Pasundan Journal of Mathematics Education Volume 14, No. 2, 2024, pp. 175 - 190

Implementation of Problem-Solving Learning with Geogebra to Improve Problem-Solving Ability and Motivation

Denie Fauzie Ridwan[1]

[1]Universitas Pasundan Bandung, Jawa Barat, Indonesia
*Correspondence: deniefauziwridwan@yahoo.co.id

Abstract

In general, there are still many students who lack problem-solving abilities. Historically, mathematics is actually very closely related to problem-solving abilities and was developed by students as a challenge to changes in learning motivation. The world of Indonesian education has various learning models and teaching aids that can be developed, one of which is Geogebra. Geogebra can be implemented with mathematical concepts as an effort to improve problem-solving abilities. Apart from that, we can make learning motivation as fun as learning mathematics at school. Therefore, this research seeks to improve students' problem-solving abilities and learning motivation. This research uses a mixed-method research method with a sequential exploratory design type. Research data was collected through problem-solving ability tests, learning motivation questionnaires, observations, and interviews with class IX students at Mts Al-Ma'tuq Sukabumi. The results of this research show that the problem-solving abilities and learning motivation of students using geogebra-assisted learning are better than students using conventional learning. Apart from that, there is no correlation between problem-solving abilities and learning motivation of students who receive geogebra-assisted and conventional learning with a weak or low level of relationship. The contribution of this research to the development of science is to provide new insights into the application of Geogebra as a tool in mathematics learning and to reveal the importance of integrating technology to improve students' problem-solving abilities and learning motivation.

Keywords: Geogebra, Learning Motivation, Learning model, Problem-Solving, Technology

How to Cite: Ridwan, D.F. (2024). *Implementation of Problem-Solving Learning with Geogebra to Improve Problem-Solving Ability and Motivation*. Pasundan Journal of Mathematics Education 14(2), 175 – 191. http://doi.org/ 10.23969/pjme.v14i2.18577

INTRODUCTION

Mathematics education plays an important role in equipping students with critical and analytical thinking skills needed to solve various problems in everyday life. At the Madrasah Tsanawiyah (MTs) level, problem-solving skills are one of the main goals to be achieved in mathematics learning. This ability helps students not only understand mathematical concepts but also apply them in real situations. However, based on observations in the field, many students still face difficulties in developing problem-solving skills. This is not only caused by a lack of understanding of basic concepts, but also by students' low motivation to learn in facing mathematical challenges (Wahyuni et al., 2020).

Learning motivation is one of the crucial aspects in the education process. Students with high learning motivation tend to be more active in understanding the subject matter, conducting independent exploration, and trying hard to solve problems. Unfortunately, many teachers in MTs still rely on conventional learning methods that are less interactive and do not encourage students to be actively

involved in the learning process. Learning that focuses on one-way teaching from teacher to student often makes students feel bored and unmotivated, especially in subjects that are considered difficult such as mathematics (Hidayat et al., 2018).

As an alternative, the problem-solving learning model has been widely recognized as one of the effective approaches in improving students' problem-solving abilities. This model emphasizes the learning process that encourages students to find solutions to problems independently through various critical and analytical thinking strategies. In problem-solving-based learning, students are faced with situations that require them to think creatively, explore various possible solutions, and systematically organize problem-solving steps. Thus, students not only learn theory but are also actively involved in its application (Rachmawati et al., 2019).

The integration of technology into mathematics learning, such as through the GeoGebra application, further strengthens the potential of problem-solving models in improving student understanding. GeoGebra is a dynamic mathematics application that can visualize various mathematical concepts, such as algebra, geometry, and calculus, in an interactive form. This application allows students to conduct direct experiments with mathematical concepts that are difficult to understand through conventional approaches. With interactive visualizations, students can more easily understand the relationships between variables and abstract concepts in mathematics. In addition, the use of GeoGebra can also increase student motivation because it provides a more enjoyable and interesting learning experience (Noto et al., 2019).

The use of technology in mathematics learning has shown positive impacts in a number of studies. For example, several studies have shown that students who learn with the help of technology tend to have a deeper understanding of concepts and higher learning motivation. Technologies such as GeoGebra not only make learning more interesting but also allow students to learn in a more flexible way, both individually and in groups. Through this application, students can visualize complex concepts more concretely, which ultimately helps them in solving more complicated mathematical problems (Rahmawati & Santosa, 2020).

However, although many studies have shown the effectiveness of using GeoGebra in mathematics learning, studies that specifically examine the application of problem-solving models with this application in madrasah environments are still very limited. Education in Madrasah Tsanawiyah, which integrates religious values with the national curriculum, has its own characteristics and challenges. Therefore, it is important to explore how the use of GeoGebra can be adapted to the context of madrasah education, especially in improving students' problem-solving abilities and learning motivation (Hanipa et al., 2019).

This study aims to answer these challenges by exploring the implementation of the problem-solving learning model with the help of the GeoGebra application in Madrasah Tsanawiyah. This study will assess the extent to which this model is effective in improving students' problem-solving abilities and its effect on learning motivation. In addition, this study is also expected to contribute to the development of mathematics learning methods in madrasahs, especially in optimizing the use of technology in the learning process (Dirmansyah, M. R., Febriandi, R. (2023).

Thus, this study not only aims to improve the quality of mathematics learning in madrasas, but also to enrich the literature related to the use of technology in Islamic education. The results of this study are expected to be a reference for mathematics teachers in madrasas to apply more interactive and innovative methods, so as to improve student motivation and learning outcomes as a whole.

METHODS

This study uses mixed-method research with a sequential exploratory design, which aims to gain a deep understanding of the implementation of the problem-solving learning model with the help of the GeoGebra application. This design consists of two main stages: first, collecting and analyzing qualitative data through observation, and second, collecting quantitative data through tests and questionnaires to support qualitative findings. This method was chosen so that the results of the study can provide a

comprehensive picture of the effects of using GeoGebra in improving students' problem-solving abilities and learning motivation.

The population in this study were 89 students of grade IX at Madrasah Tsanawiyah (MTs) Al-Ma'tuq. The selection of this population was based on the topic of learning curved side space shapes taught in grade IX, which was relevant to the research material. A purposive sampling technique was used to select the sample, where 44 students were placed in the experimental group and 45 students in the control group. The experimental group will be taught using the GeoGebra-assisted problem-solving model, while the control group will be taught using conventional learning methods.

The research instruments used in this study include several non-test and test tools. First, observations were conducted to observe the learning process, especially how students interact with the GeoGebra application in the problem-solving process. This observation also recorded the level of student engagement and how they collaborated in solving problems. Second, a learning motivation questionnaire was used to measure the level of student motivation before and after learning. This questionnaire was compiled using a Likert scale with five answer choices and consisted of 20 questions that assessed students' intrinsic and extrinsic motivation. In addition, a problem-solving ability test instrument was also given, which contained descriptive questions on the topic of curved-sided geometric shapes. This test was designed to measure students' ability to formulate and solve mathematical problems using problem-solving strategies.

The research procedure consists of three main stages. In the preparation stage, the researcher prepared the Learning Implementation Plan (RPP) for both groups, prepared the research instruments, and tested the validity and reliability of the instruments. In the implementation stage, a pretest was conducted to measure the initial problem-solving abilities and learning motivation of students in both groups. Furthermore, the experimental group was taught using the GeoGebra-assisted problem-solving model, while the control group was taught using conventional methods. After the learning was completed, a posttest was conducted to see the changes that occurred in the problem-solving abilities and learning motivation of students. In the final stage, the data obtained from the pretest and posttest were analyzed quantitatively to see significant differences between the two groups.

Data analysis was conducted by combining qualitative and quantitative techniques. Qualitative data from observations were analyzed descriptively to provide an overview of the learning process, student engagement, and the use of the GeoGebra application. Quantitative data from tests and questionnaires were analyzed using descriptive and inferential statistics. Normality and homogeneity tests were conducted first to ensure that the data obtained met the requirements for parametric statistical tests. Furthermore, paired t-tests were used to compare the results of the pretest and posttest in the same group, and independent t-tests were used to compare the differences between the experimental and control groups. This analysis was conducted using statistical software such as SPSS to ensure the accuracy of the results.

By using this mixed method, it is expected that the research results can provide a comprehensive picture of the influence of the GeoGebra-assisted problem-solving learning model on students' problem-solving abilities and learning motivation at MTs Al-Ma'tuq.

RESULTS AND DISCUSSION

Improving Problem-Solving Skills

Based on the results of the problem-solving ability test of students who received Geogebra and conventional learning, the N-Gain value of students' Problem-Solving ability was obtained. The description of the average N-Gain, standard deviation of the N-Gain data of students' Problem-Solving Ability is summarized in Table 1 as follows.

Table 1. The Average N-Gain of Students' Problem-Solving Ability

Statistics	N-Gain Learning	
	Experiment	Control
Average	0.7957	0.7243
Simp. Baku	0.23697	0.24237
Number of Students	23	23

Based on the data in table 1, a diagram will be made showing the N-Gain value of the results of the Problem-Solving ability test in classes that received Geogebra learning and conventional learning as in figure 1 as follows:

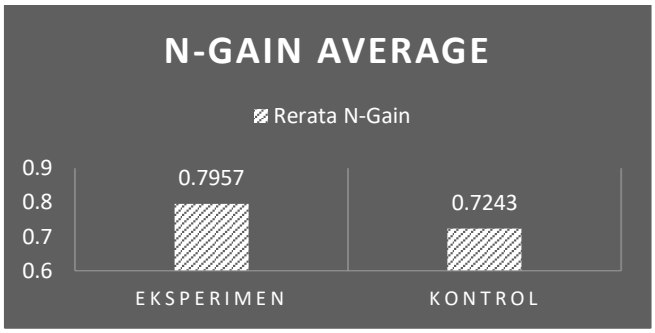

Figure 1. Comparison of Average N-Gain Results of Students' Problem-Solving Ability

Based on Table 1 and the diagram in Figure 1, it can be seen that the average N-Gain of Problem-Solving ability of students who received Geogebra learning is higher than the average N-Gain of Problem-Solving ability of students who received conventional learning. When viewed from the average N-Gain value of the experimental class with a high category, the average N-Gain of the control class is in the high category. This means that the quality of the increase in problem-solving ability of students who received learning assistance with Geogebra is better than that of students who received conventional learning.

To find out which improvement in students' Problem-Solving abilities is better, it can be seen from Table 1 that the average N-Gain of students' Problem-Solving abilities with Geogebra learning is higher than the average N-Gain of students' Problem-Solving abilities with conventional learning.

Increasing Learning Motivation

Based on the results of the questionnaire on students' learning motivation who received Geogebra and conventional learning, the N-Gain value of students' learning motivation was obtained. The summary of the average N-Gain, standard deviation of the N-Gain data of students' learning motivation is presented in Table 2 as follows.

Table 2. Description of Average Student Learning Motivation

Statistics	Motivation to learn	
	Experiment	Control
Average	0.49	0.33
Simp. Baku	0.24	0.23
Number of Students	23	23

Based on the data in Table 2, a diagram was created showing the N-Gain value of the results of the student learning motivation questionnaire in the class receiving Geogebra learning and conventional learning as shown in Figure 2 as follows.

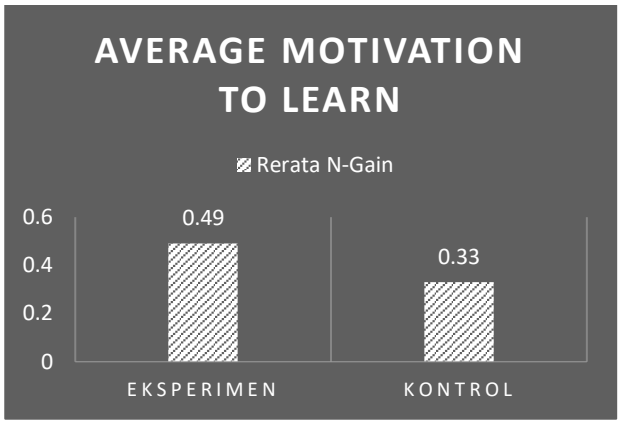

Figure 2. Comparison of Average Student Learning Motivation

Based on Table 2 and the diagram in Figure 2, it can be seen that the average N- *Gain* response to students' learning motivation who received *Geogebra learning* is higher than the average N- *Gain* response to students' learning motivation who received conventional learning. When viewed from the average N- *Gain value* of the experimental class with a high category, the average N- *Gain* of the control class is in the high category. This means that the increase in learning motivation of students who receive learning assisted by Geogebra is better than students who receive conventional learning.

To find out which increase in students' learning motivation response is better, it can be seen from Table 2 that the average N- *Gain of students'* learning motivation response with *Geogebra learning* is higher than the average N- *Gain of students'* learning motivation with conventional learning.

Motivation Questionnaire Results

The questionnaire analysis showed that students in the experimental group felt more motivated because GeoGebra provided a more interactive and satisfying learning experience. In contrast, students in the control group reported a smaller increase in motivation, indicating that the conventional approach had a less significant impact on their motivation. The initial stage carried out was to find out the initial learning motivation of each student in both classes. The second stage was to provide learning to both classes (experimental and control classes) according to the treatment model applied to the class. Then the last stage after being given treatment was that both classes were given a learning motivation questionnaire again to find out changes in student learning motivation after being given treatment through the learning model. The results of the analysis of descriptive data on the average, standard deviation of the student learning motivation questionnaire at the beginning and end of the study, these data are presented in Table 3 as follows:

Table 3. Learning Motivation Questionnaire Response Results *(Pretest-Posttest)*

Statistics	Learning			
	Experiment		Control	
	Before	After	Before	After
Average	72.96	86.65	72.61	82.04
Minimum Score	61	72	60	67
Maximum Score	85	100	83	95
Simp. Baku	6.36	6.75	6.44	7.17
Number of Students	23	23	23	23

The data contained in Table 3 can be used to create a diagram that shows a comparison of students' learning motivation responses at the beginning and end (*pretest-posttest*) between students who received *GeoGebra learning* and conventional learning as in Figure 3 as follows:

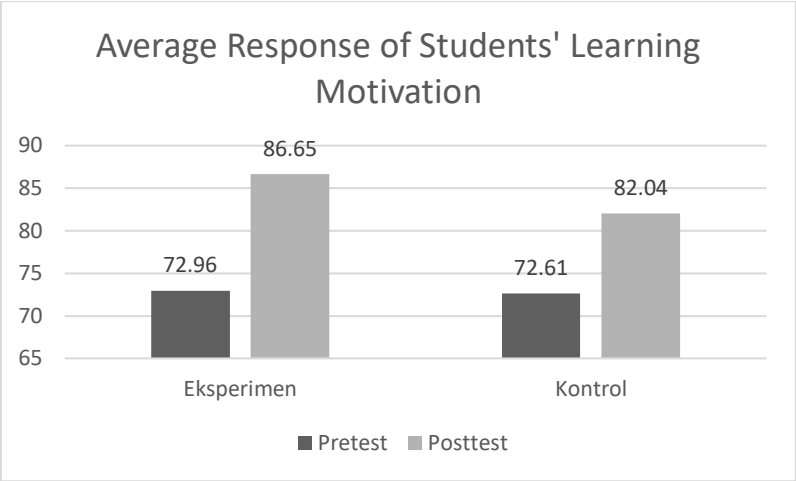

Figure 3. Comparison of Average Responses to Student Learning Motivation

Based on the data in table 3 and the diagram in Figure 3, it is found that the average value of the learning motivation questionnaire results of students in the experimental class before and after is higher than the average of the control class. This means that the learning motivation response of students who receive *geogebra learning* is better than students who receive conventional learning.

Difference between Pretest and Posttest

Students who use geogebra-assisted learning show better Problem-Solving skills compared to students who use conventional learning. Before the two classes were given treatment, the Problem-Solving skills of Mts Al-Ma'tuq students were in the low category. However, achieving Problem-Solving skills is a general goal in mathematics learning, and is even the core of mathematics (Son & Lee, 2020). To achieve learning goals, this ability must receive special attention (Sari, et al., 2021). That Problem-Solving is part of mathematics learning because the process and solution must use previously possessed abilities and experiences (Rochana, S., Wahyuniar, LS, & Mahdiyah, U., 2022).

Students' low Problem-Solving abilities can be seen from the results of their initial Problem-Solving abilities, where the results are still far from what is expected and indicate challenges that need to be overcome in the learning process. Other studies have found that students' initial Problem-Solving abilities are still relatively low (Yulianto, 2020; Zakiyah, et al., 2021). This is in line with the findings of other studies that students' Problem-Solving abilities are still relatively low (Sulistyani, et al., 2020; Kamilah, et al., 2022; Rochana, et al., 2022; Gunawan, et al., 2023). Research findings from Gunawan, et al. (2023) that students' Problem-Solving abilities in mathematical problems related to plane geometry are relatively low, with an average score of 22.28 and a success rate of 15.23%. In addition, other studies have revealed that low-ability students show extraordinary detail in problem-solving abilities, while high-ability students have difficulty writing in detail (Kamilah, et al., 2022).

Factors causing low Problem-Solving abilities of Mts students include lack of student understanding of the concept, inadequate curriculum in developing these skills, lack of teacher training in teaching methods that explore students' Problem-Solving abilities, and limited resources in Mts schools and environmental factors (Koswara, et al., 2019; Cahyaningrum & Pradipta, 2021; Xu & Qi, 2022). According to Xu & Qi (2022), environmental factors, self-efficacy, and math anxiety have a significant impact on students' Problem-Solving abilities. Another factor in students' Problem-Solving abilities in solving problems is a lack of understanding of the concept (Cahyaningrum & Pradipta, 2021). The dominant factor causing low Problem-Solving abilities in students is the learning process that has not facilitated them to develop these skills (Koswara, et al., 2019).

After being given an initial ability test, students were given mathematical Problem-Solving ability questions. Various efforts were made to overcome the problem of students' low Problem-Solving ability. One of them is the application of innovative learning models and the provision of supporting learning

resources. Students in both classes were served with different learning models. Students who used Geogebra-assisted learning and students who used conventional learning were served with different models. Geogebra-assisted learning improves students' understanding of mathematical concepts through solving real problems (Suhendar & Ekayanti, 2018). By using geogebra, students are given the opportunity to find solutions to problems.

Students experience technology-integrated learning with Geogebra-assisted learning. Students are directed to learn basic materials. In some meetings, geogebra technology is used for Problem-Solving and group discussions. Accustoming students to using sophisticated technology to facilitate learning at school (Wati & Nugraha, 2021).

The learning process takes place, students can download modules and videos on subtopics discussed through LKPD or modules provided by teachers to get material. This will certainly make it easier for students to gain extensive knowledge and freedom to learn than teachers in class. However, online learning will certainly have challenges. Some students have difficulty learning, such as not supporting the Geogebra application on their cellphones. Of course, even though the application is fun and easy to use, one of the factors that makes the learning process less effective is the need for socialization and adaptation when using it (Oktavian & Aldya, 2020). However, overall, learning with geogebra makes students more interested and increases their motivation to learn.

Unlike students who use conventional learning, students do math exercises and listen to teachers explain concepts. This material is collected from one source, namely the teacher who teaches in class with the help of a math textbook. There is no difference in the learning provided about the same idea. Conventional learning tends to emphasize students' understanding of basic concepts without teaching critical thinking skills (Darmawani, 2018). Thus, students' problem-solving abilities in conventional learning tend to be less active, less abstract, less related to the context of students' lives, and more limited in solving real problems. This is because conventional learning focuses on understanding concepts theoretically, so there is a lack of creative motivation and getting material freely (Zuliyanti & Pujiastuti, 2020; Hwang, et al., 2022).

At the end of each class, Problem-Solving skills were evaluated again. Students who used geogebra-assisted learning had better Problem-Solving skills than students who used conventional learning. After seeing the calculation results, it can be concluded that students who used geogebra-assisted learning had better Problem-Solving skills overall than students who used conventional learning.

Students' answers to the Problem-Solving ability test varied greatly. Students who used Geogebra-assisted learning were not able to solve the Problem-Solving ability questions, and almost all students who used conventional learning failed to solve the math Problem-Solving ability questions because this type of question was very difficult. This can happen when students are not used to this process and imitate the way the teacher does it. For example, students often work on math problems that have been translated into mathematical form. According to Sari, et al., (2021), one of the reasons why control class students cannot understand the problems they face is because they follow the teacher's instructions carefully.

In addition, in other cases, they can only solve problems without drawing conclusions or interpreting problem solutions. This is in line with research conducted by Utami, N., Sukestiyarno, Y. L., & Hidayah, I. (2020), which found that most students only interpret mathematical results in real-world contexts without examining mathematical concepts, solutions, and limitations. In addition, other studies have found that only a few students are able to formulate real problems in the questions given, as well as evaluate solutions to the questions given from the number of students (Utami et al., 2020). The following is an example of the results of students' answers with Geogebra in the superior group presented in Figure 4.

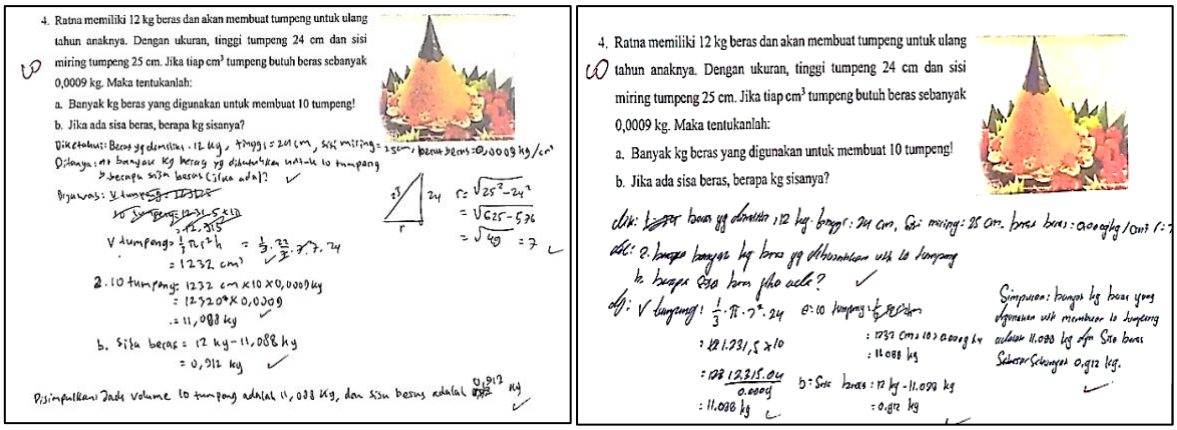

Figure 4. Example of Students' Work on Problem-Solving Questions in Geogebra Assisted Learning in the Superior Group

One example of the results of students' answers with conventional in the superior group is presented in Figure 5 below.

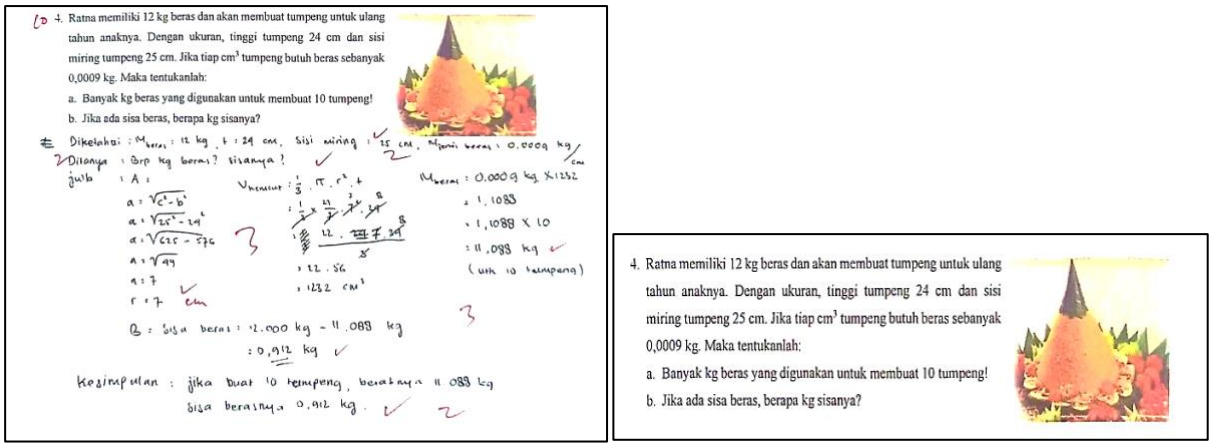

Figure 5. Example of Students' Work on Problem-Solving Questions with the Superior Group Conventional

Figure 5 shows an example of a student's answer who received *Geogebra- assisted learning* in the superior group. In this difficult question, there are students who can solve it perfectly, and because there is a repetition of practice questions that are similar in form to the problem-solving ability questions given, students can answer the question. Therefore, it is very important to help students understand and answer questions, even if the question is in the difficult category.

The factors that cause students to be able to answer questions well are the existence of an interesting learning model and make their learning motivation much better with the help of technology. This is also reinforced in other studies such as Lu, Yang and Wang (2021) who revealed that interacting with peers and learning motivation and learning involving technology have a direct impact on students' high-level thinking skills in a smart classroom environment.

In contrast to conventional learning, students tend to directly answer questions with the formulas they have obtained without using steps in solving problems, even some students do not answer the questions (Kamilah, et al., 2022). This action may be caused by several factors. For example, questions are given randomly or irregularly, so students cannot remember the explanations given during learning.

According to the results of the research data testing, there was no difference in the problem-solving ability of students who used Geogebra-assisted learning compared to students who used conventional learning. Several factors may be responsible for this disparity, including teaching methods, students' initial skills, and evaluation techniques. Although Geogebra is used in learning, the methods used may not be

different enough from conventional methods. However, if the lesson structure, learning approach, and assessment are not changed significantly, there may be no significant difference in problem-solving ability between the two groups of students. According to Ridwan, et al. (2021) Innovative learning is effective in improving the mathematical problem-solving abilities of junior high school students. So that problem-based learning using performance assessments and technology has a positive effect on students' problem-solving abilities, improved according to the stages of Problem-Solving correctly (Winarti, et al., 2019).

The results showed a significant increase in the problem-solving abilities of students who used GeoGebra compared to students who followed conventional learning. This increase supports the results of previous studies showing that GeoGebra, as an interactive visual aid, can improve students' mathematical skills. GeoGebra allows students to conduct visual and interactive exploration of mathematical concepts, which supports the constructivism theory that states that active and exploratory learning improves conceptual understanding (Brusilovsky & Millán, 2007). Research by Huang and Huang (2018) also confirmed that the use of GeoGebra can improve mathematics learning outcomes through clear and dynamic visualizations.

This difference is in line with the principles of constructivist learning that emphasize the importance of visual and interactive tools in deepening conceptual understanding. GeoGebra, with its ability to provide dynamic visualizations and interactive representations, helps students understand geometric concepts in a more intuitive and digestible way. Research by Huang & Huang (2018) and Kose (2020) shows that visual aids such as GeoGebra can improve overall mathematical understanding, which is consistent with the findings of this study. GeoGebra facilitates in-depth exploration and experimentation, which may explain the significant improvement in problem-solving ability.

In conclusion, the results of the study indicate that students who learn using geogebra-assisted learning have better Problem-Solving abilities compared to conventional learning. So it is recommended to conduct further research at a higher level.

Relation to Previous Theory and Research

The results of this study are in line with the constructivism theory which emphasizes the importance of visual aids in mathematics learning. GeoGebra as an interactive visual aid provides a dynamic representation of mathematical concepts, which facilitates deeper understanding (Jang, 2018). Research by Kose (2020) shows that GeoGebra can improve students' attitudes towards mathematics by providing a more enjoyable and motivating learning experience. This finding is consistent with a study by Gil-Doménech, D., & Berbegal-Mirabent, J. (2019), which shows that GeoGebra can improve students' engagement and problem-solving skills through more effective visual representations than conventional methods.

This study also reflects the results of previous studies that show the benefits of using technology in mathematics education. Huang & Huang (2018) showed that GeoGebra improves understanding of mathematical concepts by providing clear and interactive visualizations. Kose (2020) also found that visual aids such as GeoGebra can improve students' problem-solving skills by providing representations that facilitate understanding of complex mathematical concepts.

Learning Motivation Analysis

At first, students usually do not have high learning motivation. After the study was completed, it was found that students felt more motivated to learn using Geogebra's help. This is clearly due to certain factors, such as treatment that makes learning fun and not boring. Students who experience this improvement are included in the moderate improvement category. Rochana, S., Wahyuniar, L.S., & Mahdiyah, U., (2022) found that the level of student learning motivation was moderate.

Students' motivation in mathematics is significantly related to perceptions of teaching practices and use of resources for learning (Hossein & Hossein, 2023). Based on the results of the study, it was found

that students' learning motivation towards those who received Geogebra-assisted learning and conventional learning varied depending on various factors, including individual characteristics of students, implementation of learning, and their learning experiences.

Some possible learning motivations that occur in both learning models are mentioned below. Learning with the help of Geogebra increases students' motivation to learn. They feel more motivated to learn and learning becomes more enjoyable when they succeed in solving problems. According to research from Selvy, et al. (2020) Geogebra-assisted learning can improve students' creative thinking and mathematical motivation, so that learning mathematics becomes more enjoyable and interesting. Other studies have shown that learning using Geogebra increases students' interest, motivation, and willingness to learn geometry, as well as improving their academic achievement (Zutaah, Ondigi & Miheso, 2023) The ability to collaborate in groups, solve problems, and contribute to solutions can also increase students' motivation to learn.

Students with moderate learning motivation are also included in the moderate category, no different from classes that use conventional learning. Parents and teachers certainly have an equally important role in increasing students' desire to learn. Parents must build a sense of family and provide sincere examples so that children can imitate and create a social spirit to blend in with society through the standards and qualities that have been educated so that they can better understand children's development from feelings to their actual abilities. The teacher's equally important task is to help students who have difficulties at school, especially in terms of adjusting to friends. Students who have low learning motivation must be easily identified so that responsive interventions are useful. The better the overall climate, the more students can develop into great and confident individuals (Rosani, et al., 2021).

Students who received GeoGebra-assisted learning and students who received conventional learning experienced an increase in learning motivation after both classes received different learning treatments. This is a technology-based learning collaboration, which increases students' interest and desire to learn much more than before being given treatment. Compared to conventional teaching methods, the use of GeoGebra improves students' academic achievement and motivation (Hosseini, Mehdizadeh, & Sadeghi, 2022).

However, high learning motivation alone is not enough to get satisfactory grades in mathematics learning, often students feel dissatisfied with daily tests and exams (Fuqoha, Budiyono & Indriati, 2018). So it can be said that learning motivation cannot be said to have an effect during the test process. However, in general, students' learning motivation is able to be confident in solving problems in learning.

To achieve optimal learning outcomes, it is important for students to increase their motivation to learn mathematics. Motivation is an internal driver that encourages students to learn and actively participate in the learning process. By increasing this motivation, students tend to be more involved, enthusiastic, and persistent in understanding the mathematical concepts taught.

Several other factors that increase students' learning motivation in students who receive geogebra-assisted learning, the first factor is the use of interesting learning methods: innovative and interesting learning methods can help attract students' attention and make them more enthusiastic about learning mathematics (Gil & Berbegal, 2019). According to other research, S. Schukajlow, K. Rakoczy, and R. Pekrun (2023) revealed that involving movement-based learning and technology in mathematics will significantly increase children's enjoyment and involvement without reducing the quality of learning.

The second factor is the interactive approach, according to the use of games, and the application of educational technology can make mathematics learning more interesting and relevant for students. According to Wang, et al. (2018) the technology-based game approach produces better learning achievement and motivation to learn mathematics compared to conventional technology-enhanced learning approaches, by considering these factors and designing a supportive learning environment, teachers can help improve students' learning motivation in mathematics learning, thereby creating a meaningful and effective learning experience. Although GeoGebra succeeded in increasing students' learning motivation, the analysis showed that there was no significant relationship between increasing problem-solving abilities and learning motivation. The increase in motivation in the experimental group, from the moderate category to the high category, showed that GeoGebra made mathematics learning

more interesting. However, learning motivation is a complex construct that is influenced by many factors, including social support, personal experience, and material difficulty (Deci & Ryan, 2017). Research by Jang (2018) shows that learning motivation is influenced by engagement and positive experiences with technology, but the direct relationship with problem-solving skills may be influenced by other factors that were not fully measured in this study.

This may be due to external factors that influence motivation, such as social support, previous experience with technology, or the difficulty of the material. Research by Deci & Ryan (2000) suggests that learning motivation is a complex construct influenced by a variety of factors, including engagement in learning and students' personal experiences. This research suggests the need to understand how motivation is influenced by factors other than the tools used.

Results Not As Expected

The finding that there was no significant relationship between problem-solving ability and learning motivation may be due to other factors influencing motivation that were not measured in this study, such as social support and prior learning experiences. Research by Deci and Ryan (2017) showed that learning motivation is influenced by various factors, including social interaction and support from teachers. In addition, the level of difficulty of the material and prior technology experiences may also influence how tools such as GeoGebra affect students' motivation and problem-solving skills. These findings suggest the need for further research to explore how various factors may interact and influence student learning outcomes, as well as to better understand how educational technology can work together with other motivational factors to improve learning outcomes.

There is no relationship between Problem-Solving ability and students' learning motivation using Geogebra learning. The influence of a weak or low relationship is indicated by a large coefficient on the test. This shows that the two abilities tested have a unidirectional relationship with each other. This means that an increase in Problem-Solving ability is followed by students' desire to learn more (Zebua et al., 2022). This is not in accordance with research from Baity (2021). found that self-efficacy and high learning motivation are the most effective in influencing mathematical Problem-Solving ability.

There are several reasons why there is no relationship between the improvement of Problem-Solving ability and learning motivation of students using Geogebra-assisted learning. The first factor is that the measurement of Problem-Solving ability and learning motivation may not be sensitive enough to identify the relationship between the two. For example, the measurement used may not be able to describe well the changes in Problem-Solving ability and learning motivation of students.

Unlike learning models, external factors (such as family support, student motivation, or environmental factors) may be more dominant in influencing students' learning motivation (Aulia, Marjohan & Rakimahwati, 2019; Pohan, Asmin & Menanti, 2020). According to Aulia Marjohan and Rakimahwati (2019), learning motivation and self-confidence contribute positively to students' problem-solving abilities, and together have a significant effect on their ability to understand learning problems.

An additional factor is the time required to see the impact; the relationship between increased Problem-Solving ability and learning motivation takes time. According to Yunus, et al. (2021) that there is a positive correlation between Problem-Solving ability and students' desire to achieve, metacognitive awareness, and their attitudes towards learning. So, the positive effect on learning motivation may not be immediately visible after increasing Problem-Solving ability.

CONCLUSION

This study shows that the application of GeoGebra-assisted problem-solving learning model is more effective in improving students' problem-solving ability and learning motivation compared to conventional methods. Students who learn with GeoGebra show significant improvements in problem-solving ability

and learning motivation, with interactive visualization and challenges that provide a sense of achievement. However, no significant relationship was found between problem-solving ability and learning motivation, either in the GeoGebra or conventional groups. Although both increased, the increase in one variable did not directly affect the other variable. Thus, the use of GeoGebra can be relied upon to improve the quality of mathematics learning, but the relationship between problem-solving and learning motivation requires further research. The implication of this study is that educators should consider integrating GeoGebra into their teaching practices to enhance students' problem-solving abilities and motivation. Additionally, future research could explore other factors that may influence the relationship between problem-solving ability and learning motivation, as this study has found no direct connection between the two.

REFERENCES

Aulia, A., Marjohan, M., & Rakimahwati, R. (2019). *The contribution of learning motivation and self-confidence towards the resolution of students' learning problems*. Indonesian Journal of Science and Technology Applications, 3(3), 148-155. https://doi.org/10.24036/4.33317

Baity, N., Syaiful, R., & Muhaimin, N. (2021). *The effect of creative Problem-Solving learning models on Problem-Solving ability in learning motivation and student self-efficacy view*. International Journal of Social Science and Human Research , 4(03), 492-500. https://doi.org/10.47191/ijsshr/v4-i3-30

Brusilovsky, P., & Millán, E. (2007). *User models for adaptive hypermedia and adaptive educational systems*. In The Adaptive Web (pp. 3-53). Springer.

Cahyaningrum, L., & Pradipta, T. (2021). *Analysis of problem-solving ability of MTs students in solving geometry transformation problems through online learning*. Daya Matematis: Jurnal Inovasi Pendidikan Matematika. https://doi.org/10.26858/jdm.v9i2.20220

Darmawani, E. (2018). Metode ekspositori dalam pelaksanaan bimbingan dan konseling klasikal. Jurnal Wahana Konseling, 1(2), 30-44. https://doi.org/10.31851/juang.v1i2.2098

Deci, E.L., & Ryan, R.M. (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. Guilford Press.

Deci, E. L., & Ryan, R. M. (2000). *Self-Determination Theory and The Facilitation of Intrinsic Motivation, Social Development and Well-Being*. American Psychologist. Vol 55. 68–78 pp.

Dirmansyah, M. R., Febriandi, R. (2023). Meningkatkan Kemampuan Problem Solving MatematikaSiswa SD Melalui Implementasi Model Problem Based Learning. Jurnal Elementaria Edukasia, 6(4), 2135–2144. https://doi.org/10.31949/jee.v6i4.7591

Fuqoha, A. A. N., Budiyono, B., & Indriati, D. (2018). *Motivation in Mathematics Learning*. Pancaran Pendidikan, 7(1). https://doi.org/10.25037/pancaran.v7i1.151

Gil-Doménech, D., & Berbegal-Mirabent, J. (2019). *Stimulating student engagement in mathematics courses in non-STEM academic programs: Game-based learning*. Innovations in International Education and Teaching, 5(6), 57-65. https://doi.org/10.1080/14703297.2017.1330159

Gunawan, RG, Mudjiran, M., Suherman, S., Yerizon, Y., Musdi, E., Armiati, A., & Rozika, E. (2023). *An analysis of mathematical problem-solving skills of junior high school students*. Indonesian Journal of Science and Mathematics Education, 6(3), 351-365. http://dx.doi.org/10.24042/ijsme.v6i3.18062

Hanipa, A., Misbahudin, A.R., Andreansyah, Setiawan, W. (2019). Analisis Minat Belajar Siswa MTs Kelas VIII dalam Pembelajaran Matematika Melalui Aplikasi Geogebra. Jurnal Pembelajaran Matematika Inovatif, 2(5), p. 315-322. https://doi.org/10.22460/jpmi.v2i5.p315-322

Hidayat, N., & Nisa, RA (2018). *The role of motivation in learning mathematics for students of Madrasah Tsanawiyah*. Scientific Journal of Mathematics Education, 12(3), 112–120

Hosseini, Z., Mehdizadeh, M., & Sadegi, M. (2022). *Using GeoGebra in teaching geometry to enhance students' academic achievement and motivation*. Innovation Journal of Education, 10(3), 34-38. https://doi.org/10.22159/ijoe.2022v10i3.44792

Hossein-Mohand, H., & Hossein-Mohand, H. (2023). *The effect of motivation on secondary school students' perception of mathematics*. Frontiers in Psychology, 13. https://doi.org/10.3389/fpsyg.2022.1111600

Huang, T. H., & Huang, Y. M. (2018). *The use of GeoGebra in mathematics education*. Journal of Educational Technology & Society, 21(2), 75-87. https://doi.org/10.2307/23612443

Hwang, G. J., Chang, C. C., & Chien, S. Y. (2022). *A motivational model-based virtual reality approach to prompting learners' sense of presence, learning achievements, and higher-order thinking in professional safety training*. British Journal of Educational Technology , 53(5), 1343-1360. https://doi.org/10.1111/bjet.13196

Jang, H. (2018). *Effects of GeoGebra on mathematics learning outcomes: A meta-analysis*. Journal of Research on Technology in Education, 50(3), 239-258. https://doi.org/10.1080/15391523.2018.1472641

Kamilah, R., Siswono, TYE, & Lukito, A. (2022). *Senior high school students Problem-Solving in terms of mathematical abilities*. Technodika, 20(1), 11-17. https://doi.org/10.20961/teknodika.v20i1.56168

Kose, U. (2020). *The impact of GeoGebra on students' attitudes towards mathematics*. Educational Technology Research and Development, 68(4), 2057-2076. https://doi.org/10.1007/s11423-020-09734-3

Koswara, T., Muslim, M., & Sanjaya, Y. (2019). *Profile of Problem-Solving abilities of junior high school students in science*. In Journal of Physics: Conference Series (Vol. 1157, No. 2, p. 022041). IOP Publishing. https://doi.org/10.1088/1742-6596/1157/2/022041

Lu, K., Yang, H. H., Shi, Y., & Wang, X. (2021). *Examining the key influencing factors on college students' higher-order thinking skills in the smart classroom environment*. International Journal of Educational Technology in Higher Education, 18, 1-13. https://doi.org/10.1186/s41239-020-00238-7

Noto, M. S., Priatna, N., & Dahlan, J. A. (2019). *Mathematical Proof: The Learning Obstacles of Preservice Mathematics Teachers on Transformation Geometry*. Journal on Mathematics Education, 10(1), 117-126.

Oktavian, R., & Aldya, RF (2020). *Effectiveness of integrated online learning in the era of education 4.0*. Didaktis: Journal of Education and Science, 20(2), 129-135. https://doi.org/10.30651/didaktis.v20i2.4763

Pohan, A. M., Asmin, A., & Menanti, A. (2020). *The effect of problem based learning and learning motivation of Mathematical problem solving skills of class 5 students at SDN 0407 Mondang*. Budapest International Research and Critics in Linguistics and Education (BirLE) Journal, 3(1), 531-539.

Rachmawati, Y., Susilo, S., & Prasetyo, A. P. B. (2019). *The Effectiveness of Problem Based Learning (PBL) with Open-Ended Approach on Problem Solving Ability*. Journal of Primary Education, 8(7), 105-112. https://doi.org/10.15294/jpe.v10i1.34301

Rahmawati, F., Santoso, E. (2020). Implementasi Geogebra Untuk Meningkatkan Pemahaman Konsep Geometri Ruang. Alauddin Journal of Mathematics Education 2 (2), 107-16. https://doi.org/10.24252/ajme.v2i2.15882.

Ridwan, MR, Retnawati, H., & Hadi, S. (2021). *The effectiveness of innovative learning on mathematical problem-solving abilities: A meta-analysis*. International Journal of Research in Education and Science, 7(3), 910-932. https://doi.org/10.46328/ijres.2287

Rochana, S., Wahyuniar, LS, & Mahdiyah, U. (2022). *Application of problem-based learning model to improve Problem-Solving abilities*. Journal of Instructional Mathematics, 3(2), 101-106. https://doi.org/10.37640/jim.v3i2.1542

Rosani, W., Fatimah, S., & Supriatna, E. (2021). Studi Deskriptif Self Esteem Pada Siswa Kelas Xi Sman 1 Margaasih. FOKUS (Kajian Bimbingan & Konseling Dalam Pendidikan), 4(5), 330. https://doi.org/10.22460/fokus.v4i5.8074

Sari, NM, Setiani, A., Rinangkit, I., & Munawar, HS (2021). *The development of teaching materials based on problem-solving exploration with Microsoft Kaizala applications*. Al-Jabar: Journal of Mathematics Education, 12(2), 253-266. https://doi.org/10.24042/ajpm.v12i2.9253

Schukajlow, S., Rakoczy, K., & Pekrun, R. (2023). *Emotions and motivation in mathematics education: Where we are today and where we need to go*. ZDM – Mathematics Education (2023) 55:249–267. https://doi.org/10.1007/s11858-022-01463-2

Selvy, Y., Ikhsan, M., & Johar, R. (2020). *Improving mathematical students' creative thinking and motivation through GeoGebra-assisted problem-based learning*. In Journal of Physics: Conference Series (Vol. 1460, No. 1, p. 012004). IOP Publishing.

Son, J.W., & Lee, M.Y. (2020). *Exploring the relationship between preservice teachers' conceptions of problem-solving and their problem-solving performances*. International Journal of Science and Mathematics Education, 19, 1–22. https://doi.org/10.1007/s10763-019-10045-w

Suhendar, U., & Ekayanti, A. (2018). *Problem based learning as an effort to improve students' conceptual understanding*. Journal of Educational and Learning Dimensions, 6(1), 15-19. https://doi.org/10.24269/dpp.v6i1.815

Sulistyani, D., Roza, Y., & Maimunah, M. (2020). *The relationship between learning independence and mathematical Problem-Solving abilities*. Journal of Mathematics Education, 11(1), 1-12. https://doi.org/10.36709/jpm.v11i1.9638

Utami, N., Sukestiyarno, Y. L., & Hidayah, I. (2020). Kemampuan Literasi dalam Menyelesaikan Soal Cerita Siswa Kelas IX A. Prisma, Prosiding Seminar Nasional Matematika, 3, 626–633. https://journal.unnes.ac.id/sju/index.php/prisma/article/view/37679

Wahyuni, S. (2020). Efektivitas Model Thinking Aloud Pair Problem Solving (Tapps) dalam Meningkatkan Hasil Belajar Matematika Siswa. Journal Mathematics Education Sigma (Vol. 1, No. 1, p. 4026). https://doi.org/10.30596/jmes.v1i1.4026

Wang, S.Y., Chang, S.C., Hwang, G.J., & Chen, P.Y. (2018). *A microworld-based role-playing game development approach to engage students in interactive, enjoyable, and effective mathematics learning*. Interactive Learning Environments, 26(3), 411-423. https://doi.org/10.1080/10494820.2017.1337038

Wati, LI, & Nugraha, J. (2021). *Development of interactive learning media assisted by Adobe Flash CS6 in office technology subjects in class X OTKP SMK Negeri 1 Lamongan*. Journal of Office Administration Education (JPAP), 9(1), 65-76. https://doi.org/10.26740/jpap.v9n1.p65-76

Winarti, E.R., & Waluya, S.B. (2019). *The impact of problem-based learning using performance assessment on students' mathematical Problem-Solving abilities*. In Journal of Physics: Conference Series (Vol. 1321, No. 3, p. 032090). IOP Publishing. https://doi.org/10.1088/1742-6596/1321/3/032090

Xu, Z., & Qi, C. (2022). *Middle school students' mathematical problem-solving ability and the influencing factors in mainland China*. Frontiers in Psychology, 13, 1042315. https://doi.org/10.3389/fpsyg.2022.1042315

Yulianto, DY (2020). *The influence of online learning using digital platforms on mathematical Problem-Solving and critical attitudes of students at MA Daar El Qolam*. Symmetry: Pasundan Journal of Research in Mathematics Learning and Education, 5(1), 107–128. https://doi.org/10.23969/symmetry.v5i1.2790

Yunus, M., Setyosari, P., Utaya, S., Kuswandi, D., & Rusdi, M. (2021). *The relationship between achievement motivation, metacognitive awareness, attitudes and problem-solving abilities in students*. Cypriot Journal of Educational Sciences, 16(1), 32-45. https://doi.org/10.18844/cjes.v16i1.5506

Zakiyah, S., Usman, K., & Gobel, AP (2021). *Description of mathematical Problem-Solving ability through online learning on quadratic equation material*. Jambura Journal of Mathematics Education, 2(1), 28–35. https://doi.org/10.34312/jmathedu.v2i1.10268

Zebua, A., Hendriana, H., Subandar, J., & Sugandi, AI (2022). *The relationship between learning motivation with mathematical Problem-Solving ability in class XI students*. MaPan: Journal of Mathematics and Learning, 10(2), 312-322. https://doi.org/10.24252/mapan.2022v10n2a4

Zuliyanti, P., & Pujiastuti, H. (2020). *Contextual teaching learning (CTL) model to improve mathematical Problem-Solving skills of junior high school students*. Prisma, 9(1), 98-107.

Zutaah, P., Ondigi, S.R., & Miheso-O'Connor, M.K. (2023). *Pre-Service Teachers' Perception Of The Use Of Geogebra In Teaching And Learning Geometry In The Colleges Of Education, Ghana*. JOHME: Journal of Holistic Mathematics Education, 7(1), 1-21. https://doi.org/10.35194/jp.v9i1.899