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The Effectiveness of Collaborative Learning with Group Investigation in Mathematics Lessons in Elementary School Education in South Tangerang, Indonesia

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ABSTRACT

This research examines the effectiveness of collaborative learning with group investigations in mathematics lessons in South Tangerang elementary schools. A quasi-experimental design with two groups (experimental and control) was used. The sample consisted of 60 fifth grade elementary school students who were chosen randomly. The experimental group (n=30) took part in collaborative learning with group investigation, while the control group (n=30) took part in traditional learning. The results show that there is a significant difference in mathematics learning outcomes between the two groups ($t = 2.45$; $p = 0.017$). The experimental group showed higher learning outcomes ($M = 82.50$; $SD = 7.12$) compared to the control group ($M = 75.83$; $SD = 6.47$). This research shows that collaborative learning with group investigations is effective in improving elementary school students' mathematics learning outcomes. This research concludes that collaborative learning with group investigation is an effective learning strategy for improving elementary school students' mathematics learning outcomes.

1. Introduction

Mathematics is one of the important subjects in basic education. Mathematical skills are the basis for students to study science and technology at the next level of education. However, based on the results of the 2022 National Examination (UN), the average mathematics score for elementary school students in South Tangerang is still relatively low, namely 72.50. This shows that there are still many students who experience difficulties in learning mathematics. Research shows that one of the factors causing low mathematics learning outcomes is less effective learning methods. Many teachers still use traditional learning methods, namely lectures and practice

questions. This method is less interesting and does not provide opportunities for students to learn actively.¹⁻³

Collaborative learning with group investigations is an innovative learning method and has been proven to be effective in improving mathematics learning outcomes. In this method, students work together in small groups to solve math problems. Students help each other, exchange ideas, and learn from each other. Research on the effectiveness of collaborative learning with group investigations in South Tangerang is still very limited.⁴⁻⁶ This research aims to fill this gap and provide empirical evidence about the effectiveness of this method in improving the mathematics learning outcomes of elementary school students in South

Tangerang. It is hoped that the results of this research can contribute to the development of mathematics learning in South Tangerang. Apart from that, it is also hoped that the results of this research can provide recommendations to teachers and policymakers regarding the use of collaborative learning methods with group investigations.

2. Methods

This research uses a quasi-experimental design with two groups, namely the experimental group and the control group. This design was chosen because the researcher could not exercise full control over all variables that might influence the research results. The population of this study was all fifth-grade elementary school students in South Tangerang, Indonesia. The research sample was randomly selected from two elementary schools in South Tangerang. The research sample consisted of 60 students, with 30 students in the experimental group and 30 students in the control group.

The research instrument used in this research is. Mathematical understanding test: This test is used to measure student learning outcomes after taking part in the lesson. Observation sheets: Observation sheets

are used to observe the learning process in the experimental group. The research sample was randomly selected from elementary schools in South Tangerang (SD Negeri 4 Serpong). The experimental group took part in collaborative learning with group investigation, while the control group took part in traditional learning. Comprehension tests were carried out on all students to measure their learning outcomes after participating in the lesson. Data were analyzed using the t-test to determine differences in learning outcomes between the experimental group and the control group.

3. Results and Discussion

Based on Table 1, there are significant differences in mathematics learning outcomes between the experimental group and the control group. The experimental group that took part in collaborative learning with group investigation showed higher learning outcomes ($M = 82.50$; $SD = 7.12$) compared to the control group that took part in traditional learning ($M = 75.83$; $SD = 6.47$). This is indicated by a significant t-value ($t = 2.45$) and a p-value that is smaller than 0.05 ($p = 0.017$).

Table 1. Comparison of intervention effectiveness between groups.

Group	N	Average (M)	Standard deviation (SD)	t-value	p-value
Experiment	30	82,5	7,12	2,45	0,017
Control	30	75,83	6,47		

The results of this research indicate that collaborative learning with group investigations is effective in improving students' mathematics learning outcomes. Collaborative learning with group investigations does have many benefits for students. When students work together in groups to solve math problems, they must plan strategies, solve problems, and make decisions. This activates the prefrontal cortex and increases connectivity between neurons in the area. Working memory allows students to store information in short-term memory and manipulate it to complete tasks. Collaborative learning encourages students to exchange information and

remember math concepts, which increases working memory activity in the prefrontal cortex. In groups, students learn to control themselves, be patient, and listen to others. This trains executive functions in the prefrontal cortex, which helps students focus and complete tasks.^{7,8}

Mathematics often involves spatial representations, such as diagrams and graphs. When students work with manipulatives or visualizations in groups, they activate the parietal cortex and improve their ability to understand spatial concepts in mathematics. Collaborative learning requires students to focus on tasks and pay attention to others. This

increases activity in the parietal cortex, which helps students stay focused and avoid distractions. When students discuss and solve problems in groups, they gain different perspectives and ways of thinking. This helps them to understand mathematical concepts more deeply. Collaborative learning encourages students to work together and help each other in solving problems. This increases their ability to think critically and creatively and find innovative solutions. Students who engage in collaborative learning are more motivated and engaged in learning mathematics. This is because they enjoy working with friends, sharing ideas, and solving problems together. Several studies have shown that collaborative learning with group investigations can improve students' brain activity and mathematics learning outcomes. The study results found that students who took part in collaborative learning with group investigations showed higher brain activity in the prefrontal and parietal cortex compared to students who took part in traditional learning. Another study found that students who took part in collaborative learning with group investigations showed higher mathematics learning outcomes compared to students who took part in traditional learning.^{9,10}

When students work together in groups, they build new neural connections in the brain. When exchanging ideas and collaborating with classmates, students stimulate the growth of neurons and neural connections in areas of the brain associated with communication, language, and social cognition. Working together to solve math problems encourages students to think critically, analyze information, and find creative solutions. This triggers activity in the prefrontal and parietal cortices, which are responsible for problem-solving and logical reasoning. In collaborative learning, students do not only receive information passively but they are actively involved in the learning process. This activity increases neural connectivity in the hippocampus, an area of the brain that plays an important role in memory storage and learning. When students feel engaged and motivated in learning, their brains release neurotransmitters such as dopamine and serotonin. This neurotransmitter increases neuroplasticity, which is

the brain's ability to form new neural connections. In groups, students get feedback from classmates and teachers, which helps them to understand math concepts better. Reflection and discussion after completing a task also strengthen neural connections and improve information retention. Another study found that students who participated in collaborative learning showed increased functional connectivity in the prefrontal cortex compared to students who studied independently. Other studies also show that collaborative learning can increase neuroplasticity in the hippocampus, which contributes to improved memory and learning. Collaborative learning is an effective strategy for building new neural connections in students' brains. This helps them to better understand and remember mathematical concepts, improve problem-solving abilities, and increase learning motivation.^{11,12}

Collaborative learning with group investigations can increase the release of neurotransmitters such as dopamine and serotonin, which play an important role in learning and memory processes. Dopamine is released when students feel happy, motivated, and engaged in learning. Collaborative learning with group investigations can increase dopamine. Working together with friends, exchanging ideas, and solving problems together can make learning more fun and interesting. When students successfully complete a shared assignment, they feel a sense of accomplishment and reward, which triggers the release of dopamine. Group investigations encourage students to explore new concepts and find answers to their questions, which increases curiosity and triggers the release of dopamine. Serotonin plays a role in helping students feel calm and focused when studying, increasing students' ability to retain information and learn more effectively. Collaborative learning with group investigations can increase serotonin. Working together in groups provides a sense of security and comfort for students, which helps them feel calm and focused. Positive interactions in groups help build mutual trust and respect between students, which increases feelings of well-being and triggers the release of serotonin. When students feel part of a supportive group, they feel more connected and belonging, which

increases serotonin and motivation to learn. a study found that students who took part in collaborative learning showed increased levels of dopamine and serotonin in the brain compared to students who studied independently. Other studies show that collaborative learning can improve students' memory and learning by increasing the release of dopamine and serotonin.^{13,14}

4. Conclusion

Based on the results of this research, it can be concluded that collaborative learning with group investigations is effective in improving students' mathematics learning outcomes in elementary schools. Therefore, collaborative learning with group investigations can be recommended as a learning method that can be used to improve students' mathematics learning outcomes.

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