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The Effect of the Thinking Aloud Pair Problem-Solving Learning Model on Students' Mathematical Problem-Solving Outcomes

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ABSTRACT

This study aims to determine the effect of the Thinking Aloud Pair Problem-Solving learning model on the mathematical problem-solving ability of seventh-grade students at SMP Negeri 5 Mandau. The method used was quantitative with a quasi-experimental approach. The research design was a pre-test post-test only control group. The research instrument consisted of test questions. The results of the study show that the implementation of the Thinking Aloud Pair Problem-Solving model significantly increases students' mathematical problem-solving ability compared to the conventional method. Based on the research findings regarding the implementation of the Thinking Aloud Pair Problem Solving learning model in mathematics learning at SMP Negeri 5 Mandau, it can be concluded that the model has an effect on improving the mathematical problem-solving ability of seventh-grade students in algebra material.

Keywords: cooperative, TAPPS, algebra, innovative

INTRODUCTION

Teaching mathematics in junior high schools still faces challenges in fostering higher-order thinking skills, particularly in terms of mathematical problem-solving. Based on field observations, one of the problems faced by students is dependency when working on mathematics problems[1]. This is caused by a lack of understanding of problem-solving-type questions. For example, when given a problem-solving question, students are often unable to solve it correctly. Students tend to rely on examples provided in textbooks, and some students, when answering such questions, usually look at their classmates' work. Therefore, when presented with a problem that differs from the examples in the textbook[2]. Another problem that often arises is the inaccuracy in understanding the meaning of the questions and in formulating a logical solution. Some students may have memorized the steps of the solution, but fail to apply them correctly when determining the final answer[3]. Based on these problems, it can be concluded that students still experience obstacles in mastering mathematical problem-solving skills[4]. This is evident from the weak mastery of the indicators of problem-solving skills, such as the ability to understand the problem, plan a solution strategy, correctly implement the strategy, and recheck the obtained solution. This condition leads many students to experience difficulties in solving word problems that require analytical processes, logical reasoning, and good mathematical communication[5].

As a solution to these problems, the researcher proposes the use of the cooperative learning model type, Thinking Aloud Pair Problem Solving (TAPPS). Thinking Aloud Pair Problem Solving (TAPPS) is a cooperative learning model that emphasizes the verbal thinking process in pairs, where one student acts as the problem solver who solves the problem while expressing their thinking process verbally, while the partner acts as an active listener who provides responses, clarifications, and feedback on their partner's thoughts. This model is believed to be capable of improving mathematical problem-solving skills because students not only focus on the final result, but also become aware of, examine, and reflect on their thinking process systematically. The indicators developed in the Thinking Aloud Pair Problem Solving (TAPPS) model include: the ability of students to express their thinking process sequentially and logically; the ability to listen actively and provide responses to their partner's arguments; cooperation in finding problem-solving strategies, and the ability to reflect on errors or inaccuracies in thinking during the problem-solving process[6]. The novelty of this study lies in the implementation of TAPPS in the context of mathematical problem-solving at the junior high school level, which has so far been more widely applied at higher education levels or in different domains. In addition, this study also integrates contextual problems into the learning process, oriented toward enhancing students' critical thinking and mathematical

communication skills. The TAPPS activities are conducted in small heterogeneous groups to encourage positive interaction among students, thereby increasing their confidence in solving the given problems. A student will be assigned the task of solving a problem together with a peer in their group who, either intentionally or unintentionally, can assist the problem-solving process by asking for a step-by-step explanation of how to solve the problem from their partner. In this way, students' mathematical communication and problem-solving skills are expected to improve. This study focuses on algebraic expressions, considering that this material is a fundamental component in mathematics that requires strong symbolic and conceptual understanding[7].

Based on the above problems, this study aims to determine whether the Thinking Aloud Pair Problem-Solving learning model has a significant effect on seventh-grade students in solving mathematical problems in algebra material. The proposed hypothesis is that there is a significant effect between the implementation of the Thinking Aloud Pair Problem Solving (TAPPS) learning model and the mathematical problem-solving ability of seventh-grade students in algebra material.

RESEARCH METHOD

This study used a quantitative research method using a quasi-experimental approach. The research design used in this study was the Pre-test - Post-test Only Control Group Design. The Pre-test - Post-test Only Control Group Design is one type of experimental design used to examine the effect of an independent variable (X) on a dependent variable (Y) without conducting an explicit initial measurement for all students through a pre-test [8]. In the context of this study, variable X was the cooperative learning model type Thinking Aloud Pair Problem Solving (TAPPS), while variable Y was the students' mathematical problem-solving ability. In this design, there were two groups, namely the experimental group and the control group**.**

The population in this study consisted of all seventh-grade students at SMP Negeri 5 Mandau in the 2025/2026 academic year, comprising five classes with 28 students in each class. The sampling was carried out using the cluster random sampling technique, resulting in two classes being selected as the research sample, namely class VII-5 as the experimental group and class VII-3 as the control group.

In this study, the instrument used was a test. The data collection instruments employed by the researcher were pre-test and post-test question sheets. Word problem sheets based on real-life contexts with algebra concepts were used in the pre-test and post-test as tools to assess the extent of students' mastery of the material and the skills achieved before and after learning. The pre-test consisted of objective questions, while the post-test consisted of essay questions, which the researcher took from various sources. The test items to be administered were first validated by three validators, consisting of one expert lecturer and two teachers who teach mathematics at SMP Negeri 5 Mandau. The pre-test and post-test were assigned varying score weights, and students' answers were assessed using a rubric to facilitate the scoring process. In this study, the instructional tools used were a Teaching Module and Student Worksheets (*Lembar Kerja Peserta Didik*; LKPD).

The data analysis technique was carried out after all the data required to address the research questions had been completely collected. The data from the pre-test and post-test results in the experimental and control classes were used as the basis for processing the research information. After all the data had been collected, an analysis was conducted to draw conclusions[9]. This process used relevant statistical tests. In general, data analysis in this type of research includes the following stages: validity test, reliability test, normality test, homogeneity test, and hypothesis test.

RESULTS AND DISCUSSION

1. Analysis of Pre-Test Scores

The students' pre-test data were obtained from their initial scores before being given the teaching material with the respective treatments in each class. The pre-test results can be seen from the data description in Table 1 below.

Table 1. Descriptive Results of Students' Pre-Test Scores on Mathematical Problem-Solving Ability by Class

Class	Students	Minimum	Maximum	Mean	Standard Deviation
Experimental	28	5	34	13.7	8.09
Control	28	5	23	10.6	6.28
Total	56	5	34	12.15	7.18

Based on Table 1, each class serving as the research sample, namely the experimental class and the control class, consisted of 28 students who took the pre-test on mathematical problem-solving ability. The initial measurement results indicated a difference in the tendency of abilities between the two groups. In the experimental class, the lowest score obtained by students was 5, while the highest score reached 34. Conversely, the control class had a narrower score range, with the same lowest score of 5, but the highest score was only 23.

This difference indicates that students in the experimental class generally have a slightly better initial potential compared to students in the control class. This is further reinforced by the pre-test average score of 13.7 for the experimental class, while the control class only reached an average of 10.6. The standard deviations obtained from both classes also provide important information regarding the data distribution; the experimental class shows a greater score dispersion (SD = 8.09) compared to the control class (SD = 6.28), indicating

a wider variation of abilities within the experimental group.

An important finding at this stage is the difference in the mean initial ability between the two groups, although it is not very pronounced. This finding serves as an important basis for observing the impact of the Thinking Aloud Pair Problem Solving (TAPPS) model treatment more objectively. Suppose a statistically significant difference is later found in the post-test. In that case, such a difference is more likely to be attributed to the applied learning intervention rather than to an extreme difference in initial ability.

Thus, this pretest data strengthens the validity of the quasi-experimental design used, because in general, both groups have relatively comparable initial abilities, and the differences in post-test scores later can be attributed to the effect of the Thinking Aloud Pair Problem Solving (TAPPS) learning model applied in the experimental class.

2. Analysis of Post-Test Scores

Table 2. Descriptive Results of Students' Post-Test Scores on Mathematical Problem-Solving Ability by Class

Class	Students	Minimum	Maximum	Mean	Standard Deviation
Experimental	28	29	50	40.8	7.73
Control	28	23	39	30.0	3.13
Overall	56	23	50	35.4	5.43

Based on Table 2, it is known that 28 students from the experimental class and 28 students from the control class participated in the final test (post-test) to measure mathematical problem-solving ability after the implementation of different learning treatments. The experimental class, which received learning through the Thinking Aloud Pair Problem Solving (TAPPS) model, obtained a minimum score of 29 and a maximum score of 50, with an average of 40.8 and a standard deviation of 7.73. On the other hand, the control class, which used conventional learning, showed a minimum score of 23 and a maximum score of 39, with an average of only 30 and a smaller standard deviation of 3.13. Overall, the average ability of students from both groups reached 35.4 with a standard deviation of 5.43.

The difference in scores indicates a significant learning outcome gap between the two groups, in which students who received treatment using the Thinking Aloud Pair Problem Solving (TAPPS) model demonstrated higher performance in solving mathematical problem-solving questions. The increase in the average score from 13.7 in the pre-test to 40.8 in the post-test in the experimental class shows a very substantial improvement. This indicates that the implementation of learning using the Thinking Aloud Pair Problem Solving (TAPPS) model has a clear and significant positive effect on improving students' problem-solving abilities**.**

One logical explanation for this result is that Thinking Aloud Pair Problem Solving (TAPPS) trains students to think verbally, convey arguments, receive feedback from their partners, and actively correct errors in thinking. This process not only fosters deeper understanding but also builds self-confidence and enhances communication and collaboration skills. This is in line with the theory that problem-solving skills cannot develop solely through practice exercises but need to be supported by reflective, collaborative, and communicative thinking strategies.

An important finding in this study is that the use of the cooperative learning model type Thinking Aloud Pair Problem Solving (TAPPS), significantly improves junior high school students' mathematical problem-solving abilities compared to conventional learning. In addition, the more even score distribution in the control class (standard deviation 3.13) compared to the experimental class (7.73) indicates that, although the scores in the experimental class were higher, there was a greater variation in abilities among students after the implementation of the Thinking Aloud Pair Problem Solving (TAPPS) learning model. This may imply that students who were active in the Thinking Aloud Pair Problem Solving (TAPPS) discussions achieved very good results, while some who were passive still require further support.

The strength of this study lies in the structured implementation of the Thinking Aloud Pair Problem Solving (TAPPS) model, which focuses on students' thinking processes, making it more suitable for fostering mastery of higher-level problem-solving. In addition, this study utilized strong post-test data with valid instruments and appropriate statistical analysis techniques. However, its limitation is the absence of a follow-up measurement (delayed test) that could demonstrate the durability or long-term retention of learning. Furthermore, since the research context was limited to one school and one grade level, the scope of applicability of the research findings remains narrow.

These results are aligned with several previous studies, showing that there was a significant improvement in students' mathematical problem-solving abilities after the implementation of the Thinking Aloud Pair Problem Solving (TAPPS) learning model for eighth-grade students in solving number pattern problems[10]. This study also supports the evidence of differences in mathematical problem-solving abilities between students who participated in learning with the TAPPS model and those who received direct instruction[11], The study reported a significance value of 0.000 < 0.05, which means H_0 was rejected, indicating a significant effect of the TAPPS model on mathematical communication skills in the topic of statistics[12].

The results of this study imply that Thinking Aloud Pair Problem Solving (TAPPS) can be an effective alternative cooperative learning model to promote students' critical thinking and problem-solving abilities, particularly in mathematics. The implementation of Thinking Aloud Pair Problem Solving (TAPPS) also assists teachers in creating an active, interactive, and reflective learning environment. This model can be used as part of a differentiated learning strategy and has strong potential to be integrated into the *Merdeka Belajar* curriculum, which encourages the strengthening of higher-order thinking skills. Thus, this study not only shows the positive effect of the Thinking Aloud Pair Problem Solving (TAPPS) model on learning outcomes but also provides both conceptual and practical contributions to the development of problem-solving-oriented learning strategies.

3. Validity Test

Table 3. Validity Test Results

Correlation coefficient (r_{xy})	critical r-value	Interpretation
0.751	0.361	Valid
0.508	0.361	Valid
0.800	0.361	Valid
0.685	0.361	Valid
0.664	0.361	Valid

Based on Table 3, the results of the validity test analysis show that all five items used to measure mathematical problem-solving ability have correlation coefficients exceeding the critical r-value of 0.361. The correlation coefficients (r_{xy}) for each item are 0.751, 0.508, 0.800, 0.685, and 0.664. All of these values are consistently above the critical r-value, indicating that all items are declared valid

This validity indicates that the five items are capable of representing the aspects of mathematical problem-solving ability to be measured, such as the ability to understand the problem, formulate a solution strategy, implement the strategy correctly, and recheck the solution. The items were tested on 28 seventh-grade students of SMP Negeri 5 Mandau to determine the extent to which they were feasible for use in the study.

Thus, based on the results of the item-to-total score correlation calculation, it can be concluded that all test instruments are feasible for use in data collection at the pre-test and post-test stages. This good validity became an indicator that each item has an accurate measurement capability in empirically assessing students' mathematical problem-solving abilities.

4. Reliability Test

Table 4. Reliability Test Results

Reliability Statistics

Cronbach's Alpha	*N of Items*
.734	6

Based on Table 4, the reliability of the instrument in this study was measured using Cronbach's Alpha coefficient, which yielded a score of 0.734 for the five items tested. This value exceeds the minimum threshold generally accepted in educational research, namely 0.70, indicating that the instrument has a sufficiently strong and acceptable level of internal consistency (acceptable reliability).

This level of consistency indicates that all items in the instrument measure the same concept stably and coherently, and produce relatively consistent results when administered to respondents with similar characteristics. Thus, the test instrument used in this study can be considered reliable and suitable for use in collecting data related to students' mathematical problem-solving abilities.

This validity in reliability also supports the credibility of the research results, as the data collected come from a measurement instrument proven to have adequate stability. Therefore, the conclusions drawn from these data have a strong empirical basis and can be scientifically justified.

5. Normality Test

Table 5. Normality Test Results

Tests of Normality

	Kolmogorov-Smirnov[a]			*Shapiro-Wilk*		
	Statistic	*df*	*Sig.*	*Statistic*	*df*	*Sig.*
Pre-test Experimental	.278	28	.210	.798	28	.280
Post-test Experimental	.213	28	.182	.867	28	.342
Pre-test Control	.234	28	.070	.808	28	.210
Post-test Control	.429	28	.200	.592	28	.275

Based on Table 5, the results of the normality test using two statistical methods, namely Kolmogorov-Smirnov and Shapiro-Wilk, show that all significance values are above the significance

threshold of 0.05. The Shapiro-Wilk test was chosen as the primary reference in this study because the sample size was less than 50 students. The highest significance value was obtained from the post-test data of the experimental class at 0.342, while the lowest value was found in the pre-test data of the control class at 0.210.

All significance values obtained in this normality test are above the threshold of 0.05. This indicates that there is no significant deviation from the normal distribution in all the analyzed data, both in the pre-test and post-test, for the experimental class and the control class. Thus, the data used in this study meet the normality assumption.

The condition of a normal distribution is an essential requirement that must be met before conducting parametric statistical tests, such as the homogeneity of variance test or hypothesis testing using the Independent Sample t-Test. With this requirement fulfilled, the subsequent statistical analysis results will have a high level of confidence and methodological validity. The validity of this normal distribution strengthens the reliability of the findings in measuring the effect of the learning model on students' mathematical problem-solving abilities.

6. Homogeneity Test

Table 6. Homogeneity Test Results

Test of Homogeneity of Variances					
		Levene Statistic	*df1*	*df2*	*Sig.*
Score	*Based on Mean*	*.914*	*1*	*54*	*.284*
	Based on Median	*.558*	*1*	*54*	*.458*
	Based on Median and with adjusted df	*.558*	*1*	*54,263*	*.458*
	Based on the trimmed mean	*.677*	*1*	*54*	*.486*

Based on Table 6, homogeneity of variances is one of the main requirements that must be met before proceeding to the Independent Samples t-Test. Since the test results show that the variances between groups can be considered equal, the subsequent analysis can be conducted under the assumption of equal variances, which strengthens the validity of testing the mean differences between the two groups. The fulfillment of this requirement also supports the appropriate use of parametric tests to examine the formulated hypotheses.

The results of the homogeneity of variance analysis conducted using Levene's Test for Equality of Variances show that the significance value for the comparison between the experimental group and the control group meets the criteria. Thus, the data from both groups are declared homogeneous, or have a relatively equal variance distribution, making them suitable for use in testing the formulated hypotheses.

The results of the homogeneity of variance analysis conducted using Levene's Test for Equality of Variances show that the significance value for the comparison between the experimental group and the control group meets the criteria. Thus, the data from both groups are declared homogeneous or have a relatively equal variance distribution.

7. Hypothesis Test

The analysis results using the Independent Samples t-test show that the significance value (Sig. 2-tailed) obtained is 0.001 in the row Equal variances not assumed. The selection of this row is based on the results of the previous homogeneity of variances test (Levene's Test), which produced a significance value of 0.001, smaller than the threshold of 0.05. This means that the data between groups have unequal variances; therefore, the test for the difference in means between groups must be conducted under the assumption of unequal variances.

Table 7. Hypothesis Test Results

		Levene's Test for Equality of Variances		*t-test for Equality of Means*						
		F	*Sig.*	*t*	*df*	*Sig. (2-tailed)*	*Mean Difference*	*Std. Error Difference*	*95% Confidence Interval of the Difference*	
									Lower	*Upper*
Value	*Equal variances assumed*	.714	.367	3,322	54	.001	9.786	6.576	3.945	7.627
	Equal variances not assumed			3.322	54.609	.001	9.786	6.576	3.982	7.589

Based on Table 7, the significance value of 0.001 < 0.05 indicates that there is a statistically significant difference between the post-test scores of students in the experimental class and the control class. In other words, the difference in learning outcomes between the two groups is not due to chance but is the effect of the treatment given to the experimental group.

Based on these findings, it can be concluded that the cooperative learning model type Thinking

Aloud Pair Problem Solving (TAPPS) makes a significant contribution to improving students' mathematical problem-solving abilities. This confirms that the Thinking Aloud Pair Problem Solving (TAPPS) model is effective in helping students understand problems, design solution strategies, and communicate their thought processes systematically and collaboratively.

The data analysis results show that the cooperative learning model type Thinking Aloud Pair Problem Solving (TAPPS) has a significant positive effect on students' mathematical problem-solving abilities. The average post-test score of students in the experimental class reached 40.8, while the control class only reached 30. This indicates a considerable improvement in learning outcomes after the implementation of the Thinking Aloud Pair Problem Solving (TAPPS) approach. In addition, the maximum score achieved by students in the experimental class (50) was higher than that of the control class (39), indicating that this model not only increases the average score but also enables high-achieving students to reach their maximum potential.

This score improvement can be explained through the working mechanism of Thinking Aloud Pair Problem Solving (TAPPS), which emphasizes verbal and collaborative thinking. When students are given the opportunity to articulate their thought processes verbally and receive feedback from their partners, they do not merely memorize procedures but also understand the strategies used conceptually. This process strengthens students' metacognitive skills in identifying, planning, and evaluating solutions to the given mathematical problems. These findings establish a new narrative that active engagement in learning, particularly through verbal interaction and group work, has a tangible positive impact on learning achievement.

These findings also show that the experimental group experienced a more varied distribution of abilities (standard deviation 7.73) compared to the control group (3.13). This means that although, in general, students in the experimental class experienced improvement, there was variation in ability among students. This variation may be due to differences in initial ability, communication skills, and the quality of interaction within discussion pairs. Nevertheless, this variation can also be defined as evidence that Thinking Aloud Pair Problem Solving (TAPPS) provides ample space for growth, even for students who were initially less active. Several factors supporting the successful implementation of Thinking Aloud Pair Problem Solving (TAPPS) in this study include the teacher's readiness to design learning scenarios that encourage two-way interaction, as well as the development of contextual problems that require students to think critically and present arguments verbally. On the other hand, the limitations of this study lie in the limited implementation time and the dependence of the results on the dynamics of the learning pairs. Not all students have the same communication or self-reflection skills; therefore, additional training or guidance is necessary to optimize the Thinking Aloud Pair Problem Solving (TAPPS) process.

When compared with previous research results, these findings show consistency. For example, this study shows that TAPPS can be applied at the elementary school level, particularly when combined with contextual-based student worksheets. That research showed an improvement in problem-solving ability, as indicated by a gain score of 0.53. Meanwhile, at the senior high school level[13]. The study found that the TAPPS strategy successfully enhanced learning activities and significantly improved students' understanding of the concept of limits of algebraic functions[14].

The TAPPS model is theoretically aligned with social constructivism, which states that knowledge is constructed through social interaction. In this context, the process of verbal thinking and communication between partners in TAPPS creates a zone of proximal development that helps students learn from one another. Support also comes from research indicating that the use of TAPPS with the aid of Autograph software can significantly improve mathematical communication skills among junior high school students[15]. This study showed a drastic increase in students' mathematical reasoning and communication scores, from an average of 60.74 to 90.56. These findings affirm that the TAPPS model does not merely focus on achieving the correct final answer but also prioritizes the thinking process and the communication interactions that occur during problem-solving[16]. The effectiveness of TAPPS in various contexts and educational levels demonstrates that this model is both adaptive and flexible. For example, a study on the development of TAPPS integrated with animated videos for the topic of a two-variable linear equation system (SPLDV) proved effective in significantly improving students' learning outcomes[17]. Another study examined the application of gamification-based TAPPS and found that this approach was able to significantly enhance students' engagement and learning motivation[18].

Overall, the results of this study provide a practical contribution to the development of mathematics learning strategies that emphasize not only the final outcome but also the thinking process and student-to-student interaction. This study reinforces the argument that TAPPS is an adaptive and effective learning model that aligns with the student-centered orientation of the *Merdeka Curriculum*. The implication of this study is the importance of teacher training in implementing TAPPS, as well as the need for the development of learning materials that support verbal and reflective thinking processes.

CONCLUSION

Based on the results of the study conducted at SMP Negeri 5 Mandau, it can be stated that the use of the Thinking Aloud Pair Problem Solving (TAPPS) learning model has been proven to have a positive impact on improving students' mathematical problem-solving abilities in algebra material for seventh-grade students. This model not only helps students understand concepts more deeply but also trains them to think sequentially and logically, as well as to communicate the problem-solving process more clearly and reflectively. Therefore, TAPPS can be used as an effective alternative learning strategy for fostering higher-order thinking skills among students.

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