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Review of Pedagogical Knowledge Through the Use of GeoGebra for Junior High School Students in Improving Learning Outcomes on Straight Line Equation Material

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Abstrak

Permasalah utama dalam penelitian ini adalah rendahnya hasil belajar siswa akibat kurang optimalnya pemanfaatan teknologi dalam pembelajaran, meskipun tersedia laboratorium komputer di SMPK St. Aloysius Niki-Niki.. Tujuan penelitian ini untuk mengetahui bahwa *Pedagogical Knowledge* guru dalam pemanfaatan teknologi dengan menggunakan aplikasi *GeoGebra* dapat meningkatkan hasil belajar siswa SMP pada materi persamaan garis lurus. Jenis penelitian ini adalah Penelitian Tindakan Kelas (PTK) yang dilakukan dalam dua siklus dengan indikator keberhasilan ketuntasan klasikal adalah 70%. Instrumen penelitian yang di gunakan meliputi lembar observasi dan lembar soal tes, dengan teknik pengumpulan data berupa tes tertulis dan observasi. Subjek penelitian ini adalah siswa kelas VIII A SMP Katolik St. Aloysius Niki-Niki tahun ajaran 2023/2024 yang berjumlah 28 siswa. Hasil penelitian menunjukkan bahwa melalui *Pedagogical Knowledge* guru dalam pemanfaatan teknologi dengan menggunakan aplikasi *GeoGebra* dapat meningkatkan hasil belajar siswa SMP pada materi persamaan garis lurus. Hal ini terlihat dari presentase ketuntasan kelas pada setiap siklus. Pada siklus I presentase ketuntasan kelas adalah 60% dan pada siklus II mengalami peningkatan dengan presentase ketuntasan kelas 92%. Data aktivitas siswa pada siklus I termasuk dalam kategori cukup baik dengan rentangan nilai setiap kelompok adalah $2{,}50 \leq \boldsymbol{p} < 3{,}00$ dan pada siklus II mengalami peningkatan dengan kategori sangat baik dan berada pada rentangan nilai setiap kelompok adalah $3{,}50 \leq \boldsymbol{p} < 4{,}00$.

Abstract

The main problem in this study is the low learning outcomes of students due to the less than optimal use of technology in learning, despite the availability of a computer laboratory at SMPK St. Aloysius Niki-Niki. The purpose of this study was to determine that the teacher's Pedagogical Knowledge in utilizing technology by using the GeoGebra application can improve the learning outcomes of junior high school students on the material of straight line equations. This type of research is Classroom Action Research (PTK) conducted in two cycles with the success indicator of 70% classical completeness. The research instruments used include observation sheets and test question sheets, with data collection techniques in the form of written tests and observations. The subjects of this study were students of class VIII A of St. Aloysius Niki-Niki Catholic Junior High School in the academic year 2023/2024, totaling 28 students. The results showed that through Pedagogical Knowledge of teachers in the utilization of technology by using the GeoGebra application can improve the learning outcomes of junior high school students on the material of straight line equations. This can be seen from the percentage of class completeness in each cycle. In cycle I, the percentage of class completeness was 60% and in cycle II it increased with a percentage of class completeness of 92%. Student activity data in cycle I was in the good enough category with the range of scores for each group was $2.50 \leq p < 3.00$ and in cycle II experienced an increase with a very good category and was in the range of scores for each group was $3.50 \leq p < 4.00$.

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Introduction

The learning process is the main foundation of education. The learning process takes place when teachers interact with students and use different learning resources in the same learning environment, with the aim of educating the students. In the learning process, there are planning, implementation, and evaluation stages that are carried out to achieve the set learning objectives (Candra et al., 2020). The intended learning objective is an understanding of the learning material, which is characterized by an increase in student learning outcomes. Effective learning has a significant impact on improving student learning outcomes.

In order to carry out effective learning and optimize students' learning outcomes, a teacher must have competence in accordance with their profession. Based on the Law of the Republic of Indonesia No. 14 of 2005, Article 8, a teacher's competence consists of personal competence, pedagogical competence, social competence, and professional competence, which are acquired through professional education. Pedagogical knowledge or pedagogical competence is one of the main competencies that teachers must have to perform their duties (Somantri, 2021). The law defines pedagogical competence as the ability to manage student learning, which includes the ability to design, implement, and evaluate the learning process and outcomes, and to use research findings to improve the quality of learning. While this definition of pedagogical competence is legally clear and concise, in practice managing learning is very complex. A teacher must be able to integrate different components, including knowledge, skills, and attitudes and values in the learning process.

Teachers are required to improve the quality of teaching and create an effective and innovative learning atmosphere, as this plays an important role in improving students' learning outcomes. Mathematics education plays a crucial role in shaping students' understanding of basic concepts at the primary and secondary levels. Mathematics also teaches students to be actively involved in discovering concepts, applying them, and solving mathematical problems (Pauweni et al., 2022). One of the most important materials in mathematics is linear equations. Linear equations are the foundation for understanding other mathematical concepts such as geometry, statistics, and calculus. Therefore, a deep understanding of this material is very important, especially at the middle school level. Based on interviews with teachers and students of Linear Equations class VIII A at St. Aloysius Niki-Niki Catholic Junior High School, it was found that there are still many students whose learning outcomes have not reached the school's minimum criteria (KKM).

Based on the results of interviews conducted by researchers with mathematics teachers at St. Aloysius Niki-Niki Catholic Junior High School, the factors that cause low student learning outcomes are the learning process that is less than optimal due to the selection of learning models that do not

utilize technology. In fact, although the school has a computer laboratory that can be utilized for learning, the number of available devices is not sufficient for all students in a class. In addition, students' access to the computer lab is still limited, as the lab is only used during exams and ICT learning. Teaching methods that are less interactive and do not actively involve students are also factors that contribute to low learning outcomes. As a result, students tend to be passive in the classroom, less interested in the material, easily bored, and have difficulty understanding the lessons. One of the difficulties that students often experience is drawing graphs of linear equations, especially when locating and placing points on Cartesian coordinates. Although teachers and students are familiar with computers, they are not familiar with the GeoGebra application, so the use of technology in learning mathematics is still limited. GeoGebra itself is new to students, although this application can help them understand mathematical concepts, especially in drawing graphs. Therefore, to increase student engagement and make learning more interesting, technology should be used optimally in the learning process. This is consistent with one of the components of pedagogical knowledge, which is the use of technology in the learning process.

One of the computer programs that can be used as a medium for mathematics learning is the GeoGebra program. With its various features, GeoGebra can be used as a medium for learning mathematics for demonstrating or visualizing mathematical concepts and as a tool for constructing mathematical concepts (Tanzimah, 2019). The GeoGebra application can also be easily used by students and teachers anywhere and anytime, as it can be installed on laptops and smartphones. Other benefits of using the GeoGebra application include increasing interest in learning, motivating students to learn individually and in groups, developing students' independence, training students' analytical skills, teaching students to be thorough, collaborating with friends, and improving learning outcomes.

GeoGebra was chosen for this research because of its advantages over other applications in learning mathematics, especially in the material of straight line equations. One of the main difficulties for students is drawing graphs of linear equations and understanding Cartesian coordinates. The use of GeoGebra strongly supports the learning of this topic because GeoGebra allows students to easily plot points, draw graphs, and understand the relationship between equations and graph visualization interactively. Although students and teachers at the school are familiar with computers, they have never used GeoGebra before. Students' access to the computer lab is also still limited, as the lab is only used during exams and ICT learning, and the number of available devices is not sufficient for all students in a class. Therefore, effective learning strategies are needed to integrate GeoGebra, such as the use of students' personal devices or group-based learning. Several studies have shown the effectiveness of GeoGebra in improving mathematical understanding. Studies conducted by (Ratuanik & Feninlambir, 2022) and (Suritno, 2022) in geometry learning concluded that the use of GeoGebra can improve students' learning outcomes. Therefore, the use of GeoGebra in the linear equations material has the

potential to have a similar positive impact, helping students to better understand the concept of graphs visually and increasing their engagement in learning.

Methods

The type of research used in this study is classroom action research (PTK), which is one of the efforts teachers can make to improve the quality of their roles and responsibilities, especially in managing learning (Sanjaya, 2016). This research was conducted in two cycles, where each cycle lasted for one week with two sessions. Each cycle consisted of four stages, namely planning, action, observation, and reflection. This research was conducted at St. Aloysius Niki-Niki Catholic Junior High School in the odd semester of the 2023/2024 academic year. The subjects of this study were students of class VIIIA of St. Aloysius Niki-Niki Catholic Junior High School in the academic year 2023/2024. The type of data used in this research is primary data. The data collection instruments consisted of observation guidelines and test questions. The observation guidelines used for teacher and student activities are based on the Pedagogical Knowledge indicators as follows.

Table 1. Pedagogical Knowledge Indicators

Pedagogical Knowledge **Indicators**	**Description**
Understanding	• Knowing the ability of students • Knowing student characteristics
Undestanding the curriculum or syllabus	• Knowledge of the curriculum • Has a learning syllabus that is in accordance with the applicable curriculum
Learing design	• Able to develop lesson plans that are in accordance with the applicable curriculum • Ability to determine learning models and strategies
Implementation of educational and dialogical learning	• Have the ability to manage the class in the learning process • Provide space for students to discuss • Be a facilitator during the learning process
Utilization of learning technology	• Ability to use technology as learning media • Direct students to use technology when learning
Learning outcome evaluation	• Have the ability to assess students • Utilize student learning outcomes for improvement in the next learning process

The data analysis techniques used in this study are data analysis of observation results and data analysis of test results. Analysis of obsevation data was analyzed using the formula below

$$P = \frac{sum\ of\ scores}{number\ of\ aspects\ observed} \quad (1)$$

With categories in Table 2 below:

Table 2. Observation Assesment Categories according to Sudjana (2011)

No	Value Range	Rating Category
1	$2{,}00 \leq P < 2{,}50$	Less good
2	$2{,}50 \leq P < 3{,}00$	Good enough
3	$3{,}00 \leq P < 3{,}50$	Good
4	$3{,}50 \leq P < 4{,}00$	Very good

Data analysis of the test result is calculates using the formula below (Sudjana, 2011)

a. Individual Completeness

Students are said to be successful (achieve learning completeness) if they have reached a mastery level of at least 70%.

$$X_1 = \frac{sp}{st} \times 100\% \quad (2)$$

b. Group Completeness

A class is said to have succeeded (achived learning completeness) if at least 70% of the data in the class has reached individual completeness.

$$X_2 = \frac{s}{t} \times 100\% \quad (3)$$

The indicator of success in this study is if the class completeness of students $\geq 70\%$ the learing is successful, if the class completeness < 70% then it has not been successful and continued to the next cycle. (Kinanthi dkk., 2022).

Research Results and Discussion

Results

1. Cycle I

The researcher conducted two meetings in this cycle. In the first meeting the researcher presented the material according to the syllabus and in the second meeting the researcher carried out the Cycle I test. The number of students present was 28. The following are details of the implementation of Cycle I. Pada siklus ini peneliti melakukan dua kali pertemuan.

a. Planning

Before the research is carried out, what is done in this planning phase is the preparation of the necessary learning materials, namely Syllabus, lesson plans, LKPD, teacher and student observation sheets and test questions.

b. Implementation of Action

The action taken at the first meeting was to present the material according to the lesson plan. The GeoGebra application was used to manage the learning process. In the initial activities, greetings,

prayers and checking the presence of students, then the material, learning indicators and learning objectives were conveyed. In the core activities, the learning process was carried out in 3 phases. In the first phase, the researcher asked questions about the previous material and gave students the opportunity to answer questions. Students are given a few minutes to find answers to the questions given. The first stage lasts about 3-5 minutes. Students are then instructed to move on to the second phase.

Figure 1. Cycle I Learning Process

In the second phase, the researchers started learning by using GeoGebra. Before implementing Cycle I, the researchers first gave a brief introduction to the students on how to use GeoGebra. The researcher explained the material of linear equations by using GeoGebra to draw graphs of linear equations, determine gradients and explain the properties of linear equations. During the learning process, the researcher also provided a step-by-step explanation of how to use GeoGebra so that the students could follow and use the application properly. The second phase took about 20 minutes.

Figure 2. Working oh the LKPD in Groups

In the third phase, the researcher checked students' understanding and provided feedback by dividing students into 5 heterogeneous groups. Researchers distributed LKPD to each group, and students conducted group discussions. After completing the discussion, the teacher gave students the opportunity to present the results of each group's discussion. The third phase lasted about 30 minutes. In the closing part, the teacher and students made conclusions from the material taught. The second meeting was used for the cycle I test. This test is conducted to determine the extent of students' understanding of the material that has been learned.

From the test results there were 17 students who were declared complete and 11 students who were declared incomplete. The percentage of class completeness in Cycle I was 60%. This was obtained by dividing the 17 students who achieved individual completeness by the total number of students multiplied by 100%.

c. Observation

Based on the analysis of teacher activity observation results during the learning process using the GeoGebra application, the average value of teacher activity is 2.91, which is a fairly good category. Meanwhile, based on the analysis of the results of observations of student activities, it can be seen that the average value of student activities in each group of cycle I is as follows:

Table 3. Result of Student Activity Observation Cycle I

	Number of aspects observed	**Number of scores obtained**	**Averange score**	**Rating Category**
Group 1	12	34	2,83	Good enough
Group 2	12	32	2,67	Good enough
Group 3	12	32	2,67	Good enough
Group 4	12	33	2,75	Good enough
Group 5	12	31	2,58	Good enough

d. Reflection

Based on the analysis of the Cycle I test results, the classical completeness obtained in the Cycle I test was 60% and had not yet reached the established success indicator of 70%. This was caused by several things that came from the analysis of the students' and teachers' activity observation sheets, namely In Group I, students did not pay attention to and record important things about the material presented by the teacher, some students were still confused when working on LKPD using GeoGebra, and the teacher was too quick in explaining the use of GeoGebra. In group II, students did not pay attention and note important things about the material presented by the teacher, students did not actively discuss to complete the provided LKPD, and when explanation was given, students did not follow the teacher's explanation about using GeoGebra when working on LKPD. In group III, students are less active in discussing and working together in groups to work on the LKPD, students also do not listen and record examples of problems presented by the teacher. In group IV, students do not understand the use of GeoGebra and make it difficult for students to work on LKPD, students tend to be silent when they want to answer questions given by the teacher or other group friends. In group V, students did not pay attention and record important things about the material presented by the teacher, students did not actively discuss and work together in groups to work on LKPD, some students had difficulty in using GeoGebra because the teacher explained the use of GeoGebra too quickly. Since the percentage of class completeness did not meet the success indicator, the research will be continued in the next cycle.

2. Cycle II

The research in cycle II was carried out in two meetings. In the first meeting, the researcher presented the topic according to the curriculum and the results of the reflection from the first cycle. In this

second cycle, more attention is paid to the results of reflection or input from cycle I.

a. Planning

Make learning tools such as syllabus, lesson plans, LKPD, test questions and teacher and student observation sheets.

b. Implementation of Action

The action taken at the first meeting was to present the material in accordance with the lesson plan and the results of the reflection or improvement of the first cycle. Researchers carried out the learning process using the GeoGebra application.

In the initial activities of greeting, praying and checking the attendance of students, then delivering the material, learning indicators and learning objectives. In the core activities, the learning process was carried out in 3 phases. In the first phase, the researcher asked questions about the previous material and gave students the opportunity to answer questions. Students are given a few minutes to find answers to the given questions. The first phase lasted 3 minutes. Then students are instructed to enter the second phase.

Gambar 3. Cycle II Learning Process

In the second phase, the researchers started learning by using GeoGebra. The researchers explained the material of linear equations using GeoGebra by drawing graphs of linear equations, determining gradients and properties of linear equations. The second phase lasted 30 minutes. In the third phase, the researchers checked the students' understanding and provided feedback by dividing the students into 5 heterogeneous groups. Researchers distributed LKPD to each group and students conducted group discussions. After the discussion was completed, the teacher gave students the opportunity to present the results of each group's discussion. The third phase lasted 25 minutes. In the final part of the teacher and students draw conclusions from the material taught.The second session was used for Cycle II tests. This test is used to determine the extent of the students' understanding of the material that has been taught.

From the results of the tests given, there were 26 students who were declared complete and 2 students who were declared incomplete. The percentage of class completeness in Cycle II was 92%,

which was obtained by dividing 26 students who reached individual completeness by the total number of students multiplied by 100%.

c. Observation

Based on the analysis of the results of the observations of the teacher's activity during the learning process using GeoGebra obtained an average score of 3.67 with a very good category, while based on the analysis of the results of the observations of the student's activity it can be seen that the average value of the student's activity in each group in cycle I is as follows:

Table 4. Result of Student Activity Observation Cycle II

	Number of aspects observed	Number of scores obtained	Averange score	Rating Category
Group 1	12	44	3,67	Very good
Group 2	12	43	3,56	Very good
Group 3	12	43	3,56	Very good
Group 4	12	44	3,67	Very good
Group 5	12	43	3,56	Very good

d. Refleksi

After following the learning process and giving a test, it can be seen that the test results of Cycle II have increased compared to Cycle I, where there are 17 students who have achieved individual completeness with a percentage of 60% classical completeness increasing to 92% and the students' activity during the learning process using the GeoGebra application has achieved good results, although there are some students who have not completed. The results of the reflection showed that the researcher did not continue with the next cycle because the classical completeness for cycle II exceeded the specified success indicator of 70%.

Discussion

From the data on the results of the research conducted, it is found that there is an increase in student learning outcomes on the linear equations material using the GeoGebra application from Cycle I to Cycle II. Below is a graph of student learning outcomes.

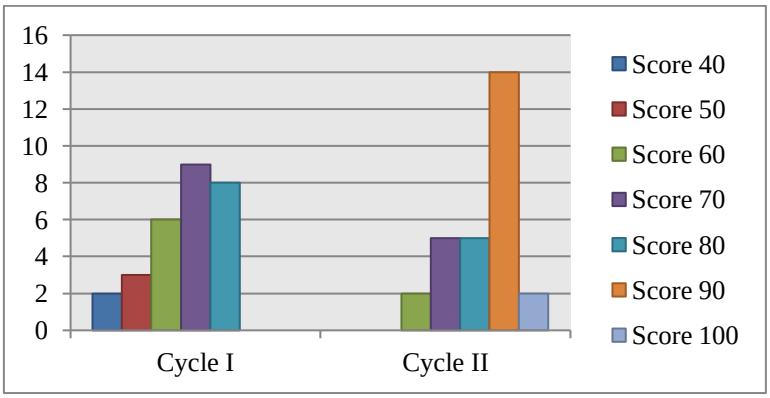

Figure 4. Diagram of Student Learning Outcomes

The improvement in student learning outcomes can be seen in the value of student learning assessment results, where there were 11 students who were incomplete in Cycle I and only 2 students who were incomplete in Cycle II. There were also 11 students whose test results were incomplete in Cycle I, but in Cycle II the test results improved and the test results were complete. Similarly, there were 2 students who were not complete in Cycle II, although the students' scores did not reach completeness in Cycle II, there was an increase in the learning outcomes achieved. This shows that there was an improvement after the students took the test in Cycle II. The increase in student learning assessment scores was followed by an increase in the percentage of complete classes in each cycle. The percentage of class completion increased by 32% where the percentage of class completion in Cycle I was 60% and the percentage of class completion in Cycle II was 92%.

The improvement in students' learning outcomes is also reflected in the observation data in Cycle I and Cycle II during the learning process of linear equations material using the GeoGebra application. The application of the teachers' pedagogical knowledge can be seen in their ability to use technology in learning, especially by using the GeoGebra application as a learning medium. The student and teacher observation sheets used in this study were prepared based on the components and indicators of pedagogical knowledge, so that the increase in the observation results in cycle II reflected the improvement in the quality of the learning process. This shows that teachers' mastery of pedagogical knowledge contributes to the effectiveness of learning, which in turn affects the improvement of students' learning outcomes. The results of the teacher and student observations are presented below in the form of graphs.

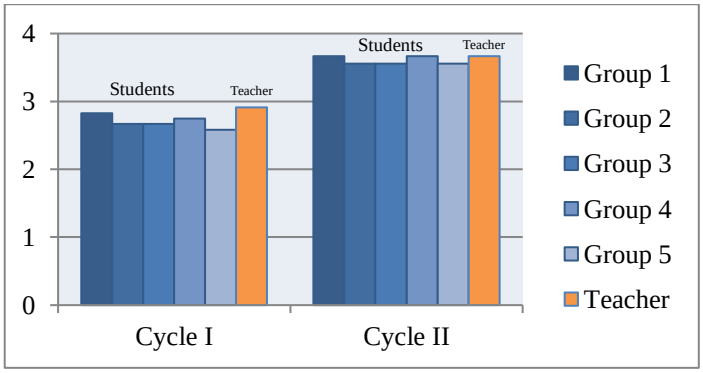

Figure 5. Diagram of Teacher and Student Observation Result

Based on the results of student observations in Cycle I, student learning activities in each group formed were in the range of values $2.50 \leq p < 3.00$ and categorised as quite good, while the results of teacher observations in Cycle I obtained an average score of 2.91 with a quite good category. The results of student observations in cycle II, student learning activities per group are in the range of values $3.50 \leq p < 4.00$ with very good categories, while the analysis of teacher observation sheets obtained an average value of 3.67 with very good categories. This increase in the observation results is supported by the reflections and improvements made by the researchers in the continuation of Cycle II. The

increase in student and teacher activities in the learning process shows good interaction, effective interaction between teachers and students plays an important role in creating a conducive learning environment and increasing concept understanding. In line with the research findings of (Sihombing et al., 2022), with good interaction, students are more active in the learning process, so they can achieve more satisfactory learning outcomes.

The increase in student learning outcomes is due to the maximisation of student and teacher learning activities. During the learning process of Cycle II, the teacher re-explained how to determine the gradient and how to draw a graph of a straight line equation using the GeoGebra application.Afterwards, the learning continued with the material of determining the equation of a straight line and the relationship between two straight lines using GeoGebra in Cycle II.Thus, students experienced reinforcement by repeating the learning material of the straight line equation. According to Thorndike's learning theory (Amsari & Mudjiran, 2018), giving students repetition (law of practice) is one of the factors so that the stimulus-response relationship occurs. The given stimulus should be repeated often so that the stimulus-response relationship becomes stronger, one of which is by providing exercises or emphasising concepts by the teacher.

In addition to the repetition of the material given to the students, there are several factors that lead to increased student learning outcomes, namely 1) The use of the GeoGebra application makes it easier for students to understand graphs of linear equations clearly and interactively. In addition, this application allows students to correct mistakes directly while working on practice problems. This not only improves concept understanding, but also facilitates the improvement of student learning outcomes. 2) In the learning process, the researcher divided the students into 5 heterogeneous groups based on the level of comprehension ability of high, medium and low. It is intended that all students in the group can help each other. Students with high comprehension ability can explain to students with medium or low comprehension ability. 3) The researcher has a role as a facilitator for the students where in the learning process and group discussions to complete the LKPD provided. If there are problems in the group discussion that cannot be solved by all the group members, the students will ask the researcher and the researcher will explain to the group members. Researchers also help students to clarify their understanding when they make mistakes in using the GeoGebra application and also in working on the LKPD.

During the implementation of Cycle I and Cycle II, it was observed that the level of students' success during the learning process was influenced by the use of the GeoGebra application. Students showed positive developments ranging from activity in working on the Learner's Worksheet (LKPD), fluency in presenting the results of group discussions to skills in using the GeoGebra application. This has an impact on the students' ability to solve test questions well and a deeper understanding of the linear equation material. The success of the efforts to improve learning outcomes is in line with the

research (Suhaifi et al., 2021) entitled "The Effect of Using the GeoGebra Application on Mathematics Learning Outcomes", which states that the use of the GeoGebra application is more effective than conventional learning, so it can be used as an alternative in the teaching and learning process. In addition, through a teacher's knowledge of content and good teaching methods, students will more easily build understanding, especially for mathematics teachers who must be able to convey abstract concepts so that they can be easily absorbed by students (Febrianti et al., 2023). This shows the importance of the teacher's role in improving pedagogical competence, where the ability to choose appropriate learning methods and media is key to creating effective and meaningful learning.

Conclusion

Based on the results of the research and discussion, the researcher can conclude that the pedagogical knowledge of teachers in the use of technology using the GeoGebra application can improve the learning outcomes of junior high school students on the subject of linear equations. This can be seen from the percentage of class completeness in each cycle. In Cycle I, the percentage of class completeness was 60% and in Cycle II it increased with a percentage of class completeness of 92%. Data on student activity in cycle I is in the good enough category with the range of scores for each group is $2.50 \leq p < 3.00$ and in cycle II has increased with a very good category and is in the range of scores for each group is $3.50 \leq p < 4.00$. The implication of this research in mathematics learning is that technology integration, especially the GeoGebra application, is able to increase the interaction between students and teaching materials, facilitate the understanding of mathematical concepts and create a more interesting and meaningful learning atmosphere. Therefore, teachers are expected to continue to develop their pedagogical competence by using relevant technology to support more effective learning. In addition, the use of technology can be used as a sustainable strategy to improve student engagement and learning outcomes in various other materials.

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