

Optimizing Student Motivation and Learning Outcomes Through Group Investigation Cooperative Learning Model on Ratio Material: A Study of Mathematical Reasoning Ability

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Abstract

This study aims to examine the effectiveness of the application of the Group Investigation cooperative learning model in optimizing student motivation and learning outcomes on ratio material, as well as analyzing its contribution to mathematical reasoning skills. This study used a quantitative approach with a pre-test and post-test design involving 20 junior high school students in grade VII. Data were obtained through mathematical reasoning ability test, motivation questionnaire, and analysis of students' learning outcomes. The results showed an increase in the mean score from pre-test to post-test by -6.50 ($p = 0.001$) which reflects more uniform student learning outcomes. Regression analysis showed a very strong relationship between the independent variable (mathematical reasoning) and the dependent variable (motivation and learning outcomes) with an R value of 0.929 and R² of 86.4%, indicating that motivation and learning outcomes explained most of the variation in reasoning ability. Specifically, the contribution of mathematical reasoning (X) to student learning outcomes (Y2) was 38.94% while the contribution of motivation (Y1) to mathematical reasoning reached 45.83%. In addition, regression analysis shows that motivation has a significant influence on mathematical reasoning ability, while learning outcomes have a positive but statistically insignificant influence. This finding indicates that the Group Investigation cooperative learning model is not only effective in improving student learning outcomes, but also has an important role in strengthening mathematical reasoning skills through increased motivation. Therefore, cooperative learning strategies that emphasize increased motivation need to be applied in mathematics learning to optimize students' analytical thinking skills.

Keywords: cooperative learning, critical thinking skills, learning atmosphere, learning motivation, learning styles, meaningful learning.

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1. Introduction

Student motivation and learning outcomes are crucial aspects in learning mathematics, especially in ratio material which is often considered difficult by students (Cahyani et al., 2024). The understanding of ratios does not only rely on arithmetic skills, but also on understanding the concept of the relationship between two quantities that can

be applied in everyday life situations (Mirna et al., 2023). However, many students have difficulty in understanding this concept due to their lack of ability to connect theory with practice and different learning styles that affect their level of understanding. The purpose of Mathematics at school is not only understanding the concepts by students but also applying the concepts learned to solve

problems in their live (Silwana et al., 2021). This difficulty is further complicated by the differences in learning styles between students that affect their level of understanding of the material. In addition, low motivation to learn mathematics is one of the main obstacles in achieving maximum learning outcomes. Research by Habibullah et al. (2022) said that many students consider math as a difficult and boring subject so they are less active in the learning process. Given these challenges, an effective learning strategy is needed to increase students' motivation and understanding of the ratio concept.

Mathematical reasoning skills play a crucial role in deepening understanding of mathematical concepts. Mathematical reasoning not only involves calculation skills, but also includes logical and analytical thinking processes that allow students to integrate various concepts and apply them in more complex situations (Norhidayah, 2023). According to research by Taliak et al. (2024) that in this dynamic era, logical and analytical thinking skills are increasingly urgent to develop, given the rapid advancement of technology and the increasing complexity of the problems faced. In the context of mathematics, these skills give students the ability to solve problems that are not just routine, but also those that require a deep understanding of the relationships between concepts as well as the ability to make decisions based on valid evidence and logic (Hasanah et al., 2019). Therefore, Firdaus et al. (2021) argued that the development of mathematical reasoning ability is very important in equipping students with the thinking skills needed to face future challenges, both in the academic realm and in everyday life. Strengthening these skills also serves as the basis for forming individuals who think critically and are able to face challenges in various fields of science and technology.

The cooperative learning model is one approach that has the potential to increase student engagement that emphasizes social interaction and cooperation in groups (Harianto, 2024). Thomas & Martina (2022) explain that this approach encourages students to work in small groups, where they can exchange ideas, discuss, and complete tasks together, thus creating a more active and collaborative learning atmosphere. According to research by Zitha et al. (2023) and Atteh et al. (2020) that in this model, collaboration becomes the main principle that demands active participation of each group member, allowing students to not only gain a deeper understanding of the material, but also develop very important social and communication skills. Through these interactions, students are expected to learn from each other which in turn improves their understanding of the material being taught. This approach also supports more meaningful learning, where students do not just passively receive information, but also play an active role in the construction of their knowledge (Indarwati et al., 2024). Thus, cooperative learning models not only improve understanding of the subject matter, but also provide room for the development of interpersonal skills that are essential in everyday life and in the world of work.

Among the various cooperative learning models, Group Investigation (GI) has shown effectiveness in improving understanding of mathematical concepts through joint exploration in groups (Fatihatussa'adah et al., 2024). This approach creates a dynamic and active learning environment, where students engage in discussions, share responsibilities, and work together to investigate a topic being studied (Kanisius et al., 2024). One of the main characteristics of this model is the division of tasks within the group, where each member is assigned a specific role that en-

courages accountability and teamwork (Acoci, 2023). According to research by Nofriansyah et al. (2024) suggests that shared responsibility is also a key principle in this model, where every student contributes to the investigation process, ensuring that every opinion is valued and taken into account. In addition, Solikah et al. (2024) said that this model facilitates peer learning, which is learning among classmates that allows students to improve their understanding through different perspectives. In the context of investigation-based exploration, students actively participate in the planning and execution of their investigations, which not only increases their motivation and interest in the subject matter, but also hones critical thinking skills, especially as they analyze information and draw conclusions based on the findings obtained (Ifaksasily & Muskita, 2024). This model often links investigations to relevant real-world problems, making learning more meaningful and applicable. Although the Group Investigation model has significant benefits in improving student engagement and learning outcomes, its implementation requires careful planning and management so that each student can participate optimally (Apriani et al., 2024). Therefore, support and guidance from the teacher is needed to ensure that this cooperative learning strategy can be implemented well.

The relationship between the application of cooperative learning methods and student learning motivation shows a significant influence, as evidenced by various studies that show a positive impact on student engagement and motivation (Aljura et al., 2025). Cooperative learning creates an interactive learning atmosphere, where students work together to achieve a common goal which in turn can increase their motivation to learn. This model has been proven to significantly improve student learning outcomes, especial-

ly in complex subjects such as chemistry (Tampubolon, 2024). The integration of cooperative learning with motivational strategies has also been shown to improve overall academic performance, as highly motivated students tend to achieve better results. In addition, cooperative learning encourages students' active participation which is essential to maintain their interest and motivation in the learning process (Sahrazad et al., 2023). Approaches such as team learning and group discussions can strengthen the sense of responsibility and build trust among students which in turn encourages them to be more engaged in the learning process. In addition, through cooperative learning students also develop important social skills, contributing to the creation of a more motivating learning environment. The collaborative nature of this model helps students build stronger relationships, thus enriching their overall educational experience (Ismunandar et al., 2023). Despite the effectiveness of cooperative learning, it is possible that some students thrive in a competitive or individualized environment, suggesting that a uniform approach may not be optimal for all types of learners.

Although various studies have shown the benefits of cooperative learning, studies on the effectiveness of the Group Investigation (GI) model in improving student motivation and learning outcomes in ratio materials are still limited (Triana & Mukhtar, 2024). In addition, this model was able to significantly improve critical thinking skills compared to conventional teaching methods at various levels of students' initial abilities. Furthermore, the GI model was found to be more effective than the Think Pair Share model in developing students' critical thinking skills (Nurmeidina et al., 2025). In terms of problem solving, the implementation of GI also resulted in an increase in students' ability to solve mathematical problems, from

the “Good Enough” category to “Good” after two implementation cycles (Wati & Fauzan, 2020). Some previous studies have revealed that this approach can improve concept understanding and critical thinking skills, but not many have specifically analyzed its impact on mathematical reasoning and student engagement in ratio learning. Therefore, this study seeks to fill the gap by examining more deeply the implementation of the Group Investigation model in ratio learning.

This study aims to analyze the effectiveness of the Group Investigation learning model in increasing student motivation and learning outcomes on ratio material. Thus, the results of this study are expected to contribute to the development of learning strategies that are more effective in increasing student engagement and understanding in mathematics learning and in various aspects of life.

2. Method

This research uses quantitative methods with an experimental or quasi-experimental approach with a pretest-posttest research design. This study aims to determine the extent to which the application of the Group Investigation cooperative learning model can improve students' mathematical reasoning ability, learning motivation, and learning outcomes on ratio material. The research

subjects are seventh grade students in junior high school. The research sample will be randomly selected using simple random sampling technique to ensure the representativeness of the participants. The selected students will be divided into one group, namely the experimental group. The experimental group will get math learning on ratio material with the Group Investigation cooperative learning model approach. The research instruments used were reasoning ability tests and student learning outcomes. The test consisted of 4 questions, namely 2 pretest questions and 2 posttest questions designed to measure understanding of the concept of ratio, mathematical reasoning ability, and problem solving skills. The validity and reliability of the test were tested using the t-test and the questionnaire consisted of 5 questions each covering aspects of mathematical reasoning ability, learning motivation, and learning outcomes. Using a Likert scale with a score range from 1 to 5, answer options ranging from strongly agree (score 5), agree (score 4), neutral (score 3), disagree (score 2), and strongly disagree (score 1). The validity of the questionnaire was tested using regression analysis. The research procedure used is as in Figure 1.

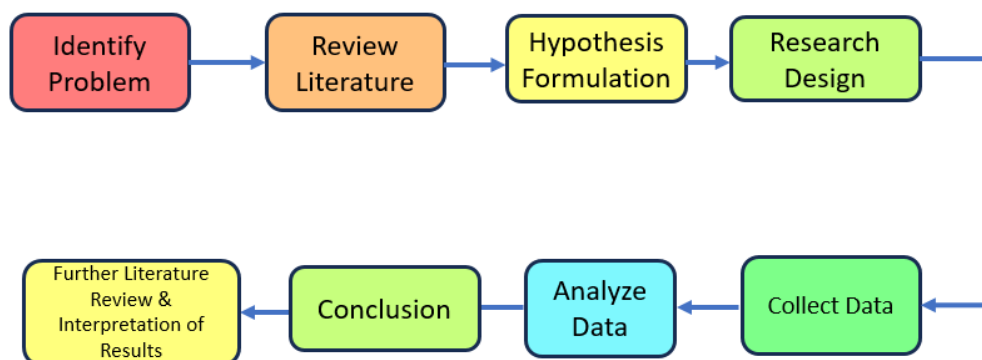


Figure 1. Research Procedure

The research procedure as presented in Figure 1. begins with problem identification where the research finds problems or phenomena in learning mathematics, especially on the concept of ratio and challenges in increasing students' motivation and mathematical reasoning. Next, the researcher conducted a literature review to trace relevant prior research. Researchers reviewed various previous studies related to cooperative learning models, Group Investigation, and their effects on students' motivation and mathematical reasoning. The next stage is research design by determining the pretest-posttest research design, sampling technique, and research instruments to be used. Then compile and test the validity and reliability of the instrument before being used in research. Furthermore, data collection, researchers held a pretest to students to determine their initial ability before the application of the Group Investigation model. The experimental group received learning with the Group Investigation model on ratio material for a certain period. After the learning was

completed, the researcher held a posttest to see changes in students' abilities. The data were then analyzed in the data analysis stage using statistical techniques. Data obtained from pretests and posttests were analyzed using statistical parametric paired sample t-test to identify significant changes in concept understanding, mathematical reasoning and student learning outcomes. Data from the questionnaire was analyzed using regression analysis to see the distribution of motivation scores before and after learning using the Group Investigation cooperative learning model. Next, the researcher conducted a further literature review and interpretation of the results. The results of the analysis were compared with previous research to see the suitability of the findings and the factors that contributed to the improvement of learning outcomes and student motivation. The final stage is conclusion and report writing, where the researcher presents the findings. The results are published or used as practical recommendations.

Table 1. Research Indicator

No	Variables	Indicator	Reference
1	Mathematical reasoning ability (X1)	Students' ability to Identify the relationship between numbers in ratios (for example, ratios in forms or fractions).	(Nugraha & Sujadi, 2016)
		Construct logical arguments to solve ratio problems.	(Firmanti, 2017)
		Apply the concept of ratio in solving contextual problems, such as dividing amounts according to a certain ratio.	(Dinata et al., 2023)
		Connecting and applying the concept of ratio to equal and inverse value comparisons.	(Dinata et al., 2023)
2	Learning motivation (Y1)	Student learning motivation score before and after intervention (from questionnaire)	(Rohmah & Zulfitria, 2024)
		Number of students who actively ask, answer, or give opinions during the learning of ratio material.	(Nababan et al., 2021)
		Students' enthusiasm in completing ratio-based group and individual tasks (from observation).	(Arief & Sudin, 2016)
		Students' perceptions of the relevance of ratio learning to daily life.	(Mabruri, 2022)
3	Learning outcomes (Y2)	The average increase in student learning outcomes test scores before (pretest) and after learning (posttest) on the ratio material.	(Huda, 2016)
		Percentage of students who reach or exceed the Minimum	(Yuliana et al.,

No	Variables	Indicator	Reference
		Completion Criteria (KKM) on ratio material.	2017)
		Students' ability to solve ratio problems based on HOTS (Higher Order Thinking Skills).	(Widhiyani et al., 2019)
		Students' ability to apply the concept of ratios in real life, such as in the distribution of goods or financial comparisons.	(Puspita et al., 2023)

3. Result and Discussion

The results and discussion in this study highlight the ability of mathematical reasoning, motivation in learning mathematics and student learning outcomes on the use of the Group Investigation

cooperative learning model. The research data is the data of students' mathematical reasoning learning outcomes by using two tests, namely the pre-test and post-test.

Table 2. Descriptive Statistic Result Values Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test	85.0000	20	5.61951	1.25656
	Post-test	91.5000	20	4.32252	.96655

Table 2 shows the descriptive statistical results of the paired samples test comparing the pre-test and post-test scores of student learning outcomes. The average pre-test score is 85 with the lowest score of 80 and the highest score of 95 and a standard deviation of 5.62 which indicates a variation in scores between students with a variance of 31.57. After the treatment, the average post-test score increased to 91.5 with the lowest score remaining at 80 and the highest score increasing to 100. The distribution of data in the post-test shows a decrease in standard deviation to 4.32 with a variance of

18.68 which indicates that student scores after treatment are more homogeneous than the pre-test. In addition, the Standard Error Mean also decreased from 1.26 in the pre-test to 0.97 in the post-test, indicating that the average learning outcomes after treatment were more stable. Overall, the average increase from 85 (pre-test) to 91.5 (post-test) shows a significant difference in student learning outcomes, so it can be concluded that the treatment provided had a positive impact on improving students' overall abilities. N-Gain results in accordance with Figure 2.

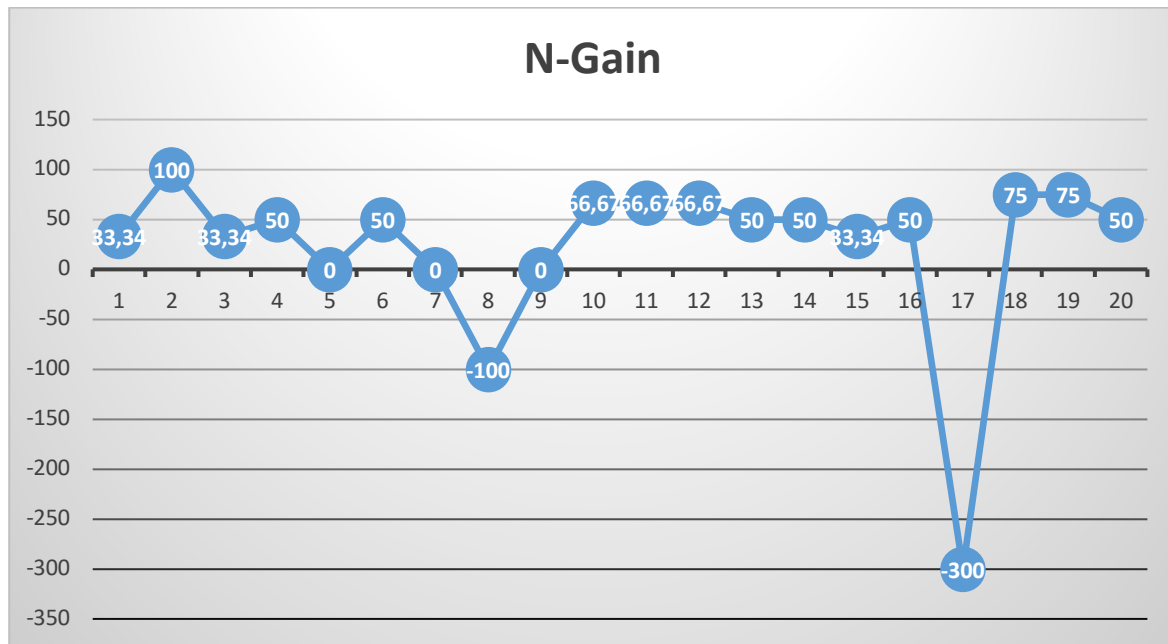


Figure 2. N-Gain value

Figure 2 shows the variation in the increase and decrease in student learning outcomes after the application of the Group Investigation cooperative learning model on ratio material related to mathematical reasoning skills. Overall, most students showed an increase in learning outcomes as seen from the N-Gain values which tended to be positive in the majority of subjects as seen in the 2nd subject with a value of 100 as well as several other samples which were relatively stable in the range of 50 to 75. However, there were significant fluctuations in the changes in N-Gain values in the 20 research samples with a range of values between -300 to 100 where some students

experienced a drastic decrease in learning outcomes even reaching extreme negative values. This finding indicates that although the cooperative learning model has the potential to optimize students' motivation and learning outcomes, its effectiveness is still influenced by individual factors and group dynamics. Therefore, a more adaptive implementation strategy is needed so that the improvement of mathematical reasoning skills can be evenly distributed to all students so that optimal learning outcomes can be achieved as a whole. The results of the paired sample t-test are shown in Table 3.

Table 3. Paired Samples Statistics t-test results

		N	Correlation	Sig
Pair 1	Pre-test & Post-test	20	-.108	.649

Table 3 shows the results of the correlation test or the relationship between two data or the relationship between the pre-test and post-test variables. The table above shows that the correlation coefficient value (correlation) of -0.108 indicates a very weak and negative relationship between pre-test

and post-test scores with a significant value (Sig.) of 0.649. Because the Sig. value of $0.649 > \text{probability } 0.05$, it shows that the relationship is not statistically significant. So it can be said that there is not enough evidence to state that there is a relationship between the pre-test variable and the post-

test variable. The results of the paired samples test as shown in Table 4.

Table 4. Paired Samples Test results

		Paired Differences					t	df	Sig. (2-tailed)
		95% Confidence Interval of the Difference							
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Pre-test & Post-test	-6.50000	7.45160	1.66623	-9.98746	-3.01254	-3.901	19	.001

Table 4 shows that there is a significant mean difference between the pre- and post-treatment data with a mean difference of -6.50 indicating the post-test mean score is lower than the pre-test. The standard deviation of the difference is 7.45 and the standard error of the mean is 1.67. The 95% confidence interval for the mean difference ranges from -9.98 to -3.01 which does not

include zero, indicating that the difference is statistically significant. The t-value of -3.901 with a degree of freedom (df) of 19 and a significant value (sig. 2-tailed) of 0.001 which is smaller than 0.05 further strengthens the conclusion that the treatment has a significant effect on changes in data. Model summary test results as shown in Table 5.

Table 5. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.929 ^a	.864	.849	7.930

a. Predictors: (Constant), X1

Table 5 shows that the results of the summary model show that the R value of 0.929 indicates a very strong relationship between the independent variable X1 and (Y1 and Y2). The R Square value of 0.864 means that 86.4% of the variation of (Y1 and Y2) can be explained by X1, while the remaining (13.6%) is explained by other

factors outside the model. Adjusted R Square of 0.849 shows the stability of the model by considering the number of predictors and the standard error of the estimate of 7.930 shows the average distance of the model prediction to the actual value. Anova test results as shown in Table 6.

Table 6. ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7187.988	2	3593.994	57.148	.000 ^b
	Residual	1132.012	18	62.890		
	Total	8320.000	20			

a. Dependent Variable: Y2, Y1

b. Predictors: (Constant), X1

Table 6 shows that the regression model involving the independent variable X1 (reasoning) is simultaneously able to explain variations in the dependent variables Y1

(motivation) and Y2 (learning outcomes) significantly. This is indicated by the calculated F value of 57,148 with a significant value of 0.001 ($p < 0.05$) which

means that the regression model as a whole is significant. The Sum of Squares Regression value of 7187.988 shows the variation in Y that can be explained by the

model. Thus, this analysis confirms that X1 has a significant influence on Y1 and Y2 together. The results of the X1 coefficients test on Y1 are as shown in Table 7.

Table 7. Results of Coefficients^a X1 on Y1

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1	(Constant)	4.993	19.243	.259	.798
	X1	.919	.235	.677	.001

a. Dependent Variable: Y1

Table 7 shows that variable X1 has a significant influence on Y1 with a regression coefficient of 0.919 and a significance value of 0.001 ($p < 0.05$) indicating that every one unit increase in X1 will significantly increase Y1. In contrast, the constant in the model has a regression coefficient of 4.993 with a significance value of 0.798 ($p > 0.05$) so the effect of Y1 is not statistically significant and does not contribute signifi-

cantly in this regression model. In addition, the standardized beta value for X1 of 0.677 and the calculated t value of 3.905 further confirms that the influence of X1 on Y1 is quite strong. Overall, these results show that an increase in X1 can significantly increase Y1, making X1 an important variable in this model. The results of the coefficients test X1 on Y2 as shown in Table 8.

Table 8. Results of Coefficients^a X1 on Y2

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1	(Constant)	23.362	16.765	1.394	.180
	X1	.692	.204	.624	.003

a. Dependent Variable: Y2

Table 8 shows that variable X1 has a significant effect on Y2 with a regression coefficient of 0.692 and a significance value of 0.003 ($p < 0.05$) which indicates that any increase in the implementation of the GI model has a significant impact on student learning outcomes.. The standardized beta value for X1 of 0.624 and the calculated t value of 3.390 further confirms that its influence on Y2 is quite strong. Meanwhile, the constant in the model has a coefficient value of 23.362 with a significance value of 0.180 ($p > 0.05$) so it is not statistically significant and does not contribute significantly

to this regression model. Overall, these results suggest that X1 plays an important role in influencing Y2, which needs to be considered in further analysis.

Based on the regression analysis results in Table 7 and Table 8, the regression equation shows that X1 has a significant effect on both Y1 and Y2. The regression equation for Y1 is $Y1 = 4.993 + 0.919X1$ while for Y2 is $Y2 = 23.362 + 0.692X1$ with significance values of 0.001 and 0.003 respectively ($p < 0.05$). The comparison shows that the effect of X1 on Y1 is greater than that on Y2 as indicated by the higher regression

coefficient value (0.919 vs. 0.692) and larger standardized beta value (0.677 vs. 0.624).

In addition, the constant in the Y2 model is larger (23.362) than in the Y1 model (4.993) indicating that without the influence of X1 the base value of Y2 is higher than Y1. Overall, these results show that while X1 has a significant effect on both variables, its effect on Y1 is stronger than on Y2. Therefore, if the analysis is looking for a simpler and more significant model, the second model is faster to use but if considering the interrelationship between the two predictor variables the first model remains relevant even though Y2 is not significant in that context.

This study shows that the application of the Group Investigation (GI) type cooperative learning model on ratio material has a positive impact on student motivation and learning outcomes, especially in mathematical reasoning skills (Sukardi et al., 2024). This can be seen from the increase in the average pre-test to post-test score from 85 to 91.5 indicating that this intervention was successful in improving students' concept understanding and skills in the material taught. This increase not only illustrates the success of the intervention in improving students' overall ability but also reflects the effectiveness of the cooperative model in facilitating meaningful learning. This is in line with the findings of Hidayah et al. (2023) who showed that the GI model is effective in improving student achievement and motivation to learn. In addition, the decrease in standard deviation from 5.61 to 4.32 indicates that student learning outcomes became more uniform after the application of the GI model, which means that disparities between individuals in the study group were reduced. This research also indicates that the GI model can improve students' mathematical

communication, collaboration, and creative thinking skills. Thus, the implementation of the Group Investigation type cooperative learning model on ratio material is effective in optimizing student motivation and learning outcomes through improving mathematical reasoning skills.

Another aspect that supports the effectiveness of this intervention is the ability of students to achieve the highest score of 100 on the post-test without any decrease in the minimum score which remains at 80 (Ebbels et al., 2022). This fact shows that cooperative learning can successfully improve students' learning outcomes, including those with lower initial abilities (Mulyono & Elly, 2020). This is consistent with the theory that cooperative learning provides opportunities for active learning through interaction between individuals, which in turn can increase students' understanding and motivation (Sudarsana, 2018). However, the t-test results confirmed that the increase in pre-test to post-test scores was significant ($p < 0.05$), indicating the effectiveness of the GI model in improving student learning outcomes. In addition, the correlation analysis between the pre-test and post-test scores showed a correlation coefficient of -0.108 with a significance value of 0.649 indicating that there was no significant linear relationship between the initial learning outcomes and students' final achievement. This suggests that the GI model can benefit all students, regardless of their initial level of understanding, making learning more inclusive and adaptive (Rahmawati, 2024).

In addition to improving learning outcomes, the GI model also has a positive impact on students' learning motivation. The regression analysis conducted shows that variable X1 (GI learning intervention) has a

significant influence on learning motivation (Y1) with a regression coefficient of 0.919 and a significance value of 0.001 ($p < 0.05$). The standardized beta value of 0.677 and t-count of 3.905 further reinforce that this intervention has a moderately strong effect on increasing student motivation. Furthermore, based on the regression results in Table 8 the GI model also contributes to improving learning outcomes (Y2) with a regression coefficient of 0.692 and a significance value of 0.003 ($p < 0.05$) which indicates that any increase in the implementation of the GI model has a significant impact on student learning outcomes. The standardized beta value of 0.624 and t-count of 3.390 support the finding that GI not only improves concept understanding but also creates a more collaborative and effective learning environment. Thus, the application of the Group Investigation cooperative learning model not only has a positive impact on student learning motivation (Y1), but also significantly contributes to improving student learning outcomes (Y2). Overall, these findings indicate that the Group Investigation cooperative learning strategy is an effective approach in optimizing students' motivation and learning outcomes on ratio materials, as well as supporting the

4. Conclusion

The results of this study show that the implementation of Group Investigation cooperative learning model on ratio material is effective in improving students' learning outcomes and motivation. The increase in mean score from pre-test to post-test by -6.50 and the decrease in standard deviation by 7.45 showed that this intervention not only improved students' understanding but also reduced the gap in learning outcomes between them. In addition, student

development of mathematical reasoning skills more optimally.

The implication of this finding confirms that learning motivation plays an important role in improving students' mathematical reasoning (Ndruru et al., 2024). Motivation not only serves as a driver of students' active involvement in the learning process but also as a significant predictor of mathematical reasoning ability (Pratiwi, 2024). Therefore, to optimize the application of the Group Investigation cooperative learning model on ratio material, educators are advised to integrate strategies that can increase student motivation such as providing constructive feedback, challenging tasks, and creating a supportive learning environment. Although this study showed positive results, further studies are needed on the contribution of learning outcomes to mathematical reasoning. Future studies could explore how factors such as additional learning strategies, students' academic background, and involvement in group discussions could strengthen the impact of cooperative learning. In addition, further research in the context of other subject matter can help understand the extent to which the effectiveness of the GI model can be applied more broadly in mathematics learning.

motivation was shown to have a significant influence on mathematical reasoning ability, indicating that cooperative learning not only contributes to academic achievement but also strengthens students' thinking skills through increased motivation. Regression analysis showed that 86.4% of the variation in X1 could be explained by Y1 and Y2 with the ANOVA test confirming the significance of the model at $p=0.000$. In addition, the contribution of X to Y1 was recorded at 45.83%, while X to Y2 was 38.94%. However, although learning outcomes have a

positive influence on mathematical reasoning, their contribution in this study is not significant so further research is needed to understand other factors that may be more influential in improving students' thinking skills. The findings provide insights for educators on the importance of integrating cooperative learning models in mathematics teaching. To increase the effectiveness of Group Investigation, educators can optimize strategies such as providing more personalized feedback, more structured group discussions, and challenging project-based tasks. In addition, creating a learning environment that supports social interaction and collaboration between students can strengthen the positive impact of this model on motivation and learning outcomes. Although this study showed positive results, there are some limitations that need to be considered. The limited sample size and limitations in controlling confounding factors such as differences in students' academic backgrounds and learning styles may affect the generalizability of these findings. Therefore, future research is recommended to use a larger and more heterogeneous sample and consider additional variables such as metacognitive strategies and learning environment factors in analyzing the effectiveness of the Group Investigation model. Thus, these findings confirm that a collaboration-based learning approach can be an effective solution in improving students' mathematical thinking skills and creating a more meaningful learning experience. The results of this study can serve as a basis for improving educational policies in designing more inclusive and innovative learning methods to support students' optimal academic achievement.

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