity and social interaction. MPSCL provides both conditions simultaneously through individual problem-solving tasks and collaborative group discussions. Consequently, the model supports not only the acquisition of geometry concepts but also the development of problem-solving ability, mathematical reasoning, collaboration, and learning engagement, all of which are essential competencies for mathematics learning in the twenty-first century.

CONCLUSION

The implementation of MPSCL improved santri's geometry problem-solving ability in the topics of circle circumference and circle area. This improvement was reflected in significant differences between pretest and posttest scores, moderate N-Gain values, and large effect sizes.

By combining individual problem-solving activities with group discussions, MPSCL provided santri with opportunities to understand problems, develop solution strategies, evaluate alternative approaches, and reflect on the solutions obtained. These processes supported the development of both conceptual understanding and mathematical thinking.

In addition to its positive impact on geometry problem-solving ability, MPSCL received highly positive responses from santri and was implemented successfully throughout the learning process. Therefore, MPSCL may be considered a promising instructional alternative for mathematics learning, particularly in geometry topics that require strong problem-solving skills.

Despite these promising findings, the study was limited by the small sample size and the use of a one-group pretest–posttest design. Future studies are therefore encouraged to involve larger and more diverse groups of santri, incorporate control groups, and examine the implementation of MPSCL across different mathematical topics. Such investigations would provide stronger empirical evidence regarding the effectiveness and generalizability of the model in Islamic boarding school contexts.

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