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The Effect of the Group Investigation Model Assisted by the "Make a Match" Game on Mathematical Problem-Solving Ability in Statistics

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ABSTRACT

This study aimed to examine the effect of the Cooperative Learning model of the Group Investigation (GI) type assisted by the Make a Match game on students' mathematical problem-solving ability in statistics. The study employed a quantitative approach with a quasi-experimental method and a Nonequivalent Control Group Design. The sample consisted of 53 eighth-grade students, with 27 students in the experimental group and 26 students in the control group. Data were collected using an essay test of mathematical problem-solving ability that met the validity and reliability requirements ($r_{11} = 0.930$). The data were analyzed using descriptive statistics, the Lilliefors normality test, the homogeneity test, an independent-samples t-test, and Cohen's d effect size. The results showed that the mean posttest score of the experimental class was 83.78, compared with 78.96 for the control class. The t-test result showed a t-count of 2.190, which was greater than the t-table value of 2.008 at $\alpha = 0.05$, indicating a significant difference between the two groups. The Cohen's d value of 0.60 indicated a medium effect. Therefore, the Cooperative Learning model of the Group Investigation type assisted by the Make a Match game had a significant and practically meaningful effect on students' mathematical problem-solving ability in statistics.

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1. INTRODUCTION

Mathematical problem-solving ability is a core competency that students must develop in mathematics education because it enables them to understand problems, devise strategies, apply concepts, and evaluate solutions. The National Council of Teachers of Mathematics (NCTM) [1] emphasizes that mathematics instruction should focus on developing problem-solving, reasoning, communication, connections, and representation skills. These abilities are important because they enable students to analyze situations,

determine appropriate solution strategies, and evaluate solutions logically and systematically [2], [3].

However, students' mathematical problem-solving abilities remain a concern. Mariam et al. [4] found that students at an MTsN in West Bandung experienced difficulties particularly in devising and reviewing solution strategies. Similarly, Pebrianti et al. [5] reported that students with different levels of prior mathematical knowledge still experienced difficulties in determining appropriate solution strategies. Statistics is closely related to these abilities because it requires students to understand data contexts and interpret information accurately rather than merely perform calculations [6], [7].

This situation was also observed during the preliminary assessment of the Grade VIII class at MTs Swasta Cerdas Murni. Mathematics instruction remained teacher-centered, with students primarily listening and taking notes. Interaction both between teacher and students and among students themselves was limited; group discussions were suboptimal because some students lacked a grasp of fundamental concepts, and few felt confident enough to ask questions or voice their opinions. When faced with problem-solving tasks, many students struggled to comprehend the problems and determine the appropriate steps for a solution. These conditions indicate that students were not accustomed to deeply analyzing problems, planning solutions, or drawing conclusions from the results they obtained.

One relevant model for addressing these issues is the Group Investigation (GI) type of Cooperative Learning, which emphasizes active student involvement in planning, investigating, and presenting learning outcomes within groups [8]–[10]. Ningsih [11] demonstrated that the Group Investigation model influenced the mathematical problem-solving abilities of Grade VIII students at MTsN Kerinci Regency, while Palupi and Rahayu [12] showed the effectiveness of GI in enhancing students' mathematical critical thinking skills compared with the Teams Games Tournament (TGT) model. To further increase student engagement, the model can be combined with the Make a Match game strategy. Sundari [13] reported that the Make a Match strategy affected students' mathematical communication skills through activities involving the matching of question and answer cards. Sahraini et al. [14] also found that integrating game elements into mathematics instruction fosters active student participation and strengthens their problem-solving skills.

Previous studies have demonstrated the potential of the Group Investigation (GI) model and the Make a Match strategy in mathematics learning, but they have generally examined the two approaches separately. Ningsih [11] found that the GI model influenced the mathematical problem-solving abilities of eighth-grade students, while Palupi and Rahayu [12] reported the effectiveness of GI in developing students' mathematical critical thinking skills. Meanwhile, Sundari [13] examined the effect of the Make a Match strategy on students' mathematical communication skills, and Sahraini et al. [14] reported that educational mathematics games could support students' problem-solving abilities. However, these studies did not specifically examine the combination of GI and Make a Match for developing mathematical problem-solving ability in statistics at the MTs level. Therefore, the present study addresses this gap by investigating the effect of the GI cooperative learning model assisted by the Make a Match game on eighth-grade students' mathematical problem-solving ability in statistics.

Accordingly, this study aims to determine the effect of the Group Investigation (GI) cooperative learning model assisted by the Make a Match game on students' mathematical problem-solving ability in statistics and to determine the magnitude of the effect.

2. METHOD

This study employs a quantitative approach using a quasi-experimental method with a Nonequivalent Control Group Design, involving an experimental group and a control group that undergo a pretest prior to the intervention and a posttest following it [15]. The experimental group receives an intervention involving the Group Investigation (GI) type of Cooperative Learning model supported by the "Make a Match" game, whereas the control group receives conventional instruction. The research design is presented in Table 1.

Table 1. Research Design

Class	Pretest	Treatment	Posttest
Experimental	O1	X	O2
Control	O1	–	O2

Note: X = treatment using the Group Investigation (GI) cooperative learning model assisted by the "Make a Match" game; O1 = pretest score; O2 = posttest score (Payadnya & Jayantika, 2018).

The study was conducted at MTs Swasta Cerdas Murni in Percut Sei Tuan District, Deli Serdang Regency, North Sumatra, during the even semester of the 2025/2026 academic year, focusing on the topic of statistics. The research population consisted of all Grade VIII students at the school, comprising four classes with a total of 106 students. The sample was selected using the cluster random sampling technique [16], [17], resulting in the selection of Class VIII-3 (27 students) as the experimental group, which was taught using the Group Investigation (GI) type of Cooperative Learning model assisted by the "Make a Match" game, and Class VIII-1 (26 students) as the control group, which was taught using conventional methods. Thus, the total research sample consisted of 53 students.

The independent variable in this study is the Group Investigation (GI) cooperative learning model assisted by the "Make a Match" game, while the dependent variable is students' mathematical problem-solving ability. This ability was measured through pretests and posttests based on four indicators: understanding the problem, planning a solution, executing the strategy, and reviewing the solution, following Polya's stages [18].

The research instrument consisted of an essay test assessing students' mathematical problem-solving ability in statistics [19], [20]. Prior to use, the instrument was pilot-tested on eighth-grade students at another school with comparable characteristics. Validity testing using the Pearson Product-Moment formula revealed that seven of the 15 tested items were valid and were subsequently used as the research instrument. Reliability testing using Cronbach's alpha [21] yielded a reliability coefficient of 0.930, which was classified as very high [22], indicating that the instrument was suitable for collecting research data.

The data analysis techniques in this study comprised four stages: (1) descriptive statistical analysis involving the mean, variance, and standard deviation [23]; (2) prerequisite analysis tests, specifically a normality test using the Lilliefors formula and a homogeneity

test using the F-test; (3) hypothesis testing using an independent samples t-test with a significance level of $\alpha = 0.05$ [24]; and (4) an effect size test using Cohen's d to determine the magnitude of the treatment effect, with interpretation criteria based on Cohen [25] and Sawilowsky [26]. The hypothesis testing criterion was as follows: if t-calculated > t-table at $\alpha = 0.05$, H0 is rejected and Ha is accepted, indicating a statistically significant difference in students' mathematical problem-solving ability between the experimental and control groups.

3. RESULTS AND DISCUSSION

This study aims to determine the effect of the Group Investigation (GI) cooperative learning model, supported by the "Make a Match" game, on the mathematical problem-solving skills of eighth-grade students at MTs Swasta Cerdas Murni regarding the topic of statistics. Prior to the intervention, both classes took a pretest to assess students' initial abilities, followed by a posttest after the intervention to measure their final abilities. Descriptive statistics for the pretest and posttest results of both classes are presented in Table 2.

Table 2. Descriptive Statistics of Pretest and Posttest Scores for Experimental and Control Classes

Statistics	Experimental Pretest	Experimental Posttest	Control Pretest	Control Posttest
Total	1417	2262	1396	2053
Mean	52.48	83.78	53.69	78.96
Maximum Score	71	97	71	94
Minimum Score	36	69	36	59
Variance	78.336	60.641	54.862	67.558
Standard Deviation	8.851	7.787	7.407	8.219
Number of Students	27	27	26	26

Based on Table 2, the mean pretest score for the experimental class was 52.48 and for the control class was 53.69; the difference was relatively small, indicating that both classes started with equivalent initial proficiency levels. Following the intervention, the mean posttest score for the experimental class rose to 83.78, while that of the control class rose to 78.96. The experimental class showed an increase of 31.30 points, which was greater than the 25.27-point increase observed in the control class. This descriptive result shows that the experimental class experienced a greater increase in the mean mathematical problem-solving score than the control class following the respective learning treatments.

The data in Table 2 also show a decrease in the variance and standard deviation of the experimental class from pretest to posttest. The experimental class's posttest variance decreased from 78.336 at pretest to 60.641 at posttest, accompanied by a drop in standard deviation from 8.851 to 7.787, indicating that differences in problem-solving ability among students in the experimental class narrowed after learning with the *Cooperative Learning*

model of the *Group Investigation* (GI) type supported by the *Make a Match* game. By contrast, the control class's posttest variance increased from 54.862 to 67.558, indicating that students' abilities in the control class remained fairly widely spread. In addition, the maximum posttest score in the experimental class reached 97 with a minimum of 69, while the control class recorded a maximum of 94 with a minimum of 59; the narrower score range in the experimental class (28 points) compared with the control class (35 points) further supports the indication that implementing the GI model supported by Make a Match not only raised the mean score but also evened out students' mathematical problem-solving achievement. This finding regarding improved mathematical problem-solving ability through structured, systematic instruction is consistent with the results of Rahmi et al. [27], who found that a clearly staged instructional approach significantly improved students' problem-solving, communication, and self-efficacy skills.

Prior to hypothesis testing, prerequisite analysis tests, specifically normality and homogeneity tests, were conducted. The normality test employed the Lilliefors formula at a significance level of $\alpha = 0.05$, with the criterion that data are normally distributed if L-calculated < L-table. The results of the normality test are presented in Table 3.

Table 3. Lilliefors Normality Test Results

Data	Class	N	L-calculated	L-table	Note
Pretest	Experimental	27	0.0843	0.1705	Normal
Pretest	Control	26	0.1737	0.1738	Normal
Posttest	Experimental	27	0.1043	0.1705	Normal
Posttest	Control	26	0.0943	0.1738	Normal

Based on Table 3, the calculated L-values for all data groups are smaller than the table L-values at a significance level of $\alpha = 0.05$; therefore, H0 is accepted, and the pretest and posttest data for both classes are deemed to be normally distributed. Next, a homogeneity test was conducted by comparing the largest and smallest variances using the F-test, with the criterion for homogeneity being Fcalculated < Ftable. The results of the homogeneity test are presented in Table 4.

Table 4. Homogeneity Test Results

Data	Experimental Variance	Control Variance	F calculated	F table	Note
Pretest	78.336	54.862	1.428	1.947	Homogeneous
Posttest	60.641	67.558	1.114	1.938	Homogeneous

Based on Table 4, the calculated F-value for both the pretest data (1.428) and the posttest data (1.114) is smaller than the critical F-value at a significance level of $\alpha = 0.05$; therefore, H_0 is accepted, and the data from both classes are deemed homogeneous. Since the data are normally distributed and homogeneous, the hypothesis testing proceeds using

the independent two-sample t-test. The results of the hypothesis testing are presented in Table 5.

Table 5. Results of the Hypothesis Test (t-Test) for Posttest Data

Class	t calculated	t table	Conclusion
Experiment	2.190	2.008	H0 rejected, Ha accepted

Based on Table 5, the calculated t-value is 2.190, which is greater than the critical t-value of 2.008 at a significance level of $\alpha = 0.05$ with df = 51. Since the calculated t-value is greater than the critical t-value, H0 is rejected, and Ha is accepted, which means there is a significant difference in means between the posttest scores of the experimental class and the control class. Thus, it can be concluded that the implementation of the Cooperative Learning model of the Group Investigation (GI) type, supported by the "Make a Match" game, has a significant effect on the mathematical problem-solving skills of eighth-grade students at Cerdas Murni Private MTs in the area of statistics.

Table 6. Effect Size (Cohen's d)

Statistic	Control Group	Experimental Group
Sample size (n)	26	27
Mean (M)	78.96	83.78
Std deviation (SD)	8.219	7.787
Pooled SD	8.002	
Cohen's d	0.60	

In addition to significance testing, this study also calculated the effect size to answer the second research question, namely the magnitude of the effect of the *Cooperative Learning* model of the *Group Investigation* (GI) type supported by the *Make a Match* game on students' mathematical problem-solving ability. The calculation was performed using Cohen's d based on the difference between the posttest means of the two classes divided by the pooled standard deviation. The classification of effect size magnitude in this study follows the original scale by Cohen [25], later expanded by Sawilowsky [26] into six categories for a more detailed classification, as presented in Table 7. The results of the Cohen's d calculation for this study are presented in Table 6.

Table 7. Interpretation Criteria for Cohen's d

Cohen's d Value	Category	Description
0.00 – 0.19	Very Small	*Negligible effect*
0.20 – 0.49	Small	*Small effect*
0.50 – 0.79	Medium	*Medium effect*
0.80 – 1.19	Large	*Large effect*
1.20 – 1.99	Very Large	*Very Large effect*
> 2.00	Very Large	*Huge effect*

Based on Table 6, the calculated Cohen's d value is 0.60, which, based on the criteria in Table 7 [26], falls within the 0.50–0.79 range, i.e., the medium effect category. This value was derived from the 4.82-point difference between the posttest means of the experimental and control classes, divided by the pooled standard deviation of 8.00. Thus, in addition to the statistically significant difference identified by the t-test, the Cohen's d value of 0.60 indicates a medium effect of the Cooperative Learning model of the Group Investigation (GI) type supported by the Make a Match game on students' mathematical problem-solving ability. This finding is consistent with Capar and Tarim [28], who reported a positive effect of cooperative learning on mathematics achievement, and with Klang et al. [29], who found that cooperative learning had a significant effect on students' mathematical problem-solving ability in heterogeneous classrooms. These findings provide supporting evidence that cooperative learning can contribute to students' mathematics learning outcomes, although the magnitude of the effect may vary across learning contexts.

These findings align with the characteristics of the Group Investigation (GI) model, which requires students to understand the problem before devising an investigation plan, conducting the inquiry systematically, and evaluating their findings—stages that essentially correspond to Polya's [18] four aspects of problem-solving: understanding the problem, planning a solution, carrying out the plan, and looking back. Rusman [8] and Sanjaya [9] explain that Group Investigation actively engages students in the inquiry process through structured group work, thereby providing them with opportunities to plan learning activities, gather data, and communicate their learning outcomes. The incorporation of the "Make a Match" game element further contributes to a more interactive learning atmosphere, ensuring that students do not merely receive information passively but actively construct their own understanding through collaboration within heterogeneous groups.

The results of this study reinforce the findings of Ningsih [11], which demonstrated the impact of the Group Investigation (GI) model on the problem-solving abilities of eighth-grade students at MTsN Kerinci Regency, as well as those of Palupi and Rahayu [12**]**, who showed the effectiveness of GI in enhancing mathematical critical thinking skills compared to the Teams Games Tournament model. These findings also align with Sundari [13], who found that the "Make a Match" strategy influences students' mathematical communication skills, and Sahraini et al. [14], who demonstrated that integrating game elements into mathematics instruction fosters active student participation and strengthens problem-solving skills. By combining GI and "Make a Match," this study addresses a gap in previous research, which had examined these models only in isolation.

Nevertheless, this study has limitations. Some students required an adjustment period at the beginning because they were accustomed to conventional instruction; limited instructional time meant that not all stages of the GI model augmented by "Make a Match" could be fully optimized; and the study was confined to a single topic (statistics), meaning the results cannot necessarily be generalized to other mathematical topics with different characteristics.

4. CONCLUSION

Based on the research results and discussion, it can be concluded that the implementation of the Group Investigation (GI) cooperative learning model supported by the Make a Match game had a significant effect on students' mathematical problem-solving ability in statistics at MTs Swasta Cerdas Murni. This conclusion is supported by the independent samples t-test, which resulted in a t-calculated value of 2.190, greater than the t-table value of 2.008 at $\alpha = 0.05$, leading to the rejection of H0 and acceptance of Ha. The experimental class obtained a higher posttest mean score (83.78) than the control class (78.96), with mean increases of 31.30 and 25.27 points, respectively. Furthermore, the Cohen's d value of 0.60 indicates a medium effect, showing that the implementation of the GI model supported by the Make a Match game produced a moderate effect on students' mathematical problem-solving ability. These findings indicate that the combination of GI and Make a Match can be considered an alternative learning approach for supporting students' mathematical problem-solving ability in statistics.

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