MATHEMATICS LEARNING USING THE TAPPS MODEL BASED ON *MIND MAPPING*: ITS IMPACT ON STUDENTS' MATHEMATICAL PROBLEM-SOLVING SKILLS

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Abstract
Students' mathematical problem-solving skills in Indonesia are still not optimal, so it is necessary to implement a learning model that can train structured thinking and increase student engagement. This study aims to determine the effect and magnitude of the effect of the Mind Mapping-based Thinking Aloud Pair Problem Solving (TAPPS) cooperative learning model on the mathematical problem-solving skills of seventh-grade MTs students in a city in Medan regarding algebra material. This is a quantitative study using a quasi-experimental method with a pretest–posttest control group design. The research sample consisted of two classes: an experimental class with 28 students and a control class with 28 students. The instrument used was a mathematical problem-solving ability test. Data analysis employed the t-test. Results from the independent samples t-test indicated $p < 0.001 < 0.05$, thus rejecting H_0. This improvement was indicated by an N-Gain value of 0.36, classified as moderate, and a coefficient of determination $R^2 = 0.372$, meaning that students' mathematical problem-solving skills were influenced by the implementation of this learning model. Thus, the Mind Mapping-based TAPPS model can serve as an alternative approach to mathematics instruction to enhance students' mathematical problem-solving skills.

Keywords: Learning Model; TAPPS; Mind Mapping; Mathematical Problem-Solving Ability

INTRODUCTION

Education is a lifelong learning process that serves to develop the potential of students and transfer cultural values from one generation to the next (Andhany & Maysarah, 2023). From an Islamic perspective, the guidance to seek knowledge applies throughout life, as explained in the Qur'an surah An-Nûr verse 51 and reinforced by various views of scholars who emphasize the obligation of continuous learning (Makuro et al., 2025). Mathematics plays a vital role in various fields of study, thereby enhancing human cognitive abilities (Jumri & Risnanosanti 2021). Mathematics is not solely regarded as a collection of formulas, but also as a discipline that plays an important role in developing students' critical thinking, analytical reasoning, and problem-solving abilities. In mathematics education standards, students are expected to possess the ability to comprehend problems, formulate appropriate solution strategies, implement suitable procedures, and evaluate the results obtained. (A. P. Lubis & Maysarah, 2025). However, in reality, many students view mathematics as a difficult subject, causing them to lack confidence, become passive, and experience difficulties in understanding abstract concepts and solving non-routine problems (Siregar et al., 2023). Thus, the goal of mathematics learning is not only to focus on mastering the material, but also on developing the ability to understand concepts, solve problems, reason, communicate, and make mathematical connections (Nurbayeni & Siregar, 2025).

Math learning is a process designed to help students build problem-solving skills, understanding of concepts, principles, and procedures through active and directed mental activity (Panjaitan & Siregar, 2024). To achieve this goal, the learning process should provide opportunities for students to actively

construct knowledge through their own cognitive processes. Therefore, mathematics education plays a significant role in developing logical thinking abilities both in academic settings and in everyday life, particularly in enhancing mathematical problem-solving skills, which represent one of the essential competencies that students are expected to master.

Mathematical problem-solving skills are one of the important competencies that students must master because they are the basis for understanding concepts, applying rational thinking strategies, and making decisions in everyday life (Asri & Maysarah, 2024). Ideally, students should be able to make decisions in daily life, but in reality, not all students dare to make decisions based on their choices, and the decisions made are sometimes not in line with what they should be (Reflina, 2022). Based on mathematics learning standards, problem-solving refers to the ability to comprehend a problem, design appropriate solution strategies, carry out the necessary procedures, and review or evaluate the solutions that have been obtained. (Barus & Hasibuan, 2023.).

However, various studies show that many students experience difficulties in the stages of understanding problems and designing strategies, so they tend to immediately perform calculations without careful analysis. Low ability in these stages makes it difficult for students to deal with non- routine problems and less able to connect information logically (Anggreini et al., 2022). Studies on students' ability to solve PISA problems reveal that many students have difficulty understanding the context of the problem. This condition is further supported by the results of the 2022 PISA assessment, which indicate that only 18% of Indonesian students were able to reach the minimum competency level (Level 2) in mathematics, while very few attained the higher proficiency levels (Levels 5–6). These findings suggest that Indonesian students' abilities in mathematical modeling, reasoning, and decision-making remain relatively low when compared with international benchmarks. (OECD, 2023). Furthermore, an analysis of students' mathematical problem-solving abilities in word problems within the Minimum Competency Assessment (AKM) at the junior high school level indicates that many students experience difficulties in connecting the information presented in the text with the appropriate mathematical concepts. These findings are consistent with the results of previous studies. (Fathimatuzzahro & Prastiwi, 2025). Which shows that the majority of students are in the category of medium and low numeracy ability, with an average score of 62.5 and 22.5, and experience difficulties, especially in analyzing information indicators so that problem-solving skills in the context of AKM questions are still not optimal, so the resulting solutions are not appropriate or incomplete.

A similar condition was also found among students at MTs Bina Bangsa. The observation results showed that students still had difficulty identifying important information in the questions, determining the right strategy, and communicating the steps to solve the problems. Students tended to be accustomed to working on routine questions, so they became confused when faced with non- routine questions that required more in-depth reasoning.

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Cakra buys cooking oil (IDR 14,500/liter), rice (IDR 10,000/kg), and flour (IDR 15,000/kg).
- Write down the information that is known and that is asked.
- If Chakra buys x liters of oil, y kg of rice, and z kg of flour, make an algebraic model of the total cost.
- Calculate the total cost for 2 liters of oil, 3 kg of rice, and 2 kg of flour.
- Check the answers and write down the conclusions according to the context of the problem.

$$.1) \text{Jumlah uang} \cdot 14.500 x + 10.000 y + 15.000 z$$
$$\text{Jadi totalnya } 14.500 x + 10.000 y + 15.000 z \text{ ribu}$$
$$b) \text{kalau } x = 2, y = 3, z = 2 \text{ berarti}$$
$$14.500 (2) + 10.000 (3) + 15.000 (2)$$
$$= 29.000 + 30.000 + 15.000 = 74.000$$

Feature 1. Student Answer Pattern

The results of interviews with mathematics teachers at MTs Bina Bangsa indicate that students' mathematical problem-solving abilities are still categorized as moderate to low. The primary difficulties are evident in several aspects, including understanding the problem, formulating a solution plan, and communicating the steps of the solution. Students frequently struggle to identify essential information and determine appropriate strategies. Consequently, when confronted with problems that require higher-order reasoning, they tend to feel uncertain and rely on examples provided by the teacher. This situation suggests the need for a learning approach that can facilitate more systematic and structured thinking among students. (Hasna et al., 2024). The pattern of students' answers to the test also shows weaknesses in mathematical problem solving. Students are not able to identify important information, compile mathematical models, and determine appropriate solution strategies. In addition, there were still errors in the calculation operation and no re-checking or final conclusion. This shows that students' mathematical reasoning and problem-solving skills still need to be improved.

Based on these findings, the low level of students' mathematical problem-solving abilities is not solely caused by limited mastery of the subject matter, but also by the lack of learning processes that encourage systematic and reflective thinking. As a result, students tend to remain passive in the learning process, dependent on teacher examples, and are not yet accustomed to expressing and evaluating their thinking processes. Therefore, cooperative learning that encourages positive interaction and meaningful discussion in small groups is needed.

Cooperative learning is an approach designed to create positive interactions between students in small groups (Izzah et al., 2024). Essential elements of cooperative learning include positive dependence, individual responsibility, shared goals, balanced division of tasks, and group evaluation (Ratna Herawati et al., 2024). One type of cooperative learning strategy that has proven effective in enhancing thinking and problem-solving abilities is the Thinking Aloud Pair Problem Solving (TAPPS) model, in which students collaborate in pairs by assuming the roles of problem solver and listener (Fitria & Rakhmawati, 2025). One of the effective cooperative strategies is the use of mind mapping. This method helps students structure ideas, understand concepts, and connect information visually (Riswanti et al., 2023).

Various studies show that innovative learning models are able to improve the quality of mathematics learning processes and outcomes. Lubis, Fitriani, and Nasution (2025) found that cooperative learning is

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based on *Mind Mapping* has a significant effect on students' understanding of mathematical concepts (Auliya et al., 2025). These findings are in line with research (Hepta et al., 2020) that indicates that the implementation of *Mind Mapping* combined with the strategy *Thinking Aloud Pair Problem Solving* (TAPPS) effectively improve the ability to think creatively mathematically. Other research by Briliana, Sri Retno, and Sulistyo (2020) also shows that the integration of TAPPS and *Mind Mapping* can improve learning outcomes, although the improvement in problem-solving skills has not been significant. Consistently, research (Pujiarti et al., 2022) confirms that the TAPPS model has a strong influence on mathematical problem-solving ability, while (Rahayu et al., 2022) prove that TAPPS assisted by LKS is able to improve learning outcomes and student activities. In general, the combination of cooperative learning with *Mind Mapping* proven to strengthen understanding of concepts and learning outcomes because students are actively involved in thinking, discussing, and summarizing information independently (Fauziah et al., 2022). Nevertheless, not all studies show completely effective results. Research (Afthina & Saputro, 2022) The findings indicate that the implementation of the learning model examined did not lead to a significant improvement in students' learning outcomes. The analysis showed that the increase in students' abilities fell within the low to moderate category, and the difference between the experimental group and the control group was not statistically significant.

However, previous studies still present several limitations, as most of them examine the TAPPS or Mind Mapping models independently and apply them to different subjects and educational levels. Research that specifically integrates the Mind Mapping-based TAPPS model to enhance mathematical problem-solving skills among junior high school or MTs students remains relatively limited. Therefore, this study offers a novelty by systematically integrating these two approaches in learning activities for seventh-grade MTs students, with a particular focus on indicators of mathematical problem-solving abilities. Accordingly, this research aims to

investigate both the effect and the magnitude of the effect of implementing the Mind Mapping-based Thinking Aloud Pair Problem Solving (TAPPS) cooperative learning model on students' mathematical problem-solving skills. Therefore, the researcher conducted a study entitled *Mind Mapping-Based* TAPPS Mathematics Learning Model: Its Impact on Students' Mathematical Problem-Solving Abilities.

METHOD

This research method uses a quantitative approach with a quasi-experimental type. Quantitative research is a scientific approach that is used to test theories or hypotheses through the measurement of social phenomena in the form of numbers and analyzed using statistics (Scott, 2019). The research employed a Pretest–Posttest Control Group Design, involving two groups: an experimental group and a control group. Both groups were initially administered a pretest to determine the students' prior abilities. Subsequently, each group received different treatments, and the study concluded with a posttest to measure the changes in students' abilities following the learning process.

This study was conducted at MTs Bina Bangsa, located in Batu Bara Regency, North Sumatra Province. The population of this research consisted of all seventh-grade students of MTs Bina Bangsa in the 2025/2026 academic year, totaling 56 students. The sampling technique employed was saturated sampling, in which all members of the population are included as the research sample (Scott, 2019). The research sample consisted of two classes: Class VII A, comprising 28 students, served as the experimental group that received treatment through the implementation of the Mind Mapping–based Thinking Aloud Pair Problem Solving (TAPPS) model. Meanwhile, Class VII B, also consisting of 28 students, functioned as the control group and participated in learning through a conventional instructional approach. This study was conducted in January 2025, with the number of learning sessions adjusted according to the schedule in each class.

Data were collected through a written test consisting of a pretest and a posttest to

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measure students' mathematical problem-solving abilities. Prior to its implementation, the test instrument underwent an expert validation process to ensure its appropriateness and validity. The validation was conducted by two lecturers with expertise in mathematics education, who evaluated the alignment of the test items with the indicators of mathematical problem-solving ability, the clarity of the language used, and the level of difficulty of the questions according to the characteristics of seventh-grade students. Based on the evaluations provided by the two validators, the instrument was considered valid in terms of content and deemed appropriate for use in the study (Sakrani & Sholahuddin, 2022).

Data obtained from the results of the pretest and posttest in both the experimental and control groups were subsequently used as the basis for the research data analysis process. The test administered to students consisted of essay-type questions that were developed based on indicators of mathematical problem-solving ability. The indicators of mathematical problem-solving ability employed in this study refer to the problem-solving stages proposed by (Polya, 1973), namely: (1) understanding the problem, (2) planning the solution, (3) implementing the solution plan, and (4) re-examining the results of the completion Each indicator measured through the scoring rubric is systematically compiled to objectively assess students' answers.

The results of the empirical validity test showed that all pretest and posttest question items had a *calculated r* value greater than *the table r* (0.355), so that all questions were declared valid. Reliability tests using Cronbach's Alpha yielded a reliability coefficient of 0.601 on the pretest instrument and 0.708 on the posttest instrument, which is included in the high reliability category. Therefore, the instrument used to measure students' mathematical problem-solving abilities was considered valid and reliable, making it appropriate for use in this research.

After students complete *the pretest* and *posttest*, the results of the answers are evaluated based on predetermined assessment criteria. The scores obtained were then analyzed using inferential statistics to test the research hypothesis and draw conclusions about the impact of the *Thinking Aloud Pair Problem Solving* (TAPPS) learning model based on *Mind Mapping* on students' ability to solve mathematical problems. The analysis process carried out includes N-Gain calculation, normality testing, homogeneity testing, and hypothesis testing.

The improvement of students' mathematical problem-solving ability was analyzed using N-Gain calculations by comparing pretest and posttest scores. The N-Gain value is used to determine the level of improvement in students' abilities which are then classified into high, medium, low, and failing categories (Wahab et al., 2021) . Next, a normality test was carried out using the Shapiro–Wilk test with a significance level of 5% ($\alpha = 0.05$) to find out if the data was normally distributed. The data is declared to be normally distributed if the significance value is ≥ 0.05 and abnormal if the significance value is <0.05 (Safitri & Supeni Edie, 2020).

After that, a homogeneity test was carried out using the Levene test to determine the similarity of variance between groups. The data is declared homogeneous if the significance value is ≥ 0.05 and inhomogeneous if the significance value is <0.05 (Sianturi, 2022). Hypothesis testing was carried out using an Independent Sample T-Test with a significance level of 5% ($\alpha = 0.05$) to determine the difference in mathematical problem-solving ability between the two groups (Scott, 2019). In addition, the determination coefficient (r^2) was used to determine the contribution of the TAPPS learning model based on Mind Mapping to students' mathematical problem-solving abilities

RESEARCH RESULTS AND DISCUSSION

Prior to the learning process, both groups were administered a pretest to assess students' initial mathematical problem-solving abilities. In the experimental group, the learning process was implemented using the Mind Mapping–based Thinking Aloud Pair Problem Solving (TAPPS) model, whereas the control group participated in conventional instruction through lecture and

question–answer methods. The learning activities were conducted over three meetings. After the completion of the learning sessions, both groups were given a posttest to evaluate the improvement in students' mathematical problem-solving abilities following the treatment.

The following is a description of students' mathematical problem-solving skills before and after the treatment is given:

Pretest *and* Posttest *Results* of Mathematical Problem-Solving Ability

Based on the pretest results, the average score of students' mathematical problem-solving ability in the experimental class was 38.92, while the control class obtained an average score of 34.07. The difference in these mean scores indicates that the initial abilities of students in both classes were relatively comparable and still categorized as low. This condition suggests that prior to the implementation of the treatment, most students were not yet able to fully comprehend the problems, formulate appropriate solution strategies, or organize systematic steps in solving the problems. Therefore, both classes had relatively similar starting points before being given different learning treatments.

After the treatment was implemented, the posttest results indicated an improvement in students' mathematical problem-solving abilities in both classes. However, the increase was more significant in the experimental class that applied the Mind Mapping–based Thinking Aloud Pair Problem Solving (TAPPS) cooperative learning model. The average posttest score of the experimental class reached 60.60, whereas the control class obtained an average score of 49. This difference suggests that the implementation of the Mind Mapping–based TAPPS model provides a more positive

impact compared to conventional learning approaches.

The improvement of mathematical problem-solving skills in the experimental class is inseparable from the characteristics of the TAPPS model which emphasizes verbal thinking activities through activities *Thinking aloud*. Students are trained to express their thought processes verbally when solving problems, helping them understand problems, evaluate strategies used, and correct mistakes directly through feedback from their partners. In addition, the use of Mind Mapping helps students organize known information, concepts used, and solution steps visually and systematically, making it easier for students to plan and implement problem solving. In contrast, in control classes that use conventional learning, student activities tend to be passive and centered on the teacher's explanation. Students more imitate the examples of questions given without being trained to express the thought process and strategize independently. This causes the improvement in students' mathematical problem-solving abilities in the control class to be not as optimal as the experimental class.Thus, the results of this study show that the application of the TAPPS learning model is based on *Mind Mapping* It is more effective in improving students' mathematical problem-solving skills compared to conventional learning, especially in algebraic materials. These findings are in line with the objectives of the study (Jannah et al., 2025) and reinforcing that learning models that are oriented towards thinking, cooperation, and conceptual visualization activities are able to help students develop better problem-solving skills. The following is a description of students' mathematical problem-solving skills before and after the treatment presented in table 1 and table 2.

Table 1. Control and Experiment Class Pretest Results

Classes	Students	Minimal	Maximum	Average	Standard Deviation
Experiments	28	20	56	38.92	7.25
Kontrol	28	18	52	34.07	7.06

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Table 2. Results of the Posttest of the Control and Experiment Class

Classes	Students	Minimal	Maximum	Average	Standard Deviation
Experiments	28	43	76	60.60	7.34
Kontrol	28	34	64	49	7.99

After obtaining the pretest and posttest results, the next stage was to calculate the N-Gain in order to determine the level of improvement in students' mathematical problem-solving abilities after the learning process. The results of the N-Gain analysis are presented in Table 3.

Table 3. N-Gain Results

Max Score	N-Gain
63.71	0.36

Based on the results of the N-Gain calculation, the average score obtained was 0.36, which falls into the moderate category. This finding indicates that the implementation of the Mind Mapping–based Thinking Aloud Pair Problem Solving (TAPPS) learning model is fairly effective in improving students' mathematical problem-solving abilities.

Furthermore, a normality test was conducted as a prerequisite for hypothesis testing. This test aimed to determine whether the research data were normally distributed, which is one of the requirements for applying parametric statistical tests, particularly the independent samples t-test.

The results of the normality test analysis are presented in Table 4 and were obtained using the statistical software Jamovi version 2.6.44.

Table 4. Normality Test Results

	Pre-ex	Pre-kon	Post-ex	Post-ko
Shapiro-Wilk W	0.971	0.980	0.974	0.941
Shapiro-Wilk p	0.597	0.856	0.684	0.117

Based on the analysis of the table above, it is known that all significance values (Sig.) in both test methods are above 0.05. The highest significance value in the *Shapiro-Wilk* test is 0.856 (pretest_control), and the lowest is 0.117 (posttest_control). The researcher used the *Shapiro-Wilk* test because the sample size was less than 50 samples. Therefore, all significance values were > 0.05, so it can be concluded that all data were normally distributed.

Next is the homogeneity test to see the data. The homogeneity test is performed after ensuring the data is normally distributed, to find out if the data of the two groups have the same variance The homogeneity test using *the Jamovi 2.6.44* program can be seen in table 5 using the Jamovi 2.6.44 *statistical application.*

Table 5. Homogeneity of Variances Test (Levene's)

	F	Df	df	P
GRADES	3.54	1	110	0.063

Based on the results of the homogeneity test conducted using the Jamovi 2.6.44 application, a significance value of 0.063 was obtained. Since this value is greater than 0.05, it can be concluded that the data have homogeneous variances. Therefore, the data

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fulfill one of the assumptions required for conducting an independent samples t-test. The results of the t-test analysis are presented in Table 6 and were generated using the Jamovi 2.6.44 statistical software.

Table 6. Independent Samples T-Test

		Statistic	df	p	Mean difference	The difference	95% Confidence Interval	
							Lower	Upper
GRADES	Student's t	3.65	110	<.001	8.23	2.25	3.77	12.7

Based on the results of the independent samples t-test presented in the table, it can be observed that the significance value in the P < 0.05 column is p < 0.001 < 0.05. Therefore, H_0 is rejected and H_1 is accepted. This indicates that the implementation of the Mind Mapping–based Thinking Aloud Pair Problem Solving (TAPPS) cooperative learning model in the experimental class has a significant effect and provides a positive impact on improving students' mathematical problem-solving abilities compared to the learning applied in the control class.

To determine the magnitude of the effect of the Mind Mapping–based Thinking Aloud Pair Problem Solving (TAPPS) cooperative learning model on students' mathematical problem-solving abilities, an analysis of the coefficient of determination was conducted. The results of this analysis are presented in Table 7 using the Jamovi 2.6.44 statistical software.

Table 7. Coefficient of Determination

Models	R	R²
1	0.610	0.372

Based on the results of the analysis, a correlation coefficient of R = 0.610 was obtained, indicating a moderate to strong relationship between the Mind Mapping–based TAPPS learning model and students' mathematical problem-solving abilities. Furthermore, the coefficient of determination value $R^2 = 0.372$ indicates that 37.2% of the variation in students' mathematical problem-solving skills can be attributed to the implementation of the Mind Mapping–based TAPPS learning model, while the remaining 62.8% is influenced by other factors not examined in this study.

The discussion was developed by connecting the results of the research data analysis with relevant learning theories and findings from previous studies. Based on the pretest results, the mathematical problem-solving abilities of students in both the experimental and control classes were relatively low and comparable. This condition indicates that many students still encounter difficulties in the stages of understanding the problem, planning appropriate strategies, and systematically formulating solution steps. These findings are consistent with previous studies which report that students' mathematical problem-solving abilities generally fall within the low to moderate category, particularly in the initial stages of Polya's problem-solving process (Z. Aulia & Hidayati, 2023). This indicates the need to implement a more active and student-centered learning model to develop the mathematical thinking process optimally (Agustina et al., 2025). This condition occurs because conventional learning practices often emphasize procedural explanations delivered by the teacher, while students are given limited opportunities to actively construct their own understanding. Consequently, students tend to rely on memorized procedures rather than engaging in deeper analytical thinking when solving mathematical problems.

After the initial explanation, students work on the LKPD in pairs by applying the

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principles *Thinking aloud*, where *Problem solver* expressing the thought steps verbally and *Listener* provide feedback and clarification. At the first meeting, some students still showed doubts in expressing their thought process, but this activity began to train students' awareness and reflection thinking. This is in line with the findings (Ratnasari et al., 2023) which states that the strategy *Thinking aloud* It requires a level of adaptation, but it is gradually able to improve cognitive engagement and collaborative problem-solving skills. The improvement occurs because the thinking aloud strategy encourages students to articulate their reasoning processes explicitly, allowing them to monitor their thinking, identify errors, and refine their problem-solving strategies through peer feedback. At the second meeting, the application of the TAPPS model was based on *Mind Mapping* takes place more optimally. Students not only solve algebra problems, but also compile *Mind Mapping* which contains information, concepts, strategies, and completion steps in a systematic manner. Usage *Mind Mapping* help students organize concepts and support structured problem-solving (Hasanah et al., 2021). Through the use of visual representations, students are able to organize relationships between mathematical concepts, identify key information in the problem, and develop clearer solution pathways. This process supports students in transforming abstract mathematical ideas into more structured and meaningful representations.

The learning stages include the formation of a partner, activities *Think aloud*, Drafting *Mind Mapping*, role exchange, discussion-reflection, and mutual conclusion drawn. Theoretically, these findings are in line with Bruner's theory of learning (Jerome, 1966) that emphasizes the active involvement of students in building knowledge, as well as Gagné's theory (1985) which states that intellectual skills develop through the use of symbols and concepts in a structured manner. Therefore, the integration of verbal reasoning through TAPPS and visual organization through Mind Mapping creates a complementary learning process that facilitates deeper conceptual understanding and more systematic problem-solving

strategies. In addition, the results of this study are consistent with previous research stating that TAPPS-based learning and *Mind Mapping* effective in improving high-level thinking skills, especially mathematical problem-solving skills (Aulia et al., 2025 ; Hepta et al., 2020); Nusywari et al., 2022). This can be seen from the increase in results *Post-test* in the experimental classroom after the application of learning, which shows that students are able to solve problems better than before the treatment. This improvement can be explained by the learning environment created through TAPPS activities, where students actively discuss, evaluate, and refine their thinking processes. Such activities stimulate higher-order thinking skills, including reasoning, analysis, and evaluation, which are essential components of mathematical problem solving. The increase occurred because the TAPPS model encourages students to actively communicate thinking steps and reflect on the problem-solving process, while using *Mind Mapping* Help students organize concepts and strategies visually so that the understanding and accuracy of problem solving becomes more optimal. In addition, collaborative interactions between students allow them to exchange ideas and alternative strategies, which further enriches their understanding of mathematical concepts and problem-solving procedures.

The results of the N-Gain analysis indicate that students' mathematical problem-solving abilities improved to the moderate category, with a score of 0.36. Furthermore, the results of the Independent Samples t-Test revealed a significance value of $p < 0.001$, indicating a statistically significant difference in mathematical problem-solving abilities between the experimental and control classes. The magnitude of the effect of the Mind Mapping–based TAPPS model is reflected in the coefficient of determination (R^2) value of 0.372, which means that 37.2% of the variation in students' mathematical problem-solving abilities can be attributed to the implementation of the learning model. This finding suggests that the learning model plays a meaningful role in supporting the development of students' mathematical thinking processes, although other factors such as students' prior knowledge,

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motivation, and learning environment may also contribute to the improvement of their abilities.

These findings support previous research which suggests that the integration of TAPPS and Mind Mapping provides a positive contribution to the improvement of students' mathematical problem-solving abilities. Based on the results of this study, the Mind Mapping–based Thinking Aloud Pair Problem Solving (TAPPS) cooperative learning model has been shown to have a positive effect on students' mathematical problem-solving skills. This is evidenced by the average posttest score of the experimental class, which reached 60.60, higher than that of the control class, which was 49.00, as well as by the results of the Independent Samples t-Test showing a significance value of $p < 0.001$.

Moreover, the coefficient of determination ($R^2 = 0.372$) indicates that students' mathematical problem-solving abilities are influenced by the implementation of the Mind Mapping–based TAPPS model. Therefore, this learning model can be considered an alternative approach for mathematics instruction, particularly in algebra topics. Furthermore, the model promotes active student engagement, collaborative learning, and reflective thinking, which are important components in fostering higher-order mathematical thinking skills and improving students' ability to solve complex problems.

CONCLUSION

The results of this study indicate that the implementation of the Mind Mapping–based Thinking Aloud Pair Problem Solving (TAPPS) cooperative learning model contributes positively to the improvement of students' mathematical problem-solving abilities. The learning process that combines verbal reasoning through the TAPPS strategy with visual organization through Mind Mapping enables students to express their thinking processes, organize mathematical concepts, and develop more systematic problem-solving strategies.

Based on these findings, it can be concluded that the Mind Mapping–based TAPPS learning model is effective in supporting the development of students' mathematical problem-solving skills, particularly in algebra learning. Therefore, this model can be considered an alternative instructional approach to create more active, collaborative, and reflective mathematics learning environments.

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