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Improving Students' Problem Solving Abilities through the Application of Auditory Intellectually Repetition Model

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Article Info	Abstract
Received April 27, 2022	The purpose of this study is to know the improvement of students' problem solving ability through the Application of auditory intellectually repetition (AIR) model. This research method uses the quantitative method by taking one experimental class. Samples were assigned from one Public Vocational School in Indramayu, by a purposive technique, based on the selection of teaching teachers. They were from X TKJ2 consisting of 29 students. Data retrieval uses a pretest and posttest of problem solving abilities. Based on the results of data analysis: (i) the student's pretest got the lowest and highest score respectively 6 and 23, and the average was 14.42, (ii) the student's posttest got the lowest and highest score respectively 21 and 38, and the average was 31.17. The maximum score for the pretest and posttest is 40. Based on the hypothesis test using the <i>t</i> -test obtained the observation value of <i>t</i> was 6 and the critical value of <i>t</i> was 2.03, because of that the AIR model was effectively implemented in learning in the classroom. Furthermore, a gain score test was carried out, and then the results were obtained by using the AIR model to improve students' problem solving abilities.
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Keywords	
Auditory, intellectually, repetition model; Mathematical ability; Problem solving.	

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INTRODUCTION

According to Suherman (in Afrida & Handayani, 2018), problem solving is part of the mathematics curriculum which is very important because in the learning process and its completion, students are expected to gain experience, use the knowledge and skills they already have to apply to problem solving that is not routine. One of the problems in learning mathematics is the low level of students' ability to solve problems related to daily life. These results are in line with the researcher's preliminary study of mathematics students and teachers conducted at the vocational school where the research was carried out. The results of the preliminary study obtained information that the problem solving ability of most vocational high school students is still low. Based on an initial interview conducted by researchers to one of the teachers, that one of the causes of low problem solving abilities is due to the lack of practice questions given to students. In addition, according to mathematics teachers, it is stated that the models used in mathematics learning are still not effective. One of the methods used by teachers

in teaching is to use conventional methods, namely teachers teach with lectures and discussions and then give practice questions. In the process of learning mathematics, students only memorize the knowledge provided by the teacher and are less able to use this knowledge if they encounter problems in real life (Lestari, Andinny, & Mailizar, 2019). So that a learning model is needed that can make students hear and repeat the material that has been taught by the teacher. Thus students not only memorize, but can understand the material.

National Council of Teacher of Mathematics (in Mariani & Susanti, 2019; NCTM, 2000), set five standards of mathematical ability to be able to realize goals in mathematics learning, namely problem solving ability, reasoning and proof, communication, connection and representation abilities. In addition, the results of The Third International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA) also reflect the low mathematics problem solving ability of students. From the results of TIMSS 2015, Indonesia is in 44th position out of 49 countries with a score of 397, the score obtained by Indonesia is below the average international score of 500 (Mahmudah, 2018). Based on the results of PISA 2015 Indonesia is ranked 61st for reading material, 63rd for mathematical material and 62nd for science material from 69 participating countries (Pratiwi, 2019).

One of the abilities needed by students to solve problems is to familiarize students with creative thinking (Diyanah & Firdausi, 2018; Ismunandar et al., 2020). In the initial interviews that have been carried out by researchers, data were obtained that students' problem solving abilities were still lacking. This happens because in mathematics learning students ask the teacher to provide the fastest formula so that students can solve math problems. Another reason, the lack of students' problem solving abilities is that during group discussions, students are less focused on discussing the material so that when given problems that are similar to the examples given by the teacher, students have difficulty discussing the material so that when given problems that are similar to the examples given by the teacher, students have difficulty. The learning method carried out by the teacher is appropriate in developing students' problem solving abilities, but it is necessary to have a learning model that can support the teacher's method. Mathematical problem solving abilities can develop, if there is interactive or exchange of opinions in solving problem solving problems (Rostika & Junita, 2017).

Siwono (in Mawaddah & Anisah, 2015), argues that problem solving is a process or effort by individuals to respond to or overcome obstacles or obstacles when an answer or method of answer is not yet apparent. In addition, Ruseffendi (in Rahayu, Anggo, & Fahinu, 2019) stated that, problem solving abilities are very important in mathematics, not only for those who will later explore or study mathematics, but also for those who will apply it in other fields of study and in everyday life. The importance of mathematical problem solving abilities to be possessed by students is also stated by Sumarmo (in Ariawan, 2016), namely the possession of problem solving abilities in students is important, because problem solving ability is the goal of teaching mathematics, even as the heart of mathematics. Through problem solving, it is hoped that students can find the mathematical concepts learned (Putra et al., 2018).

Polya divides four main steps of solving mathematical problems, namely understanding the problem, finding a plan (devising a plan), implementing the plan (carry out your plan), and looking back (Lestari et al., 2019). According to Sumarmo (in Rahayu & Afriansyah, 2015), problem solving ability can be detailed with the following indicators: (1) identify existing information for troubleshooting; (2) create appropriate mathematical models to solve the problem; (3) select and use appropriate strategies to solve problems; (4) Explain or interpret the results obtained, and check the correctness of the completed results; (5) applying mathematics meaningfully. Poyla explained the problem solving indicators (Rostika & Junita, 2017), including:

Table 1. Problem Solving Indicators According to Poyla

Problem Solving Stage	Indicators
1. Understanding the problem	Identifying known elements, the question and the adequacy of the necessary elements.
2. Drawing up a problem solving plan	Formulating a mathematical problem or drawing up its mathematical model.
3. Implement a problem solving plan	Applying strategies for solving various problems inside or outside of mathematics.
4. Double-check results	Explain or interpret the results according to the problem of origin.

Based on the description above, it can be concluded that problem solving ability is one of the important abilities in mathematics, because this ability allows students to find ways of the problems faced both in learning activities and in daily life. Indicators of problem solving ability in this study are understanding problems, drawing up problem solving plans, implementing problem solving and re-examining.

One learning model that can improve problem solving abilities is Auditory Intellectually Repetition (Awaliyah, Soedjoko, & Isnarto, 2016). Using this method, mathematics learning carried out in the classroom involves students to speak, listen, analyze experiences, do problem planning creatively, and repeat so that the understanding received is broader and deeper. So that with this method students can improve problem solving abilities.

RESEARCH METHODS

The research method used in this study was One Group Paired Design, because in this study there was only one experimental group and were given pretests and posttests. The following was a design of this research which cited Senjaya (2017).

$$R: O_1 \quad T \quad O_2$$

At the design, R is for the randomization of sampling, T is a treatment, O_1 is an observation before treatment (pretest), and O_2 is an observation after treatment (posttest)

The population in this study was grade students in 10th from the one Public Vocational School in Indramayu for the 2019/2020 academic year. The material

taken in this study is a system of two-variable linear equations. The sampling technique in this study used purposive sampling, while to measure students' problem solving ability, researchers used test questions. Test questions are given at the time before the material is given (pretest) and after the material is completed (posttest) to improve students' problem solving abilities. Data analysis carried out, using the help of PESTRIPP software (Senjaya, 2017) with a significant degree $\alpha=0,05$.

RESULT AND DISCUSSION

The following are the results of pretests and postes of applying the AIR model to the problem solving ability shown by the frequency distribution like Table 2 and Figure 1.

Table 2. Pretest Data in Frequency Distribution

Interval	Frequency
6 - 8	1
9 - 11	5
12- 14	13
15 - 17	13
18 - 19	1
20 - 23	3
Total	36

The Result Pretest of Students' Problem Solving Abilities

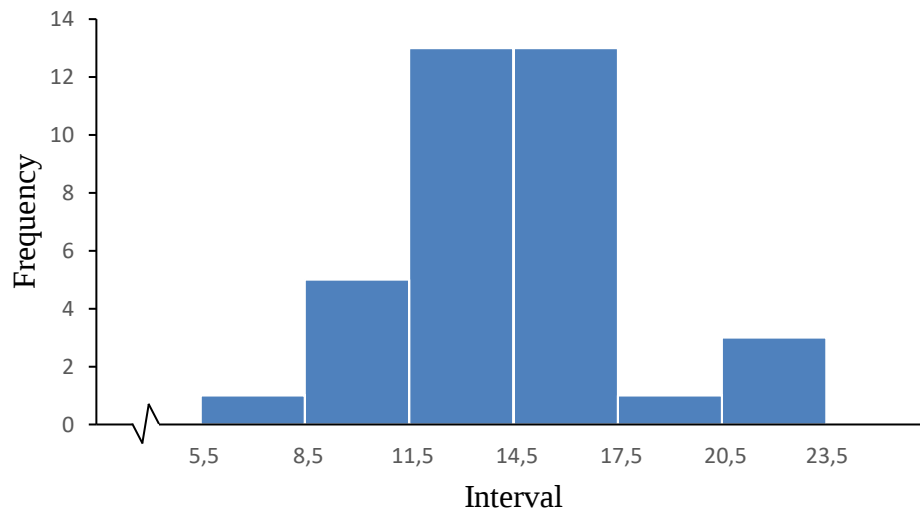


Figure 1. The Result Pretest of Students' Problem Solving Abilities

From the frequency distribution in Table 2 and Figure 1 above with a total of 36 students, it can be seen that the results of the problem solving ability pretest have a minimum score of 6-8, namely 1 student, the maximum score at intervals 20-23 is 3 students, and the highest frequency is at intervals 12-17, namely 26

students. At the following shown by the frequency distribution Table 3 and Figure 2 as the descriptive data for the posttest result.

Table 3. Posttest Data in Frequency Distribution

Interval	Frequency
21 - 23	1
24 - 26	3
27 - 29	10
30 - 32	8
33 - 35	7
36 - 38	7
Total	36

The Result Posttest of Students' Problem Solving Abilities

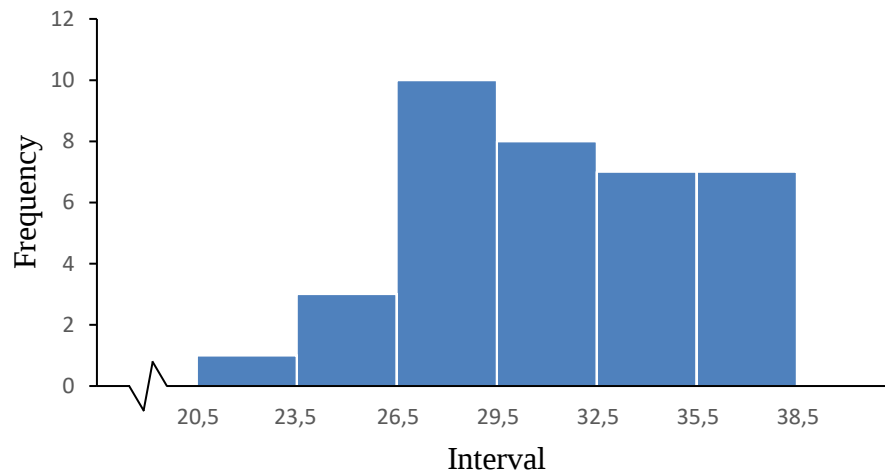


Figure 2. The Result Posttest of Students' Problem Solving Abilities

Based on the frequency distribution table and histogram of postes above with a total of 36 students, it can be seen that the results of problem solving ability postes have a minimum score of 21-23, namely 1 student, the maximum score at intervals 36-38 is 7 students, and the most frequency is at intervals 27-29, namely as many as 10 students. In this study, Table 4 is the results of the normality test were obtained as follows.

Table 4. Normality Test Results

	L_0	$L_{(0.05;36)}$	Description
Pretest	0,137	0,1454	Normal
Posttest	0,122	0,1454	Normal

Based on Table 4, it shows that in the pretest obtained $L_0=0.137$ and $L_{(0.05;36)}=0.1454$, on the posttest obtained $L_0=0.122$ and $L_{(0.05;36)}=0.1454$, because $L_0 < L_{(0.05;36)}$, failed to reject/accept H_0 . This means that the sample comes from a normally distributed population.

Based on the calculation of the normality test, it was concluded that the pretest and posttest data are normally distributed. Then the next alternative using the gain test is the t -test. The data obtained from this study include pretest, posttest and Gain score data. The data can be seen in Table 5 and Figure 3.

Table 5 Research Data

Data	Pretest	Posttest	Gain Score
Lowest Score	6	21	16,67
Highest Score	23	38	
Average	14,42	31,17	

The t -test value obtained $\bar{d} = 16.67$, $sd = 4.45$, $n = 36$ to a significant extent $\alpha = 0.05$ with degrees of freedom $db = n - 1 = 36 - 1 = 35$. Next we take the value of the distribution of t from the sample $t_{obs} = 6$ and the critical value of t is ($t_{\alpha} = 2.03$), if $t_{obs} > t_{\alpha}$ so it can be concluded that learning that applies the AIR model is effective for improving problem solving abilities.

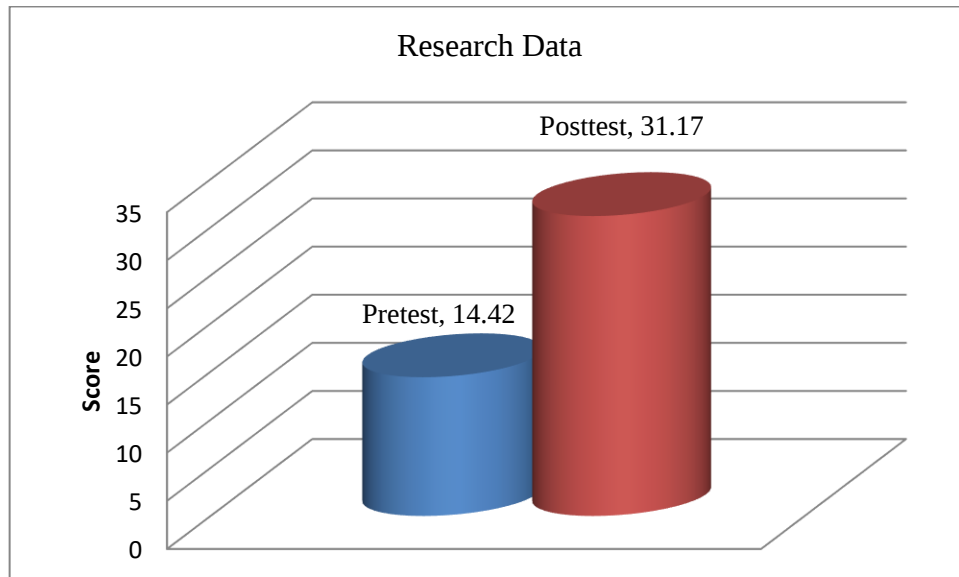


Figure 3. Gain Decreasing Results

During the first learning process, only a few students dared to express their opinions when the researcher asked because there were still many students who did not understand the material of the two-variable linear equation system, during the process of doing the questions some students could do it even though the steps in working on the questions were still not right and some others still remembered how to answer the questions and could do the questions in a longer time.

During the second learning process, many students have been more active in learning activities, not just answering questions from researchers, but also daring to ask and respond to questions from fellow students, during the process of working on questions, many students already understand how to answer questions with sequential steps unlike during the first learning process where many students still remember when doing questions. Research that is almost similar to this study is that the use of the AIR model using a lesson study approach is better than the

use of AIR in conventional learning (Agustiana & Putra, 2018). In addition, according to Ulva and Suri (2019), the use of the AIR model also affects students' mathematical abilities. In other studies, the use of the AIR model also affects the mathematical solving ability of junior high school students (Widyazuniarti, Misdalina, & Marhamah, 2019).

CONCLUSION

Based on the results of research, data processing and analysis as well as hypothesis testing, the conclusions of these research results are (1) the results of problem solving ability before the implementation of the AIR model have the lowest score of 6, the highest score of 23 with an average of 14.42, while the results of problem solving ability after the implementation of the AIR model have the lowest score of 21, the highest score of 38 with an average of 31.17; (2) The application of the AIR model can improve problem solving abilities.

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Implementing the Geogebra Applet-Based Connecting, Organizing, Reflecting, Extending (CORE) Learning Model for Students' Critical Thinking Ability in Learning Styles

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Article Info	Abstract
Received July 3, 2022	In the era of globalization, the 21st century requires learning integrated with technological developments and innovation. This study aims to analyze the implementation of the Connecting, Organizing, Reflecting, Extending (CORE) learning model based on the Geogebra Applet on students' critical thinking ability regarding learning styles. The design of this study is quasi-experimental. The samples in this study were students of class XI MIPA 1 and XI MIPA 2 SMA Negeri 2 Magelang who were selected by the cluster random sampling technique. The instruments used in this study were critical thinking ability tests and learning style questionnaires. Based on the results of the hypothesis test conducted with the ANOVA test of two unequal cell paths and the LSD (Least Significance Difference) follow-up test, results were obtained: (i) The Core learning model based on the Geogebra Applet produces students' critical thinking ability better than the direct learning model; (ii) There are differences in critical thinking ability between students and the learning styles of divergers, convergers, assimilators and accommodators; (iii) There is no interaction between the Geogebra Applet-based CORE learning model and the direct learning model with the student's learning style.
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INTRODUCTION

In the 21st century era of globalization, the rapid increase in science and technological innovation requires the role of educators with character. This condition results in a nation that is not ready to adapt and will fall into the enormity of changes in civilization and advances in science and innovation. This way, education must be improved (Kemendikbud, 2017). Commonly referred to as the 4C skills of the 21st century, schools teach children to think creative thinking, communication, critical thinking and problem solving, and collaboration.

As one of the talents of the 21st century, critical thinking or critical thinking abilities contain components often faced by students in their daily lives. Critical thinking is investigating and assessing information based on observation, application, reasoning, and communication results to determine whether the data should be trusted or ignored (Purwati, Hobri, & Fatahillah, 2016). Observation of a

person's behavior can realize the thinking process in critical thinking abilities. In daily life, a person cannot be separated from the use of essential thinking skills; that is, a person is not only influenced by information or issue but must be able to choose the information he obtains and present reasons and evidence logically and rationally. In line with (Ruggiero, 2012) opinion that critical thinking is assessing the ideas we have to make the best choice in solving problems or making logical conclusions. Then evaluate and refine the decision.

The impact that occurs when someone cannot think critically is that it is easy to make decisions without conducting an analysis first, resulting in decisions taken less in line with expectations. Someone who cannot think critically will be easily influenced by a problem and find it challenging to find ideas to solve it. Therefore, critical thinking abilities are essential for students (Agustina, 2019).

According to Facione (2011), critical thinking abilities have six primary skills, including (1) interpretation, understanding problems, (2) analysis, the process of analyzing the relationship between concepts and statements, (3) evaluation, applying correct strategies in solving problems, (4) Inference, making conclusions based on the previous step, (5) explanation and (6) self-regulation, where students describe what they have learned and how their work develops from beginning to end. According to discussions with teachers at SMA Negeri 2 Magelang, students are rarely given questions that require critical thinking. The initial test of essential thinking skills at SMA Negeri 2 Magelang resulted in 52.13 out of 100. This result was categorized as low because the category of critical thinking ability was <55 (Pertiwi, 2018).

One of the things that affect critical thinking abilities is the learning model (Hasibuan, Abubakar, & Harahap, 2018). A learning paradigm is needed that can involve students' necessary thinking skills. Observations at SMA Negeri 2 Magelang show that educators often adopt a teacher-centered learning paradigm. The learning model is still teacher-centered and has not changed. As a result of this condition, only a few children are active, so students' abilities are not emphasized in class.

The CORE learning model is one of the learning models that can improve students' ability to think critically (Ayudia & Mariani, 2022). Connecting, organizing, reflecting, and extending is part of the CORE learning model (Miller & Calfee, 2004), where each step cannot be completed without completing or leaving the previous one. In the linking stage, students activate prior knowledge (Curwen et al., 2010) and relate it to newly acquired information (Dymock, 2005). In the organizing step, students are directed to organize the knowledge they have developed in the previous stage (Miller & Calfee, 2004) so that the principles learned by students are clearly defined (Dymock, 2005). In the reflecting stage, students re-examine the organizational structure that has been formed (Curwen et al., 2010), and explain or criticize the information structure that has been made previously (Dymock, 2005), while in the extending stage, students develop or expand knowledge (Dymock, 2005).

Previous research has shown that CORE learning benefits critical thinking abilities (Ningsih et al., 2020; Udayani, Gita, & Suryawan, 2019; Wati et al., 2019). Using the CORE paradigm, students learn how to relate and organize their accumulated knowledge. When using the CORE learning model, students are more involved in the educational process.

The supporting factor in the learning model is the learning media. Learning media is very helpful in delivering and understanding the material. One of the learning media that helps to learn and can explore students' critical thinking abilities is Geogebra (Andriani et al., 2022; Batubara, 2019).

Geogebra is an innovative mathematics program that integrates calculus, algebra, and geometry (Hohenwarter et al., 2008). This program is used for mathematics education. Students who use Geogebra are expected to learn freely, even without explicit instruction. In addition, this curriculum allows students to strengthen their talents. According to (Hohenwarter et al., 2008), Geogebra learning media can provide several benefits, such as helping the process of demonstrating and visualizing specific mathematical ideas to minimize the amount of mathematical abstraction. This media can also be used as a building tool for several mathematical topics. Geogebra can also be applied as a discovery tool, enabling students to discover specific mathematical ideas.

Geogebra can be a medium of learning in helping students understand one of them in learning mathematics at school. The output created in Geogebra is called a Geogebra applet. The derivative of the algebraic function is one of the materials that must be visualized through learning media. The derivative of algebraic functions is a complex topic because it requires a high level of abstraction. In understanding this fairly complex material, teaching aids are needed in the learning process. The Geogebra applet can be applied to material derived from algebraic functions. This material requires visualization in the concept of derivatives of algebraic functions. Students have difficulty imagining derivatives of algebraic functions because they cannot interact directly with relevant images and observe content without much curiosity (Pradhana, 2020).

The CORE learning model can take advantage of the Geogebra Applet learning media. Besides being able to help students understand and create more exciting and interactive learning, the use of the Geogebra Applet is also in line with the use of developments in science and technology. 21st-century learning must be integrated with technological developments (Kemendikbud, 2017). Therefore, students must be given the knowledge by the development of civilization to fulfill 21st-century skills.

Besides being influenced by the learning model, other factors affect students' ability to think critically, namely learning styles (Karim, 2014). A person's learning style is an individual's way of obtaining, processing, and manifesting information in daily behavior (Rambe & Yarni, 2019). Kolb & Kolb (2005) divides learning styles into four categories: (1) divergers, individuals who are adept at observing concrete situations from multiple perspectives, (2) convergers, individuals who are adept at finding practical applications for ideas and theories, (3) assimilators, individuals who have the ability to processing diverse information and pouring it into a logical and definite form, and (4) accommodator, individuals who have advantages can learn from direct experience.

Every student has a unique learning style. Therefore, every student in the learning process needs a separate way to understand the subject matter simply (Rahmi & Samsudi, 2020). Because of this variation, each student's understanding and absorption of information during learning differs, as are his abilities.

RESEARCH METHODS

This research is a type of quantitative research with quasi-experimental methods. In this study, there were two free variables and one bound variable. The free variables in this study are learning models, namely learning models and learning styles. The learning model used is the Geogebra Applet-based CORE (P_1) and the direct (P_2) learning models. Then the learning style used is a Kolb-type learning style, namely the learning style of diverger (Q_1), converger (Q_2), assimilator (Q_3), and accommodator (Q_4). At the same time, the bound variable used in this study is the ability to think critically. So the two-track experimental design of this study is shown in the following table.

Table 1. Experimental Research Design

Learning model (P_i)	Learning style (Q_i)			
	Q_1	Q_2	Q_3	Q_4
P_1	P_1Q_1	P_1Q_2	P_1Q_3	P_1Q_4
P_2	P_2Q_1	P_2Q_2	P_2Q_3	P_2Q_4

This research was conducted at SMA Negeri 2 Magelang in the 2022/2023 school year. The population in this study was all students of class XI MIPA, with a total of 179 students. This study used class XI MIPA 1 as the experimental class and class XI MIPA 2 as the control class. The number of students in each class amounted to 36 children, so the total number of the sample was 72 students. The sampling technique used in this study was random cluster sampling. This technique is used if the sample to be studied is substantial.

The instruments used in this study were learning style questionnaire instruments and critical thinking ability test instruments. The learning style questionnaire used in this study was David Kolb's learning style questionnaire. This questionnaire is a standard questionnaire sourced from Miami University. Because David Kolb's learning style questionnaire is a standard questionnaire, this questionnaire is suitable for use without having to be validated and tested. David Kolb's learning style lifting instruments are given in practical and control classes to determine the characteristics of students' learning styles. Meanwhile, the test instruments in this study must be validated and tested. Validation of the critical thinking ability test is carried out to determine the validation of the contents of the test instrument. The content validators on the critical thinking ability test instrument are based on the assessment by the three validators, five questions were stated to be content worthy of testing. The following Table 2 is presented a summary of the results of the analysis of the trial item of the critical thinking ability test instrument.

Table 2. Summary of Instrument Calibration Analysis Results

No.	Validity	Reliability	Difficulty index	Discriminatory power	Conclusion
1	Very Good	Good	Keep	Enough	Proper
2	Very Good		Keep	Good	Proper
3	Very Good		Keep	Enough	Proper
4	Very Good		Difficult	Enough	Proper
5	Very Good		Difficult	Enough	Proper

Based on Table 2 of the analysis on the instrument item, the critical thinking ability test instrument is worth using.

The collection techniques carried out in this study were observation, interviews, tests and questionnaires. The test instrument is used to determine the student's critical thinking ability, while the questionnaire instrument is used to determine the student's learning style.

The data analysis techniques used in this study were ANOVA, two unequal cell paths and LSD follow-up tests. However, before conducting the test, conduct a pre-requisite test, namely the normality test and the homogeneity test. The normality test in this study used the Lilliefors test, while the homogeneity test carried out in this study used the Barlett test.

RESULTS AND DISCUSSION

Pre-Requisite Test

The pre-requisite tests carried out in this study are normality tests and homogeneity tests. The normality test aims to find out whether the sample is from a normally distributed population or not. The normality test used in the pre-condition test uses the Lilliefors test. Normality tests in the final data analysis were carried out in practical classes, control classes, diverger learning styles, converger learning styles, assimilator learning styles and accommodator learning styles. The following is a summary of the normality test results presented in table 3.

Table 3. Summary of Normality Test Results

Kategori	L_{obs}	L_{critic}	Conclusion
P_1	0,110	0,148	Normally distributed data
P_2	0,069	0,148	Normally distributed data
Q_1	0,089	0,173	Normally distributed data
Q_2	0,122	0,227	Normally distributed data
Q_3	0,111	0,173	Normally distributed data
Q_4	0,227	0,234	Normally distributed data

The conclusion of the Lilliefors normality test is if the observation value of L less than the critical value of L ($L_{obs} \leq L_{critic}$), then the sample is usually distributed. Based on Table 3, known values $L_{obs} \leq L_{critic}$. To meet the conclusion of the normality test that the sample used is from a normally distributed population.

Furthermore, a homogeneity test is carried out. The homogeneity test carried out in this study used the Bartlett test. The homogeneity test in the final data analysis was carried out in both classes, namely the experimental class and the control class. Then the homogeneity test was also carried out on the diverger learning style, converger learning style, assimilator learning style and accommodator learning style. The following will describe the results of the homogeneity test in the pre-condition test in Table 4.

Table 4. Summary of Homogeneity Test Results

Category	χ^2_{obs}	χ^2_{critic}	Conclusion
P_i	3,60	3,84	Homogene
Q_i	4,13	7,82	Homogene

Based on Table 4, in learning model category obtained values of $\chi^2_{\text{obs}} = 3.60$ dan $\chi^2_{\text{critic}} = 3.84$. This means that these categories are expressed homogeneously between the experimental and the control class ($\chi^2_{\text{obs}} \leq \chi^2_{\text{critic}}$). Then the learning style categories obtained values of $\chi^2_{\text{obs}} = 4.13$ dan $\chi^2_{\text{critic}} = 7.82$. This means that these categories are expressed homogeneously ($\chi^2_{\text{obs}} \leq \chi^2_{\text{critic}}$) between the forth category of learning style.

Variance Analysis of Two Unequal Cell Paths

The results of the analysis of the variance of two unequal cell paths are presented in Table 5 as follows.

Source	<i>JK</i>	<i>dk</i>	<i>RK</i>	<i>F</i> _{obs}	<i>F</i> _{critic}	Conclusion
Line	5105	1	5105	28,99	3,99	Significant
Column	1938	3	646	3,66	2,75	Significant
Interaction	354	4	118	0,66	2,75	Not significant
Error	11295	64	176			
Total	18692	71				

The criteria for the ANOVA test is that if the observation value of *F* less than the critical value of *F* ($F_{\text{obs}} \leq F_{\text{critic}}$), it means that there is no significant difference, and while if it is $F_{\text{obs}} > F_{\text{critic}}$ so that means there is significant difference one of other(s). Based on Table 5, it can be concluded as follows: (i) because of $F_{\text{obs}} = 28.99 > 3.99 = F_{\text{critic}}$, so that based on the criteria of the ANOVA test, the conclusion was there are difference achievement between students who have been implemented the Geogebra Applet-based CORE and direct learning model for critical thinking abilities, (ii) because of $F_{\text{obs}} = 3.66 > 2.75 = F_{\text{critic}}$, so based on the criteria of the ANOVA test, the conclusion was there are difference between students with diverger, converger, assimilator, and accommodator learning styles with critical thinking abilities, (iii) because of $F_{\text{obs}} = 0.66 < 2.75 = F_{\text{critic}}$ so that based on the criteria of the ANOVA test, the conclusion was there is no interaction effect between models and learning styles toward students' critical thinking abilities.

Advanced Test Post-Analysis of Variance of Two Unequal Cell Paths

Further tests after analysing the variance of two unequal cell paths in this study used the LSD (Least Significance Difference) double comparison test. Follow-up tests are essential, considering that the results of the two-way ANOVA test show some analysis result was in significant different. A summary of marginal averages is presented in Table 6 as follows.

Based on the ANOVA test, two unequal cell paths that have been carried out, it is stated that H_{0A} was rejected, which means that there is a difference in critical thinking abilities between students who obtained the Geogebra Applet-based CORE learning model and students who obtained the direct learning model. Then to find out a better learning model, there is no need to do an LSD follow-up test because it is enough to look at the marginal average between the two learning models. Sourced

from Table 6, it is known that the marginal mean value for the Geogebra Applet-based CORE learning model is 79, and the marginal average value for the direct learning model is 60. Based on the differences in marginal averages between the two learning models, it can be concluded that the Core learning model based on the Geogebra Applet is better than the direct learning model for critical thinking abilities.

Table 6. Marginal Average Summary

Learning model	Learning Styles				Average Marginal
	Q ₁	Q ₂	Q ₃	Q ₄	
CORE Based Geogebra Applets	83	83	78	68	79
Direct Learning	62	69	55	56	60
Average Marginal	72,43	76,94	64,91	62,51	

Sourced in Table 5 regarding the summary of ANOVA results of two unequal cell paths, it can be seen that H_{0B} is rejected; it can be concluded that there are differences between learning styles. Multiple comparative tests need to be performed to analyze the differences in each group. A summary of the double comparison test between columns is presented in Table 7 as follows.

Table 7. Summary of Double Comparative Test Results

No.	Interaction	$ \mu_i - \mu_j $	LSD	Conclusion
1	$(\mu_1 \text{ vs } \mu_2)$	4,51	9,06	Not significant
2	$(\mu_1 \text{ vs } \mu_3)$	6,52	7,90	Not significant
3	$(\mu_1 \text{ vs } \mu_4)$	9,92	9,27	Significant
4	$(\mu_2 \text{ vs } \mu_3)$	11,03	8,98	Significant
5	$(\mu_2 \text{ vs } \mu_4)$	14,43	10,21	Significant
6	$(\mu_3 \text{ vs } \mu_4)$	3,40	9,20	Not significant

Based on Table 7, it can be concluded as follows:

1. Test result $(\mu_1 \text{ vs } \mu_2)$, $|\mu_i - \mu_j| = 4,51 < \text{LSD} = 9,06$ so that there is no significant difference between students with diverger learning styles and students with converger learning styles.
2. Test result $(\mu_1 \text{ vs } \mu_3)$, $|\mu_i - \mu_j| = 6,52 < \text{LSD} = 7,90$ so that there is no significant difference between students with diverger learning styles and students with assimilator learning styles.
3. Test result $(\mu_1 \text{ vs } \mu_4)$, $|\mu_i - \mu_j| = 9,92 > \text{LSD} = 9,27$ so this means significant differences exist between students with diverger learning styles and students with accommodator learning styles.
4. Test result $(\mu_2 \text{ vs } \mu_3)$, $|\mu_i - \mu_j| = 11,03 > \text{LSD} = 8,98$ so that there are significant differences between students with converger learning styles and students with assimilator learning styles.
5. Test result $(\mu_2 \text{ vs } \mu_4)$, $|\mu_i - \mu_j| = 14,43 > \text{LSD} = 10,21$ so that means significant differences exist between students with converger learning styles and students with accommodator learning styles.

6. Test result (μ_3 vs μ_4), $|\mu_i - \mu_j| = 3,40 < \text{LSD} = 9,20$ so that there is no significant difference between students with assimilator learning styles and students with accommodator learning styles.

Discussion of the First Hypothesis

Based on the results of the first hypothesis testing, learning that uses the Core learning model based on the Geogebra Applet is better than learning with a direct learning model regarding students' critical thinking ability.

The learning process in the experimental class begins with the connecting step (connecting the material already learned by the student with the material to be studied). In this step, students are directed to relate the material of straight-line equations (gradients of secant lines) and the limits of functions to find the concept of derived definitions of algebraic functions. The process of connecting can involve students' critical thinking abilities. Because in this step students are directed to find the concept of definition of the derivative of an algebraic function using the material that has been studied, namely the material of the straight line equation (gradient of the secant line) and the limit of the algebraic function. In line with Ausubel's theory of meaningful learning (Lestari & Yudhanegara, 2017), meaningful learning is the process of relating new information to relevant concepts in a person's cognitive processes. Sourced from Ausubel's theory, in assisting in instilling new knowledge, it is necessary to have early concepts of students related to the concepts to be studied.

The next step is organizing (dividing students into groups). The students, totalling 36 children, were divided into nine groups in the experimental class. Each group has four students. The formation of groups aims to involve the active role of all students due to the division of tasks for each group. In addition, discussions with one group that takes place during the learning process can help passive students to be able to understand the material. This is because passive students lack the courage to convey questions and express their incomprehension to the teacher in class; they tend to be more comfortable asking and discussing with their group. At the organizing stage, students who have been divided into several groups are directed to discuss in, explore and understand the material during learning.

This is because passive students lack the courage to convey questions and express their incomprehension to the teacher in class; they tend to be more comfortable asking and discussing with their group. At the organizing stage, students who have been divided into several groups are directed to discuss in, explore and understand the material during learning.

The final stage is extending (expanding knowledge). Students are given practice questions and evaluations to expand their knowledge at this stage. The questions given contain the ability to think critically. At the organizing stage, reflecting and extending align with Bruner's learning theory (Lestari & Yudhanegara, 2017). In learning theory, Bruner students are directed to have active involvement by constructing their knowledge by discussing groups, presenting and doing practice questions.

The CORE learning model in this study is also supported by the Geogebra Applet learning media. This medium can help students visually understand abstract mathematical material. In the learning process, the Geogebra Applet can help students find the concept of the derivation of algebraic functions through the

material of gradients of secant lines and limits of algebraic functions. Then the Geogebra Applet also helps to understand the concept of graphics in more detail with a varied and attractive appearance. The Geogebra Applet learning media can be more interactive because students can interact directly with images.

Geogebra Applet-based CORE learning is better than the direct learning model of critical thinking ability. This is because, in the Core learning model based on the Geogebra Applet, students are directed to find new material concepts by relating their understanding to the learning material that has been learned. Then students can actively discuss in groups and present the results of their discussions with other groups. In this final stage of learning, students are directed to expand their knowledge by working on practice questions and evaluations. The questions given contain the ability to think critically. This learning is also supported by the Geogebra Applet learning media which can help students visually understand abstract concepts. Applet Geogebra learning media can increase students' curiosity about learning materials because they are more interactive and varied. Learning with the Core learning model based on the Geogebra Applet is students centred. This means that student involvement in learning is more dominant. This learning is also supported by the Geogebra Applet learning media which can help students visually understand abstract concepts. Applet Geogebra learning media can increase students' curiosity about learning materials because they are more interactive and varied. Learning with the Core learning model based on the Geogebra Applet is students centred. This means that student involvement in learning is more dominant.

Meanwhile, learning in control classes that use the student's direct learning model only obtains material from the teacher. During learning, students listen only to lectures from the teacher. This results in students not being actively involved during learning. Students have difficulty understanding the derived material of algebraic functions because they cannot interact directly with images resulting in weak student curiosity towards learning. At the end of the lesson, the teacher will give students the opportunity to ask questions if there are things that are not yet understood. However, no student dared to ask questions or express his incomprehension to the Master. Then, when given the practice questions, students do it in groups, which means there are still students who do not understand the material and cannot do the practice questions independently.

This result is in line with (Rahman, 2018) under the title "Application of The Connecting, Organizing, Reflecting, Extending (CORE) Learning Model in Mathematics Learning to Improve Mathematical Critical thinking abilities of Class X Science Students at SMA N 1 Sungayang". The result of this study is that the CORE learning model positively affects students' mathematical critical thinking ability.

Discussion of the Second Hypothesis

Based on the results of the second hypothesis test, diverger, converger, assimilator and accommodator learning styles were obtained to have different critical thinking abilities. This is in line with (Nanda, Maharani, & Ubaidah, 2019) research that students with diverger, converger, assimilator and accommodator learning styles have different critical thinking abilities. Then to see a significant difference, it is necessary to conduct a double comparison test between columns using the LSD

(Least Significance Difference) test or the BNT (Smallest Real Difference) test. Based on the results of the double comparison test between columns, which can be seen in Table 7, 6 comparisons of learning styles were obtained as follows.

Comparison of students with diverger learning styles and students with converger learning styles obtained grades $|\mu_i - \mu_j| = 4,51 < \text{LSD} = 9,06$. This means that there is no significant difference between students with diverger learning styles and students with learning styles converging on critical thinking abilities. Students with a diverger learning style have an excellent ability to see situations from different points of view. This learning style can perform better when finding ideas to solve problems. Students with diverging learning styles prefer to study in groups to discuss openly and receive feedback. Meanwhile, students with a converger learning style have the best ability to find practicality using ideas and theories. This learning style can solve problems and make decisions based on solution discovery. Based on the description above, it can be concluded that the critical thinking ability of students with a diverger learning style is as good as a converger learning style. This is because both of them can find ideas to solve problems. Then these two learning styles also like learning that is carried out in groups so that they can discuss openly to find solutions to problems.

Comparison of students with diverger learning styles and students with assimilator learning styles obtained grades $|\mu_i - \mu_j| = 6,52 < \text{LSD} = 7,90$. This means there is no significant difference between students with diverger learning styles and students with assimilator learning styles towards critical thinking abilities. Students with an assimilator learning style can understand various information best. This learning style prefers to think independently or less focused on the crowd. The learning style of assimilators is more interested in abstract concepts. Assimilator learning and diverger learning styles have similarities in terms of seeing situations and processing information from different points of view. Both are very fond of examining a problem and then putting it into a logical form. Thus it can be concluded that the critical thinking ability of students with diverger learning styles is as good as students with assimilator learning styles.

Furthermore, comparing students with diverger learning styles and accommodator learning styles obtained scores $|\mu_i - \mu_j| = 9,92 > \text{LSD} = 9,27$. This means that there are significant differences between students with diverger learning styles and students with accommodator learning styles to critical thinking abilities. Students with accommodator learning styles can learn from direct experience. This tendency of learning styles acts on feelings of kindness, not logical analysis. Accommodator's learning style relies heavily on people to solve problems rather than self-analysis. In contrast to the diverger learning style, which can find ideas to solve problems and see concrete situations of problems. Based on the preceding, it can be concluded that the diverger learning style has a better critical thinking ability than students with an accommodator learning style. This is because the accommodator's learning style is lazier if the emotional condition is not good and still depends on others.

Then the comparison of students with converger learning styles and assimilator learning styles obtained scores $|\mu_i - \mu_j| = 11,03 > \text{LSD} = 8,98$. This means that there is a significant difference between students with converger learning styles and students with assimilator learning styles towards critical thinking abilities. The

difference lies in how to process information and solve a problem. The converger learning style can find practicality in using ideas and theories. This learning style can process information into concrete forms, and there is an element of practicality in solving a problem. Meanwhile, the learning style of assimilators can process various information into a form that is still abstract. This learning style is still not meticulous in terms of solving a problem because too much is observed and is still abstract. Thus it can be concluded that the critical thinking ability of students with converger learning styles is better than students with assimilator learning styles.

Following Comparison of students with converger learning style and accommodator learning style obtained value $|\mu_i - \mu_j| = 14,43 < \text{LSD} = 10,21$. This means that there are significant differences between students with converger learning styles and students with accommodator learning styles to critical thinking abilities. The difference between students with converger learning styles and accommodator learning styles is that converger learning styles are superior in finding practical ideas to solve problems. Meanwhile, the accommodator's learning style still depends on others to find ideas for solving problems. Accommodation's learning style is also lazier when the atmosphere is not good enough. Based on the description above, it can be concluded that the critical thinking ability of students with a converger learning style is better than students with an accommodator learning style.

Comparison of students with assimilator learning style and students with accommodator learning style obtained value $|\mu_i - \mu_j| = 3,40 < \text{LSD} = 9,20$. This means there is nothing significant between students with assimilator learning styles and students with accommodator learning styles towards critical thinking abilities. These two learning styles have something in common: it is still not suitable for determining ideas in solving a problem. Thus, it can be concluded that the critical thinking ability of students with an assimilator learning style is as good as that of students with an accommodator learning style. This is in line with the theory teaching Piaget (Lestari & Yudhanegara, 2017) that the development of individuals in receiving and processing different information results in different critical thinking abilities that they have are also different.

Discussion of the Third Hypothesis

Based on the results of the third hypothesis, there was no interaction between the learning model and the student's learning style on the ability to think critically. The absence of this interaction means that students with diverger, converger, assimilator and accommodator learning styles who obtain learning with the Geogebra Applet-based CORE learning model have better critical thinking abilities than students with diverger, converger, assimilator and accommodator styles who obtain learning with a direct learning model. This is not in line with the third research hypothesis, so the third research hypothesis has not been fulfilled.

There is no interaction between the learning model and student learning styles because the Core learning model based on the Geogebra Applet has fulfilled all four student learning styles. The Core learning model based on the Geogebra Applet involves students in critical thinking abilities, which include connecting (linking), organizing (in groups), reviewing (presenting) and expanding knowledge (doing practice questions and evaluations). In addition, the CORE learning model is also

supported by the Geogebra Applet learning media which can help students visually find abstract mathematical concepts.

Then in the Core learning model based on the Geogebra Applet, students with a diverger learning style can use their skills in seeing problem situations concretely because this learning uses GeoGebra learning media that helps students find abstract concepts to be visually concrete, Students whose learning style is converger can apply their ability to find the practicality of using ideas and theories because this learning involves the ability to think critically to find solutions to problems; students whose learning styles are assimilators can use their skills in processing information abstractly to find ideas because this learning uses connecting steps (connecting new knowledge with the knowledge that students already have) and students whose learning style accommodators can use their expertise in learning with direct experience because this learning is assisted by the Learning Media Applet Geogebra which can be used with direct actions and interactions (Kolb & Kolb, 2005).

Meanwhile, these four learning styles feel limited in learning with a direct learning model because they are only teacher-centred. Students feel bored and saturated during learning which results in weak student curiosity. In the direct learning model, students are allowed to ask questions, trying to practice questions. However, it has not been able to encourage students in critical thinking abilities because, in reality, students are just silent and do not ask questions. In this condition, the teacher will not necessarily be able to recognize whether the student understands the material or not. This has resulted in these four learning styles' critical thinking ability developing less well. Thus, whatever learning style students have (diverge, converger, assimilator and accommodator) who obtain learning with the Core learning model based on the Geogebra Applet have better critical thinking abilities than students who obtain learning with a direct learning model.

CONCLUSION

Based on the results and discussion above, it can be concluded that 1) students who obtain learning with the Geogebra Applet-based CORE learning model have better critical thinking abilities than students who obtain learning with a direct learning model; 2) students with a diverger learning style have the same good critical thinking ability as students with converger learning styles, students with diverger learning styles have critical thinking abilities that are as good as assimilator learning styles, and students with diverger learning styles have better critical thinking abilities than students with accommodator learning styles, students with converger learning styles have better abilities than students with learning styles assimilators and accommodators and students with assimilator learning styles have the same good critical thinking ability as students with accommodator learning styles; 3) there is no interaction between the learning model and the student's learning style on critical thinking ability, namely students with diverger, converger, assimilator and accomodator learning styles who obtain learning with the Geogebra Applet-based CORE learning model have better critical thinking abilities than students with diverger, converger, assimilator and accomodator learning styles who obtain learning with a direct learning model. The results of this study can be used as a

reference for teachers in using learning models and adjusting to student learning styles.

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Using Flipped Classroom Model to Enhance the Junior High School Students' Achievement and Engagement in Algebra

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Article Info	Abstract
Received August 10, 2022	This study examines whether using flipped classroom model could enhance junior high school students' achievement and engagement in algebra. A quasi-experimental design which is a switching replication model with posttest only is used in this study to determine whether the students' achievement in the experimental group (using flipped classroom model) differs from the control group (using traditional classroom model). A questionnaire is used to evaluate the students' engagement during the lessons in the experimental group, and the results then are presented in the descriptive statistics. The result of this study is that the experimental group has significantly (p -value=0.001) higher gain mean scores ($M=61.54$, $SD=20.49$) than those in the control group ($M=55.63$, $SD=23.76$). It describes that students in the experimental group have better achievement than the students in the traditional classroom. This study also shows that the students in the experimental group agree that they are more engaged and active during the lesson, with the mean of the items engagement being more than 3,7 ($3.72 \leq M \leq 4.19$). The correlations between the engagement items and the posttest from flipped classroom show positive, moderately strong correlations. Thus, this study sheds light on flipped classroom models as one of the great teaching models nowadays.
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Algebra; Flipped classroom; Students' achievement; Students' engagement.	

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INTRODUCTION

The rapid growth of science and technology has caused changes to mathematics curricula, which now focus more on developing the students' critical thinking and reasoning. Furthermore, these curricula should also provide a learning environment that attracts students to more engage in the lesson, and provide opportunity for students to improve their skill of using technology. According to Bloom's Taxonomy, there are six levels of students' thinking, which are remembering, understanding, applying, analyzing, evaluating, and creating (Prismana, Kusmayadi, & Pramudya, 2018). The focus of current mathematics curricula is how to bring students to achieve at least level 3 on the Bloom's Taxonomy above. In order to get this level, students need meaningful lessons and enough time to process their understanding.

Flipped classroom model may be the answer for this situation. It is a new instructional model in teaching which presents lectures as homework to be completed outside of class using online video, while the class time is used for engaging students with the materials (Gaughan, 2014). Flipped classroom model requires students to learn the material content before class which will create space during class for learning opportunities where students can discuss, and apply their knowledge to deepen their understanding (Wallace et al., 2014).

We select algebra for this study because it is an essential part of mathematics, and the contents of algebra are structured. This means that students should master the previous contents before moving to the next contents. In other words, it is very important to deepen junior high school students' understanding in algebra because it will be the basis for the high school algebra. Furthermore, the contents are usually represented by symbols that are abstract. For the junior high school students, it is challenging to understand the abstract concepts. When students struggle to understand the abstract concepts, they will lose their focus to the lesson. They will not be interested to study mathematics anymore. In other words, they will not engage curiously in the lesson.

To help students gain the abstract concepts, and to make them actively involved in the lesson, they need appropriate instructional models that provide them more time to engage in the lesson in order to build their understanding in these concepts. Flipped classroom model may be one of the proper instructional models in this case. This study may provide useful information for teachers especially for the junior high school mathematics teachers. Therefore, the purpose of this present study is to investigate whether using flipped classroom model could enhance the junior high school students' achievement and engagement in algebra.

Literature Review

In 2007, Bergmann and Sams (2012; 2013) were the first teachers who used flipped teaching at a high school level. They recorded their lectures to help their students who missed the class. In the flipped classroom model, teachers' positions are the guides or facilitators who encourage the students to become active learners (Bennett et al., 2012).

Many studies were conducted to analyze the effects of using this model in students' attitude, engagement and achievement. Jamaludin and Osman (2014) found that flipped classroom models enhanced students' engagements in undergraduate TESOL students.

Strayer, Hart, and Bleiler (2015) found that flipped classroom models helped instructors/teachers to identify the gaps of students' understanding or misconceptions to the mathematical concepts before the class. This information eased the teachers to address the errors during the class sessions. It increases comprehension of students' thinking that helps students to make sense in the mathematical problems. They described that flipped classroom model enhanced students' reflection and elicited responses from other students. In addition, students were able to develop new knowledge using this model.

Kirvan, Rakes, and Zamara (2015) examined the effect of flipped classroom model in students' conceptual understanding and improving learning outcome in linear equations system topic. They found that flipped classroom models provided more time for exploration and enrichment activities, but more focus on the

substance of the videos and class activities were needed to increase students' conceptual understanding. Although they found that there were similar levels of achievement growth in both groups, students in the flipped classroom model showed greater improvement in their ability to solve systems of linear equations than the control group.

A study conducted by Clark (2015) examined the effects of using the flipped classroom model on students' engagement and performance in algebra in a secondary school. He found that this model could significantly improve the students' engagement compare to the traditional model. However, this study did not find the significant difference in the students' achievement between the treatment group and the control group.

Another study conducted by Ogden (2015) investigated the student perceptions of the flipped classroom in college algebra. He noted some findings in this study. First, students felt that they had more time to discuss the topic with their lecture or friends. Second, students felt that this model provided multiple instructions that supported their needs. Third, they could learn the topic at their own pace. With these findings he thought that this model would also have a positive impact on the students' achievement. Therefore, he suggested that the future research should evaluate the use of flipped classroom models in students' achievement.

The suggestions from Ogden's study (2015) are the references for this current study. So, there are two teaching models, that are flipped and traditional classroom model. The focus analyzes of this study will be on the students' achievement and engagement. Therefore, this current study will investigate whether using flipped classroom model could increase the junior high school students' achievement and engagement in algebra.

This study will address two research questions: (1) Is the students' achievement in the flipped classroom model better than the traditional model?, (2) Does the flipped classroom model have more impact in the students' engagement than the traditional classroom?

Regarding these research questions, the hypotheses in this study are as follows: (1) the students' achievement in the flipped classroom model is better than the students' achievement in the traditional model, (2) the flipped classroom model has more impact on the students' engagement than the traditional classroom model.

RESEARCH METHODS

The design of this study will be the quasi-experimental design which is an experimental design that has the same purposes and structures to true experiment, but it lacks random assignment of the units (Shadish, Cook, & Campbell, 2002). The design model is the switching replication with posttest only. There are four classes in this study which are 9A, 9B, 9C and 9D. Two classes (9A and 9B) become the first group (NR_1) and another two classes (9C and 9D) become the second group (NR_2). In the first duration, the first group (NR_1) becomes the experimental group, while the second group (NR_2) becomes the control group. The experimental group (NR_1) gets the treatment which is flipped classroom model (X) while the control group (NR_2) gets the traditional classroom model. Both groups learn the same topic which is exponents. After two weeks, both groups take the first posttest (O_1) to

measure the students' achievements. In addition, the treatment group (NR₁) also take the survey (questionnaire) to measure the students' engagement.

In the second duration, the groups are switched—NR₁ becomes the control group and NR₂ becomes the treatment group. Both groups still continue to learn the exponents topic, especially about roots. After two weeks, both groups then take the second posttest (O₂) and the treatment group (NR₂) also take the same survey. The design is diagrammed as the Table 1.

Table 1: Experimental Model

Research Group	Treatment	Posttest 1	Treatment	Posttest 2
NR ₁	X	O ₁	-	O ₂
NR ₂	-	O ₁	X	O ₂

The independent variable in this study is the teaching classroom models that consists of two models – the flipped classroom model, and the traditional classroom model. The dependent variables are students' achievement and engagement. The participants in this study are 91 students from 4 classrooms of 9th grade on Public Junior High School at Sentani Jayapura.

Instruments

The posttest is used to determine whether the students in flipped classroom model could perform better than the students in the traditional classroom model in their achievement. The posttest model is 25 multiple-choice questions with three confounding and one correct answer.

A questionnaire is used to measure the students' engagement. The questionnaire is based on Reeve and Tseng (2011) which consist of a 5-point Likert scale that ranges from 1=strongly disagree, 2=disagree, 3=neither agree nor disagree, 4=agree, to 5=strongly agree. This questionnaire includes five items of behavioral engagement, seven items of agentic engagement, four items of cognitive engagement, and five items of emotional engagement. This questionnaire has been assessed the inter-item consistency reliability. The Cronbach's alpha values were above of 0.95 (Jamaludin & Osman 2015). Thus, these instruments have high reliability measure. However, this study does not use all the items, only 2 items from each part of engagements are used. So, the total items are 8 which are: 1) During class, I ask questions, 2) During class, I express my preferences and opinions, 3) I pay attention in the class, 4) I try very hard in the class, 5) I enjoy learning new things in class, 6) When I am in class, I feel curious about what we are learning, 7) When I am in class, I feel curious about what we are learning, 8) I make up my own examples to help me understand the important concepts I study.

Procedure

This study is conducted at Public Junior High School, Sentani, Jayapura regency, Papua in August 2019. It is implemented over two weeks in the first duration and another two weeks for the second duration to the 91 9th grade students in the topics of algebra. The duration of each lesson is 2×40 minutes twice a week, and the schedules is depend on the schools' schedules.

The process of this study is as follows: the students in the experimental group prepare for class by watching videos the night prior the class. For example, if the

next day's schedule is for flipped classroom, they will prepare the class by watching the video lessons, however if the schedule for the next day is traditional classroom, they will do their homework from the past lesson. During the class time, in the experimental group: the teacher starts the class by checking whether the students already watched the video or not, and then the students do many activities to deepen their understanding, such as discussing the difficult video's contents, doing hand-on-activities, and doing exercises. In this time, the students engage the lessons actively, while the teacher become their facilitator. In the control group: during the class time, the students do the same activities as the experimental group except disusing the video lesson. In addition, the deep of the subject materials in this group depend on the time. After the lesson, teacher gives them homework.

The lesson videos are uploaded on YouTube a day prior to the lessons, and the links are shared in the students' WhatsApp group. For those students who do not have internet access, the videos are sent using Bluetooth or copied into flash disk.

The data from two posttests then is analyzed using paired samples *t*-test. This analyzed determine whether the two groups have difference students' achievement. In other word, do students in the experimental group have better achievement than students in the control group. The data from the survey questionnaire is also analyzed to determine how high students' engagement in the flipped classroom model.

RESULT AND DISCUSSION

Students' Achievement Data Analysis

The descriptive statistics are used to compare the means, the standard deviations, the maximum and minimum scores from two groups. The results is as in Table 2.

Table 2. Descriptive Statistics for Data Test		
	Trad. class	Flipped class
Mean	55.63	61.54
Standard Deviation	23.76	20.49
Minimum	20.00	32.00
Maximum	96.00	100.00

Table 2 shows that number of participants is $N=91$ students and all of them are valid. The mean score in the flipped classroom model ($M=61.54$, $SD=23.76$) is higher than the mean score in the traditional classroom model ($M=55.63$, $SD=20.49$). In addition, the minimum score (min=32) in the flipped classroom model is also better than the minimum score in the traditional classroom model (min=20). The maximum score students' achievement by using flipped classroom model is 100 and the traditional classroom model is 96.

A paired samples *t*-test is run to evaluate the difference of the means students' achievement between the two groups, and whether this difference is significant or not as in the Table 2.

From the Table 2, we see that the students in the experimental group have significantly higher gain scores ($M=61.54$, $SD=20.49$) than those in the control group ($M=55.63$, $SD=23.76$). Moreover, the paired samples *t*-test indicates that *t* value for *df* 90 is significant (*p*-value=0.001). Thus, the null hypothesis that the

experimental and the control group have the same mean gain scores is rejected. Therefore, the students in the flipped classroom perform better than to the students in the traditional classroom in their achievement. Since this finding, flipped classroom could be considered as a good classroom model.

Tabel 2. Paired Samples Test Analysis

Learning model	Mean difference	<i>t</i>	<i>df</i>	<i>Sig.</i>	Conclusion
Flipped classroom Traditional classroom	5.912	-3.895	90	0.000	Significant difference

This study reveals that flipped classroom model enhances the students' achievements. This finding is similar to the previous studies like Strayer, Hart, and Bleiler (2015) and Kirvan, Rakes, and Zamara (2015).

Students' Engagement Data analysis

This description will explain the data from the survey after is analyzed using SPSS. The result will describe whether the students agree that flipped classroom model make them more engage during the lessons. Means, standard deviations, minimum values and maximum values are used to answer this relation. The result is as follow in Table 3.

Table 3. Descriptive Statistics for Data Survey

	<i>Q</i> ₁	<i>Q</i> ₂	<i>Q</i> ₃	<i>Q</i> ₄	<i>Q</i> ₅	<i>Q</i> ₆	<i>Q</i> ₇	<i>Q</i> ₈
Mean	3.934	4.165	4.209	4.143	4.033	3.747	3.846	3.725
Std. Deviation	0.712	0.703	0.624	0.724	0.640	0.825	0.893	0.684
Minimum	3.000	3.000	3.000	3.000	2.000	2.000	2.000	2.000
Maximum	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000

The data above shows that question: (*Q*₁) during class, I ask questions has mean almost 4 ($M=3.93$, $SD=0.71$) which indicates agree. In addition, the minimum value (min=3) explains that there is no negative responses in this item. In other words, all students agree with this statement. The same results are also for item 2 to item 4, that was: (*Q*₂) during class, I express my preferences and opinions, (*Q*₃) I pay attention in the class, (*Q*₄) I try very hard in the class. Item (*Q*₅) I enjoy learning new things in class, has mean ($M=4.03$, $SD=0.64$). It reveals that most of the students also agree with this statement. However, the minimum value (min=2) indicates that there are few students do not agree with this item. This result is similar to item 6 to item 8, that was: (*Q*₆) When I am in class, I feel curious about what we are learning, (*Q*₇) When I am in class, I feel curious about what we are learning, (*Q*₈) I make up my own examples to help me understand the important concepts I study. Students in the flipped classroom model agree that their engagement increase because of this class model.

Another analyzed is used to see whether all items of engagements above have correlations to the posttest from flipped classroom model. Furthermore, this analysis is also used to see how strong the correlations and what kind of correlations they are. The result is on the Table 4.

Table 4 reveals that all items have positive correlation, which mean that the more students engage in the lesson the better their posttest results. According to Akoglu (2018), the Pearson's correlation coefficients of $0.3 \leq r \leq 0.6$ have moderate strong correlation. Based on the table, seven items (item 2 to 8) have coefficients' correlation above of 0.3 ($0.337 \leq r \leq 0.596$, $n=91$, $p\text{-value}=0.001$). These indicate that the correlations between them are moderate strong. Only item 1 has a weak correlation ($r=0.269$, $N=91$, $p\text{-value}=0.010$). It explains that item 1 has little influence to posttest result. Therefore, all of these findings hint that engagement has positive and moderate correlation to the students' achievements.

Table 4. Correlations Analysis for Data Survey

	Q ₁	Q ₂	Q ₃	Q ₄	Q ₅	Q ₆	Q ₇	Q ₈
Flipped	0.269	0.337	0.479	0.471	0.436	0.478	0.596	0.493
Sig	0.010	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Another finding is that the students' engagement also increases during the lesson because of this classroom model. This finding relates to some previous studies which conducted by Jamaludin and Osman (2014) and Clark (2015). Because of these positive results of using flipped classroom model, this model could be implemented to other subjects in junior high schools.

CONCLUSION

This study has given great experiences not only for students but also for the teacher itself. It shows that the flipped classroom model is one of the excellent teaching models which provides the students enough opportunity and time to deeper their understanding and enhance theirs' engagement during the lessons. This study reveals that flipped classroom model enhances the students' achievements. Another finding is that the students' engagement also increases during the lesson because of this classroom model. Because of these positive results of using flipped classroom model, this model could be implemented to other subjects in junior high schools.

To increase the quality of flipped classroom model, teachers gathering is needed to discuss and share how to create interesting videos lesson before implementing this model. In addition, more attention from students' parents is also essential to guide their children when they are watching the videos lesson.

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Development of Inverse Matrix Module Related to Student's Mathematical Connection Skills

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Article Info	Abstract
Received November 2, 2022	The purpose of this study was to describe the process and results of the development of the matrix Inverse module related to students' mathematical connection skill, as well as to describe the quality of the matrix Inverse module in terms of validity and practicality. The method used was design research with Plomp model, includes the initial research stage, development stage, and assessment stage. The data was obtained from interview, document analysis, and questionnaire. The result of this study showed that developed module was valid based on validation of material experts, media experts, and practitioner. The validation results of this module show that this module was quite feasible to use with a percentage of 80.83% from material experts and 75.93% from media experts, and was quite practical to use with a percentage of 76.90% from the educator's response questionnaire. From the validation results and educator responses, this module can be implemented as a learning resource or teaching material. In conclusion, the Inverse matrix module was declared fit and practical to be used as teaching material and learning resources.
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INTRODUCTION

Covid-19 pandemic made a lot of changes in various sectors, one of them in the education sector. This pandemic was a special condition that causes different learning lags or learning losses in the achievement of student competencies.

In addition to learning loss, many national and international studies state that Indonesia has also experienced a learning crisis for a long time. These studies found that many children in Indonesia have difficulty understanding simple reading or applying basic mathematical concepts. The findings also show that there was a fairly steep education gap between regions and social groups in the country (Kementrian Pendidikan, Kebudayaan Riset dan Teknologi, 2022).

The Ministry of Education has published an alternative curriculum to overcome this problem. That was a follow up of the learning policy in response to the covid-19 pandemic. Later in February 2022, The Ministry of Education revised the

curriculum to deepen its essence with aim the curriculum was focused on material and development of the student's competencies that according with mental development phase. In other side, with recommendation from Government of Indonesia, the school must develop a simplified curriculum with the principle of diversification in accordance with the conditions of the school, regional potential, and student (Sanjaya & Rastini, 2020).

The curriculum was a competency-based curriculum to support learning recovery by implementing project-based learning. Educational units in school have been able to choose three options for implementing the curriculum. One of those was developing their own various teaching tools in the form of module. The module was a learning plan with the concept of project-based learning. Its aim was to arranged the material according to the phase or stage of student's mental development, to the learning's themes and topics, and to student's long-term development.

Mathematics learning in Indonesia was entering a new paradigm. Curriculum development was directed at achieving all domains in knowledge, not only cognitive domain but also affective and psychomotor domains. It also was to develop students' mathematical power through innovation and implementation of various approaches and methods. The goal was to build confidence in their mathematical abilities through the process of: 1) solving problems; 2) provide inductive and deductive reasons for making, defending, and evaluating mathematical arguments; 3) communicate, convey ideas/ ideas mathematically; 4) appreciating mathematics because of its relevance to other disciplines, its application to the real world (Abidin & Jupri, 2017).

If a topic was given to the student's separately, the learning will lose a moment in an effort to improve student learning outcomes in learning mathematics. Therefore, it was important for students to develop mathematical connection skills in studying mathematics so that they can see the relationship between one topic and another (Romiyansah, Karim, & Mawaddah, 2020). Furthermore, students will lose the moment to improve their learning outcomes if the mathematics topic that given to them were independent. Therefore, it was very important for students to understand the relationship between one topic and other topics that were interconnected in learning mathematics. Understanding or seeing the relationship between one topic and another was one of the mathematical connection skills.

One of the subjects that was closely related to mathematical connection skills was the matrix and vector course. In this course, there are several topics require mathematical connection skills such as connecting a problem to a mathematical model, solving a mathematical model, and reasoning in concluding a solution (Fitriawan, 2020).

Based on the facts found by researchers from document studies and interview results at the Mathematics Education Study Program, the achievements of students that learning in matrix and vector algebra courses was relatively low. This was evidenced by the results of the mid-semester exams where the class of 2019 has an average score of 81.93, the class of 2020 has an average score of 62.12, and the class of 2021 with an average score of 49.76. The result showed a declining trend every year. In addition, the last class of 2021 showed the lowest score in according to the assessment system in the university. These values were obtained from the Inverse matrix problems in exam which contains one of the mathematical

connection skills, namely the relationship between one topic and another topic. Some of the factors were student's experience distance learning that caused learning loss during Covid-19 pandemic, learning activity that carried out only through Whatsapp Groups, and the unavailability of teaching materials in accordance with the needs of students and curriculum development.

The results of the cognitive diagnostic tests that conducted on students on the Inverse matrix material related to mathematical connection skills shown an average value of 17.67 on a scale of 0-100. In according to Arikunto (2010), this shows that the students' mathematical connection skill in Inverse matrix material was still relatively low.

Based on theoretical studies and problems obtained in the field, the low students' mathematical connections skills were due to the unavailability of teaching materials. Yet according to Andesta, Lestari, & Pratiwi (2021), the availability of teaching materials can improve learning outcomes. Therefore, in this study the researcher wanted to describe the process and results of the development of the Inverse matrix module related to students' mathematical connection abilities, as well as describe the quality of the module in terms of validation and practicality, so that it was hoped that it can be an alternative learning resource that can be used.

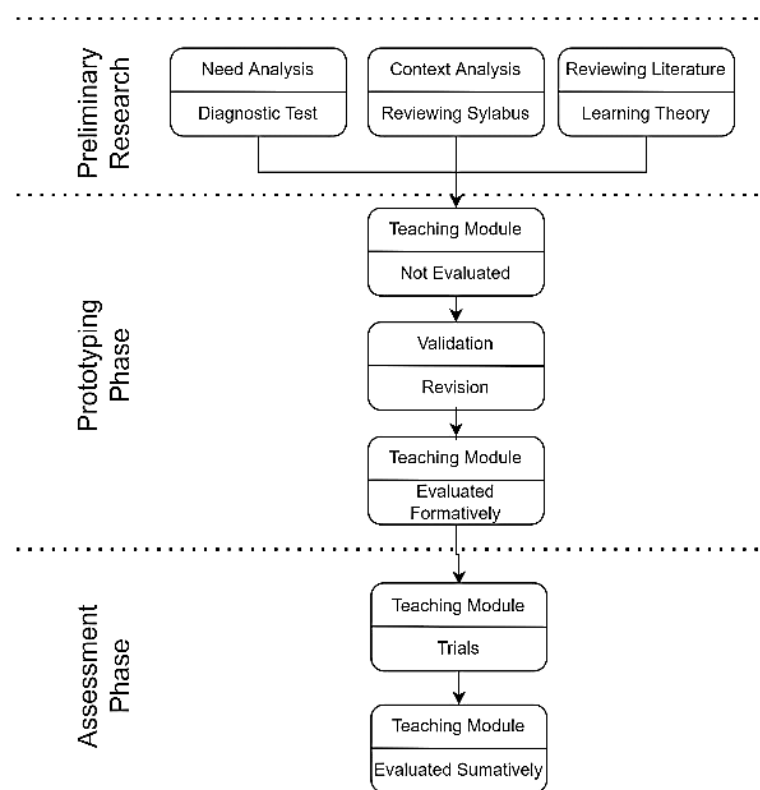


Figure 1. Flowchart of Design Research Steps with Plomp model

RESEARCH METHODS

This study was used Design research methode. Design research can be used for research that has a function to design or to develop an intervention with the aim of solving complex problems in the field of education (Plomp & Nievee, 2013; Plomp,

2007). The development design used in this research is the Plomp model design. The Plomp model was chosen because the model more flexible than other models. The Plomp development model consists of three stages, namely the preliminary research phase, the prototyping phase, and the assessment phase. However, this research has implemented only to the preliminary research phase (initial research phase) and the prototyping phase (development phase). The subjects of this study were high school mathematics teachers and lecturers in mathematics education at the Universitas Islam Nusantara.

The research and development trial design was carried out in three stages, that is: 1) the validation of material and media expert that intended to obtain product validity, 2) product practicality tests given to educators, and 3) the effectiveness of the module that would be given to students in the form of evaluation questions. The product trial in this research and development was carried out on a small group of students of mathematical education at the Universitas Islam Nusantara. The overall research and development stages of the module can be seen in Figure 1.

The score guide for validation was using Likert scale with four alternative score that displayed on Table 1 (Source: Mukholifa, Tisngati, & Ardhyantama, 2020).

Table 1. Scoring Guide Validation

No	Score Scale	Score
1	Very Good	4
2	Good	3
3	Not Good	2
4	Very Not Good	1

Validation Analysis

The analysis of validation was determined by:

- Evaluate the score of validation using formula (Rohmaini et.al, 2020).

$$\text{Validity} = \frac{\text{Total score obtained}}{\text{Total score maximum}} \times 100\%$$

- The result then categorized to validation criteria which is displayed on Table 2 (Source: Fatmawati, 2016).

Table 2. Validation criteria

No	Score (%)	Validation criteria
1	85,01 - 100,00	Very Valid
2	70,01 - 85,00	Quite Valid
3	50,01 - 70,00	Not Valid
4	01,00 - 50,00	Invalid

Practicality Analysis

The result of practicality analysis of module obtained from mathematics teacher and mathematics lecturer in the form of questionnaire. The analysis of practicality was determined by:

- a. Evaluate the score of practicality using formula that adopted from by Sudjono (in Rahma, Laila, & Saidah, 2022):

$$\text{Practicality} = \frac{\text{Total score obtained}}{\text{Total score maximum}} \times 100\%$$

- b. The result then categorized to practicality criteria that shown on Table 3 (Source: Rahma et al., 2022).

Table 3. Practicality criteria

No	Score (%)	Practicality Criteria
1	85,01 - 100,00	Very Practical
2	70,01 - 85,00	Quite Practical
3	50,01 - 70,00	Not Practical
4	01,00 - 50,00	Impractical

RESULT AND DISCUSSION

The result of the initial research indicates that the student's score on the Inverse matrix material related to mathematical connection skill was not good. The learning resources used are also only books written by Howard Anton in 1997 and Dr. Ruminta and lessons are given via Whatsapp Group. Thus, it was relatively easy to understand by students and according to the demands of curriculum development.

The learning resource developed was in the form of an Inverse matrix module related to the students' mathematical connection skill. The process was carried out through the plomp model. Students' mathematical connection skills were discussed further in the third phase. The following are two stages of research and development of the plomp model.

Preliminary Research Phase

At the preliminary research phase, there are two steps of analysis, namely needs analysis and context analysis. At the needs analysis step, it was carried out through document analysis, questionnaires, and cognitive diagnostic tests to students regarding the mathematical connection skills in Inverse matrix material and conducting interviews with lecturers of matrix and vector algebra courses related to the learning process and student achievement on Inverse matrix material. Meanwhile, at context analysis step, it was done by analyzing the Inverse matrix material syllabus, learning outcomes, mathematical connection skill indicators, and learning model syntax that was adapted to the material.

Prototyping Phase

At the prototyping phase, the researcher collects information that supports the development of the Inverse matrix module. The collected data has been integrated to the module. The initial product written in the form of a temporary module draft. Then, the module will be designed iteratively as perfect as possible by carefully matching the components of the module for suitability to the curriculum. The following was display of the cover page and its component of the module that was developed as shown in Figure 2.

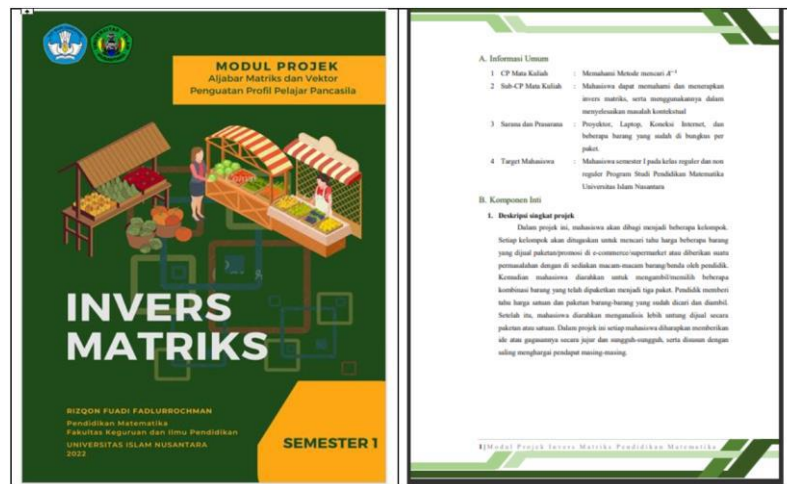


Figure 2. Cover and Component's Module

Validation of the Development of Inverse Matrix Module Related to Student's Mathematical Connection Skill

After the module was designed, the researcher validates the initial product to material experts and media experts. The validators of material experts and material experts are mathematics education lecturers and high school mathematics teachers. Expert validation results are used as initial product suggestions or improvements. The module validation steps are as follows.

a. Material Expert Validation

The validation consist: (1) aspects of content or material feasibility, (2) presentation feasibility, and (3) language feasibility. Mathematical connection skills are integrated into examples and evaluation test questions. The material expert validator checks whether or not mathematical connection capabilities are integrated into the module. Validation data was obtained by using a questionnaire. The results of material expert validation can be seen in Table 4.

Table 4. The Result of Material Expert Validation

No	Aspect	Mean Score (%)	Criteria
1	Content Feasibility	79.58	Quite Valid
2	Presentation Feasibility	83.88	Quite Valid
3	Language Feasibility	77.56	Quite Valid
Total		80.83	Quite Valid

Based on Table 4, the result has an average score of 80.83% with quite valid criteria. That mean the developed module was declared feasible to be used as teaching materials and learning resources.

b. Media Expert Validation.

The Validation was carried out after the product was finished. That was carried out to determine the feasibility of the media listed in the Inverse matrix module. The assessment that was carried out by media experts consist of; aspects of module size, module cover design, and module content design. The experts filled out the

validation sheet that had been provided by the researcher. The results of media expert validation can be seen in Table 5.

Table 5. The Result of Media Expert Validation

No	Aspect	Mean Score (%)	Criteria
1	Module Size	75	Quite Valid
2	Cover Design	75	Quite Valid
3	Design Module	76.38	Quite Valid
Total		75.93	Quite Valid

Based on Table 5, the result has an average score of 75.93% with quite valid criteria. That mean the developed module was declared quite feasible to be used as teaching materials and learning resources.

Based on the description of several validations as a whole, both material expert and media expert validation, the results of the Inverse matrix module validation related to mathematical connection capabilities can be seen in Figure 3.

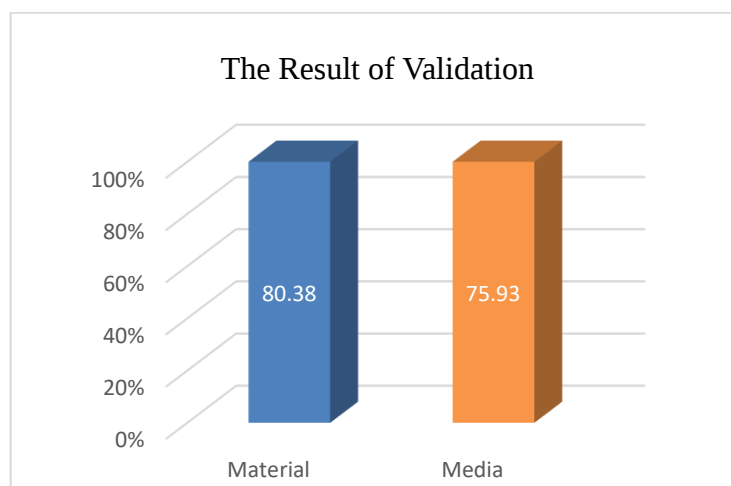


Figure 3. The Result of Validation of Material and Media Expert Overall

Practicality of Inverse matrix Module Related to Student's Mathematical Connection Skills

The practicality test was used to determine the practicality of the Inverse matrix module that developed. That was carried out by high school mathematics teachers and mathematics education lecturers at the Universitas Islam Nusantara in the form of questionnaire. The result of practicality test was shown as follows.

Based on Table 6. The result has an average score of 76.90% with quite practical criteria. That mean the developed module was declared quite practical to be used as teaching materials and learning resources.

The product produced in this research was a Inverse matrix module related to students' mathematical connection skills. The modules used as teaching materials in studying matrix Inverse material were developed by reviewing the conditions of curriculum development and learning conditions. Conditions were analyzed through preliminary studies which included field studies and literature studies. Field studies were carried out through interviews, distributing questionnaires, and formative tests to students to find out how learning was being carried out, whether

or not products were being developed, and the level of student and educator needs for the products being developed.

Table 6. The Result of Practicality Test

No	Indicator	Mean Score (%)	Criteria
1	Cover Page	75	Quite Practical
2	Clarity of Tables/Illustrations/Pictures	75	Quite Practical
3	Language and Sentence	75	Quite Practical
4	Writing Clarity	80	Quite Practical
5	Color Composition	75	Quite Practical
6	Module Content	80.33	Quite Practical
7	Motivate to respond to learning	70.80	Quite Practical
Total		76.90	Quite Practical

The development of the Inverse matrix module related to the student's mathematical connection skills that have met valid and practical criteria was due to the following factors. First, the developed module was designed according to the characteristics of project-based learning and mathematical connection skills so that it can see the interrelationships between topics and understand topic relationships in the real world. Second, the problems presented were problems that are known to be close to everyday life. Presentation of material that connects students to provide an overview of the benefits of the material so as to make learning mathematics more meaningful in students' memory and thinking power. This was in accordance with what was stated by Triyanto (in Widyaningrum, Sarwanto, & Karyanto, 2013), that meaningful learning will not be realized if students only listen to lectures from the teacher. Third, the developed modules were arranged in a unified whole and are interconnected. In addition, the feasibility of the content, the feasibility of presentation, and the eligibility of language that was easy to understand, as well as the module design make the module practical for use in learning. The findings of this study were in line with previous studies (e.g. Fitriawan, 2020). The matrix Inverse module produced in this study was expected to enrich teaching materials for educators, especially in order to increase students' active participation in learning mathematics.

The advantages of this Inverse matrix module were that it was easy to share for anyone to access at any time, it was easy for developing further learning resources, the flexibility of this learning resource because it can be used and changed based on the needs of educators and students, the examples of questions presented in real contexts, and can be used independently by students. The drawback of this module was that it can be accessed only via devices such as laptops and cell phones.

CONCLUSION

Based on the results of the study, it was found that the Inverse matrix module related to the student's mathematical connection skill was declared quite feasible to be used as teaching materials and learning resources in mathematics learning by overall average score of 80.38% from material experts and 75.93% of media experts. The results of the practicality test of the module from the validator has an average score of 76.90% and the criteria is quite practical. It was hoped that the developed module

can contribute to developing student knowledge and used in learning activities to improve student's insight.

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Matrix Concept Understanding Ability: A Quantitative Descriptive Study on Grade XI Vocational High School Students

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Article Info	Abstract
Received November 3, 2022	Understanding and completing a basic mathematical concept is often faced by students. This problem is fundamental to mathematical ability. This ability is part of the competency to understand mathematical concepts. Therefore, this study was conducted to describe the students' ability to understand matrix concepts. This study is a quantitative descriptive, be held on grade XI students from Multi Media I of a vocational high school at Kefamenanu. The number of participants in this study was 26 students. The instrument used is a test of the ability to understand the concept of the matrix and interviews. The results of this study indicate that the ability to understand the matrix concept of grade XI Multi Media I students is in the medium category with a percentage of 56.6%, with details of 7 students in the high category, 13 students in the medium category, and 6 students in the low category. There are 96% of students can restate a concept, 46% of students can classify objects according to the concept, 57% of students can give examples and non-examples of concepts, 61% of students can present concepts in various forms of mathematical representation, and 23% of students can use, utilize and select settlement procedures.
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Keywords	
Concept understanding; Mathematical ability; Matrix.	

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INTRODUCTION

Mathematics is one of the branches of science that plays an important role in everyday life. In accordance with the fact that mathematics is already taught in schools from elementary school to college. This shows that mathematics has an important role in the world of education and technological developments today (Khamidah, 2013). Learning mathematics takes the most time to recall the material already taught. Mathematics learning in schools aims to enable students to understand mathematical concepts, explain the relationship between concepts, use reasoning on patterns and properties, and be able to explain mathematical ideas and statements (Astriani, 2017; Sudirman et al., 2020). The purpose of learning mathematics according to Permendiknas No. 22 of 2006 is to understand mathematical concepts, explain the relationship between concepts and apply concepts or algorithms in a flexible, accurate, efficient and precise way in problem solving (Depdiknas, 2006).

The Minister of National Education above shows that the ability to understand mathematical concepts is one of the objectives of learning mathematics in schools.

The ability to understand this concept is important in mathematics learning. Understanding mathematical concepts is one of the mathematical abilities that must be mastered by students. According to Arifah and Saefudin (2017), the ability to understand concepts is an important point in the mathematics learning process. If students have good concept understanding skills, students will achieve mathematics learning goals. Students who have a good understanding of mathematical concepts will be able to create relationships between concepts that have been studied (Pratiwi, 2016), and be able to deduce information in their own words used in solving a problem (Alam, 2012). Students who already understand the concept correctly will be able to develop thinking skills in solving everyday problems, and the learning process in the classroom will be more meaningful (Murnaka & Dewi, 2018).

One of the mathematics learning materials that must be mastered by grade XI students is matrix. Matrix material is one of the mathematical materials used to measure students' concept comprehension ability. Therefore, the matrix material needs to be mastered by students. However, the reality in the field, the results of learning student matrices have not been satisfactory (Nuritasari, Hasanah, & Sholeludin, 2017). Many students have difficulties both in the learning process, and in solving matrix questions during daily tests or exams, although the questions are related to simple matrix concepts. Based on the results of an interview with a teacher of mathematics subjects at one of the vocational high schools in Kefamenanu, that there are problems during the mathematics learning process at school. Many students do not understand mathematical concepts, are less thorough in the use of formulas, less thorough in the use of symbols and less thorough in calculations and problem solving. In relation to matrix materials, there are many students whose understanding is still low. During interviews, math teachers said that they often find students who solve matrix multiplication problems using how to add matrices or vice versa.

Some of the problems above show that students' ability to understand matrix concepts is still low. This is supported by the results of research by Fadzillah and Wibowo (2016) that there are still many students who have difficulty in understanding mathematical concepts. Mathematics concepts including matrix has been taught in schools are still poorly understood by students. Many previous researchers have researched students' understanding of concepts. Some of them are by Effendi (2017) who concluded that students' understanding of the concept of cube material is still low. Another research by Mawaddah and Ratih (2016) shows that students' mathematical concept comprehension ability is in the good category. These two studies provide contrasting results. The contrast of the results of previous studies is the basis for researchers to conduct this research. The difference between this study and previous researchers is that this research focuses more on the ability to understand matrix concepts, with the aim of describing the ability to understand the matrix concepts of grade XI students of a vocational high school at Kefamenanu.

RESEARCH METHODS

This research is a descriptive study of quantitative. The quantitative descriptive research method is to aim to make an image or descriptive about a state

objectively using numbers, without making generalizations (Siyoto & Sodik, 2015). The type of data used is primary data, which is data obtained directly from research participants. Participants in this study were grade XI Multi Media I students on a Vocational High School at Kefamenanu, totaling 26 people. The participant retrieval technique uses purposive sampling.

The instruments used to collect data in this study were tests and interviews. The test is used to measure students' comprehension. The form of the test is in the form of a description test of a matrix of 5 questions. The 5 items of the matrix question represent 5 indicators of the ability to understand the concept, namely 1) restating a concept (P_1), 2) classify the object according to the concept (P_2), 3) giving examples and non-examples (P_3), 4) presenting concepts in various forms of mathematical representations (P_4), 5) using, utilizing and choosing procedures (P_5). Indicator P_1 is measured through questions about the definition of matrices, indicator P_2 is measured through questions about understanding of identity matrix, indicator P_3 is measured through questions about matrix examples and not matrix, indicator P_4 is measured through questions that ask the matrix form of a story question, and indicator P_5 is measured through questions about matrix addition and subtraction.

After the test, 6 students were selected to be interviewed. The purpose of this interview is to confirm the student's concept comprehension ability with the test results in writing. The 6 students consist of 2 students representing the level of ability to understand matrix concepts in the high category, 2 students in the medium category, and 2 students in the low category.

The value of understanding the concept of the student's matrix is obtained using equation 1.

$$\text{Value} = \frac{\text{Student score}}{\text{Ideal score}} \times 100 \quad (1)$$

Students' matrix comprehension ability scores will be grouped by high, medium, and low categories. The categorization is based on the criteria for understanding students' concepts in Table 1.

Table 1. Criteria for Understanding Student Concepts

Value Range	Criterion
$x \geq 70$	High
$55 \leq x < 70$	Medium
$x < 55$	Low

The criteria in Table 1 above are used to determine the category of students' mathematical concept learning ability adopted from the student's grade criteria according to Nursaadah and Amelia (2018).

In addition to calculating the scores obtained by students, it is also analyzed the percentage of fullness of the achievement of each indicator of understanding the matrix concept, which is calculated using Equation 2.

$$P_i = \frac{Q_i}{r} \times 100\% \quad (2)$$

P_i means persentase achievement of i -th concept understand indicators, Q_i means the number students who meet i -th concept comprehension indicators, and r means the number of participants.

RESULTS AND DISCUSSION

The data of this study were obtained through tests and interviews. Therefore, in this section the results of the study will be described both in the form of te result data and interview result data.

Research Results.

Based on the results of the test, the scores of students' matrix concept understanding ability (MCUA) were obtained in the high category as many as 7 people, the medium category as many as 13 people, and in the low category as many as 6 people. The percentage of students' comprehension ability in the high, medium, and low categories can be seen in Table 2.

Table 2. Percentage of student MCUA criteria

	Category		
	High	Medium	Low
Percentage of MCUA category	27%	50%	23%

Table 2 indicates that most students have MCUA in the moderate category at 50%, while the lowest category is the lowest percentage at 23%.

The MCUA indicators in this study were 5 indicators expressed in P_1 , P_2 , P_3 , P_4 , and P_5 . The percentage of achievement of each indicator is seen in Table 3.

Table 3. Percentage of achievement of the indicator

	Score of Each Question				
	P_1	P_2	P_3	P_4	P_5
Percentage of achievement of the Indicator	96%	46%	57%	61%	23%

Table 3 shows that as many as 96% of students are able to restate a matrix concept, 46% of students are able to classify the objects of a matrix, 57% of students are able to provide examples and non-examples, 61% of students are able to present concepts in various forms of mathematical representation, and 23% of students are able to use, utilize and select procedures and complete matrix concepts.

The MCUA data above is the result of data analysis based on test results and interviews. Interviews were conducted with 6 people, but in this section, the author only showed data on the results of work and interviewed 1 person representing each category.

Students who have high MCUA

One of the subjects who had MCUA in the high category was ADT students. The results of tests and interviews show that ADT students are able to meet indicator 1, indicator 2, indicator 3, indicator 4, and indicator 5. In this section, the researcher only displays the results of work and excerpts of interviews with ADT students on the answers to question number 1. Answer number 1 of ADT students as in Figure 1.



Figure 1. ADT student answer

Figure 1 above is the ADT student's answer to question number 1. To convince the correctness of this student's answer, the researcher conducted an interview as the following.

- Researcher* : What do you know about matrix definition?
ADT : A matrix is a collection of numbers containing rows and columns and expressed in shapes such as square or square long.
Researcher : Are you sure your answer is correct?
ADT : Yes, sure mom.

The results of the interview above show that the subject of ADT is able to define the matrix. The interview results of the answers to questions number 2, 3, 4, and 5 are also the same as the answers in the written test.

Students who have medium MCUA

One of the subjects who has MCUA in the moderate category is MJM students. The results of tests and interviews show that MJM students are able to meet indicator 1, indicator 3, and indicator 5, but have not met indicator 2, and indicator 4. In this section, the researcher only displays the results of work and excerpts of interviews with MJM students on the answers to question number 3. Answer number 3 MJM students as in Figure 2.

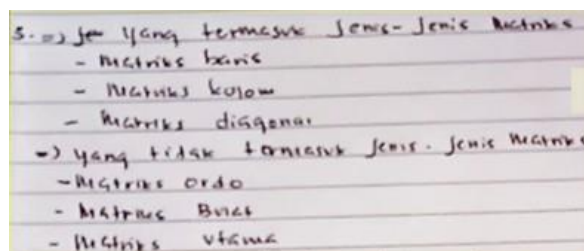


Figure 2. MJM student answer

Figure 2 is the MJM student's answer to question number 3. To convince the correctness of this student's answer, the researcher conducted an interview as the following excerpt.

- Researcher* : Can you name the types that belong to the matrix and which does not belong to the types of matrix?

MJM : Which includes the type of matrix, namely row matrix, column matrix, and the identity matrix, whereas those that do not include types-Types of matrices are order matrices, main matrix and spherical matrix.

Researcher : Are you sure?

MJM : I am sure, mom

The results of the interview above show that the MJM subject is able to distinguish between matrix and non-matrix examples. The interview results of the answers to questions number 1, 2, 4, and 5 are also the same as the analysis of the written test results

Students who have low MCUA

One of the subjects who had MCUA in the moderate category was NBK students. The test results and interviews showed that NBK students were able to meet indicator 1, and indicator 3, but did not meet indicator 2, indicator 4, and indicator 5. In this section, the researcher only displays the results of work and excerpts of interviews with NBK students on the answers to question number 5. Answer number 5 of NBK students as in Figure 3.

Handwritten student work for question 5. The student is given two matrices: $A = \begin{pmatrix} 5 & -2 \\ 3 & 1 \end{pmatrix}$ and $B = \begin{pmatrix} 4 & 2 \\ 5 & -6 \end{pmatrix}$. The student is asked to find $A+B$ and $A-B$. The student's work shows:

$$A = \begin{pmatrix} 5 & -2 \\ 3 & 1 \end{pmatrix} \quad B = \begin{pmatrix} 4 & 2 \\ 5 & -6 \end{pmatrix}$$

$$A+B = \begin{pmatrix} 9 & 9 \\ 8 & -5 \end{pmatrix}$$

$$A-B = \begin{pmatrix} 1 & -2 \\ 1 & -2 \end{pmatrix}$$

Figure 3. NBK student answer

Figure 3 is the answer of an NBK student who is one of the students who has MCUA in the low category. To convince the correctness of this student's answer, the researcher conducted an interview as the following excerpt.

Researcher : Let you explain how the steps in solved question number 5!

NBK : From the problem, it is known that matrix A and matrix B then which is asked matrix $A+B$ and matrix $A-B$.

Researcher : How is the procedure for adding up and subtracting two matrix?

NBK : Our $A+B$ matrix sums up, and our $A-B$ matrix subtract.

Researcher : Try to find the results of the $A+B$ matrix and the $A-B$.

NBK : Writes answers from matrix $A+B$ and matrix $A-B$, but the answer is still wrong.

Researcher : Are you sure your answer is correct?

NBK : Sure mom

The results of the interview above show that NBK subjects have not been able to use, utilize and select the right procedures to complete matrix addition and

subtraction operations. The interview results of the answers to questions number 1, 2, 3, and 4 are also the same as the analysis of the written test results.

Discussion

The results of the above study are described based on the ability to understand the concept of the matrix of students in the high, medium, and low categories. In this section will be discussed each of them according to this category.

The first, students who have high MCUA. Students who are in this category are able to define matrix concepts, are able to calibrate objects according to their concepts, are able to give examples and non-examples, are able to present concepts in various forms of mathematical representation, and are able to use, utilize and choose procedures. This suggests that students in the high category are able to master all indicators of the ability to understand mathematical concepts. This conclusion is in line with the results of research by Fajar et al. (2018) who said that students in the high category can master all indicators of mathematical conceptual understanding ability. Those who are in this category, have a good memory, have a good memory of storing previously learned mathematical concepts. Students have good conceptual skills because they are able to recall what has been learned (Mawaddah & Maryanti, 2016).

The second, students who have medium MCUA. Those who have MCUA in this category are able to define from the matrix correctly, have not been able to calibrate objects according to the matrix concept, are able to give examples and non-examples, have not been able to present concepts in various forms of mathematical representation, and are able to use, utilize and choose procedures. Indicators that have not been met do not mean that students are not capable. They can decipher the answer but there is still a fallacy in their answer. Their answers are still not quite right. This is supported by research conducted by Rosali (2019) that moderately capable students are able to meet every indicator even though it is not yet appropriate. This requires action from a mathematics teacher when teaching to make a breakthrough in facilitating students' understanding of concepts, because students in this category have the potential to meet all indicators of concept comprehension ability. This potential is supported by research by Fajar et al. (2018) that students in the medium category can master all indicators of the ability to understand mathematical concepts.

The third, students who have low MCUA. Students who are in this category are able to define the concept of matrix correctly, have not been able to calibrate objects according to the concept of matrix, are able to give examples and non-examples, have not been able to present concepts in various forms of mathematical representation, and have not been able to use, utilize and choose procedures. This is in accordance with Kartika (2018) that the low ability to understand concepts is due to students not being able to explain the concepts they get and present concepts in the form of mathematical representations. Students in this category are only able to master 2 indicators out of 5 indicators of concept comprehension ability used in this study. Students' answers to questions that measure other indicators still have many errors. They still spell out the answer according to their ideas even though the answer is wrong. This has the potential to undergo changes. There is room for students in this category to meet many indicators from a number of indicators used. This is supported by the results of

research by Fajar et al. (2018) that students whose concept comprehension ability is low can master 4 indicators of 6 indicators of mathematical concept comprehension ability used.

CONCLUSION

Based on the results of research and discussion, it can be concluded that the ability to understand the matrix concept of grade XI students of a vocational high school at Kefamenanu is in the medium category with a percentage of 56.6%. Based on achievements in this medium category, 96% of students can restate a concept, 46% of students are able to classify objects according to their concepts, 57% of students are able to give examples and non-examples of concepts, 61% of students are able to present concepts in various forms of mathematical representation, and 23% of students are able to use, utilize and choose completion procedures.

Understanding concepts is a fundamental ability in mathematics. Therefore, recommend to mathematics teachers in schools to facilitate this ability in the learning process. Future researchers should focus on conducting research to improve these basic abilities before moving on to other mathematical abilities.

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Application of Problem-Based Learning Model to Improve Problem Solving Ability

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Article Info	Abstract
Received September 29, 2022	This study aims to improve the problem solving ability of class VIII junior high school students. This research was conducted after the preliminary study it was found that problem solving abilities were still relatively low. Observational shows that more than 50% of class VIII students of SMP Muhammadiyah 3 Depok have poor problem solving skills. Based on the theory put forward some expert of experts, the researchers decided to apply the problem-based learning model. This study uses classroom action research design with a target of 50% of students having a problem solving ability score above the <i>Kriteria Ketuntasan Minimal</i> (KKM). There are four stage of this research, namely planning, implementation, observation and reflection. The data collection technique using the test and non-test techniques. Data analysis using descriptive analysis of quantitative and qualitative analysis descriptive. From the results of the study, it was found that 77% of students had problem solving scores above the KKM. Besides that, it was found that student were able to work on the questions in a more structured manner and could better understand the questions given.
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Keywords	
Mathematical abilities; Problem solving; Problem-based learning.	

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INTRODUCTION

To improve the quality of human resources, one of the main means is education. One of the basic education provided in Indonesia is mathematics. The Law of the Republic of Indonesia Year 2003 concerning the National Education System Article 37 confirms that mathematics is one of the compulsory subjects for students at the primary and secondary education levels. This is because mathematics can improve students' reasoning so that it can help students in solving and solving problems (Chotimah et al., 2020).

The ability to solve problems is one of the higher-order thinking skills needed by students in responding to the increasingly complex challenges of life in the future (Fajri, 2017; Irawati, 2018; Hidayati, 2017; Simanjuntak, Meiliasari, & Ambarwati, 2021). Tarhadi and Pujiastuti (2006), defines problem solving as a way of thinking, analyzing, and reasoning using experience and knowledge related to the problem. Roebyanto and Sri (2017) mentions that mathematical problem solving is a process in which a person relates to mathematical concepts,

skills and processes to solve a mathematical problem. However, from the initial pre-survey data at SMP 3 Muhammadiyah Depok by providing problem solving questions, it was found that 50% of students had poor mathematical problem solving abilities. This can be seen that there are still many students who are still often confused in finding, understanding problems and presenting solutions when given problem-based problems.

According to Eggen and Kauchak (2012) problem-based learning is a set of teaching models that use problems as a focus to develop problem solving skills, materials, and self-regulation. This learning model requires students to be active and work collaboratively (Sigia, 2020). Based on this opinion, the problem-based learning model will be able to improve students' ability to improve problem solving skills.

The steps of the problem-based learning model according to Abidin (2014) problem-based learning has the following characteristics. (a) Problems become the starting point of learning, (b) Problems used are contextual and authentic, (c) Problems encourage students to think in multiple perspectives, (d) Oriented to the development of independent learning, (e) Develop knowledge, attitudes, skills, and competence, (f) Utilizing various learning resources, (g) Emphasizing collaborative, communicative, and cooperative activities, (h) Emphasizing the importance of acquiring research skills, problem solving, and mastery of knowledge, (i) Encouraging students to think at a higher level high: analysis, synthesis, and evaluative, and (j) Ended with evaluation, study of learning experience, and study of learning process.

Based on the problems that have been described previously and supported by the theory of experts, the formulation of the problem studied in this study is how to improve mathematical problem solving skills in class VIII students of SMP Muhammadiyah 3 Depok Sleman by using problem-based methods. learning model. The stages of the problem-based learning model in this study include finding problems, building work structures, defining problems, collecting and sharing information, formulating solutions, determining the best solutions, and presenting solutions. This stage is assessed in more detail and can be tracked in improving students' problem solving abilities. In addition, there is no research in the field of mathematics that mentions problem solving abilities in schools. The purpose of this study was to improve the mathematical problem solving ability of eighth grade students of SMP Muhammadiyah 3 Depok Sleman in the 2014/2015 academic year after receiving a problem-based learning model.

RESEARCH METHODS

This type of research is Classroom Action Research (CAR). CAR actually begins with the term "action research" which is generally used to find solutions to problems faced by someone in their daily tasks. CAR consists of 4 stages, namely: (1) planning, (2) acting, (3) observing, and (4) reflection. For the characteristics of students, most of the students have cognitive abilities that are in the lower middle range. In terms of motivation, most students still have low motivation.

The planned action is the teaching and learning process with a problem-based learning model, the steps are as follows, (1) Each subject is delivered for 2 hours and 3 hours of lessons. The teaching and learning process is carried out by

learning with a problem-based model. (2) The implementer of the lesson is a mathematics teacher for class VIII B SMP Muhammadiyah 3 Depok Sleman Yogyakarta. (3) The teaching and learning process is carried out in class VIII B of SMP Muhammadiyah 3 Depok Sleman Yogyakarta. (4) The initial activity begins with conducting a pretest for the material of a two-variable linear equation system. Data collection techniques were carried out through filling out motivational questionnaires, interviews, and observations. The data collection instruments used in this study were motivation questionnaires, interview guidelines, and learning implementation observation sheets.

The results of the problem solving ability scores given before the action, after the first cycle, and after the second cycle and so on reflect how the mathematical problem solving ability is. Indicators of increasing students' mathematical problem solving abilities are seen by comparing test scores before the action at the end of each cycle. The data collected were analyzed in the following way: (1) Giving a score for each question that has been answered by students which is then added up for each student. This research is said to be successful if 50% of all students have reached the minimum category above the KKM that has been set by the school, namely 66. In this study researchers were required to attend because the homeroom teacher only acted as a collaborator. The validity of the data is important in a study. To check the validity of the data, a technique for checking the validity of the data will be used, namely persistence of observation and peer review. Persistence of observation is carried out by making careful, detailed, and continuous observations at each meeting. Peer Examination is done by discussing the process and results of research with experts, mathematics subject teachers, or colleagues.

RESULTS AND DISCUSSION

Pre Research

Before conducting research, pre-research activities were carried out, namely to determine the initial condition of students' problem solving abilities. From pre-study data collection (interviews and observations) it is known that the mathematical problem solving ability of class VIII B students is classically in poor condition, with details of 63.3% in poor condition, 33.3% in poor condition. quite good, and 3.33% in good condition. From the pre-research it was also obtained data that only about 22% of students were able to find problems, 15% build work structures, 17% compile problems, 26% collect and share information, 15% formulate solutions. , 10% determine the best solution, and present the solution.

Cycle Data Exposure I

Some of the research findings in cycle I are the first. Many students are not disciplined during class hours, so it takes time and as a result class hours are interrupted. Second, students have not completed the LKS assignments on time because they are still not familiar with the LKS problem-based learning model. Third, cooperation in each group has not run optimally. Some groups still have members who are not actively working on the worksheets and making noise and disturbing other friends. Fourth, many students ask the teacher to present more

material before being given worksheets, this is because students feel they have not mastered the material if it is not explained by the teacher. Fifth, the level of problem solving ability of students in classical mathematics learning slightly increased when compared to the results obtained before the implementation of the action, less than 50% of students who had problem solving ability scores below the KKM became more than 50% or more precisely 77.3% of students. have a problem solving ability value above the KKM. Based on the findings in cycle I, the desired target of success indicators has been achieved so that the cycle can be stopped.

Discussion

The purpose of this study was to improve the problem solving ability of students at SMP Muhammadiyah 3 Depok by using a problem-based learning model. The steps in the problem-based learning model include finding problems, building work structures, defining problems, collecting and sharing information, formulating solutions, determining the best solutions, and presenting solutions.

At the beginning of the action, the teacher conveys the material and the initial learning objectives to be achieved. Then the teacher tries to grow motivation by giving apperception. Then proceed with group formation. At this stage the group discusses to find problems and build a work structure on the worksheets that have been given. In this case the teacher only acts as a facilitator. After that, students are expected to be able to define the problem, collect and share information so that they actively seek knowledge.

After the discussion time is over, each group is asked to formulate a solution and determine the best solution. Then each group presents the solution that has been agreed upon. In this case, according to the statement of Smith and Cook (2012) teachers are also expected to provide scaffolding to improve academic abilities and achievements. Then the teacher gives the opportunity to other groups to provide feedback. And at the end of the discussion the teacher and students make conclusions about the material that has been discussed. In the final stage, the teacher conducts questions and answers with students.

For problem-solving ability scores have increased, from pre-action less than 50% who have a score above the KKM after going through cycle 1 it increases to 77.3% who have a score above the KKM. In accordance with Abidin (2014) the problem-based learning model does have several characteristics that emphasize the importance of acquiring research skills, problem solving, and mastery of knowledge. In addition, according to Arends and Kilcher (2010) that the purpose of the problem-based learning model is a process that emphasizes the ability to find and solve problems, self-confidence, collaboration skills, and project management skills.

From the CAR conducted, knowledge was obtained regarding the application of problem-based learning models: First, students felt happy when asked to seek and share information. Second, students need strict sanctions in order to be disciplined towards their obligations. Third, students have difficulty understanding the problem. Fourth, students become bored if they are asked to work on LKS continuously.

This study still has several limitations, including: First, the implementation of the action is only carried out within a period of 3 weeks so that the increase in

students' problem solving abilities is not optimal. Second, during group discussions, each student demands a lot of attention from the teacher so that many students ask questions during the discussion and make the class a little noisy. Third, this research focuses attention on improving problem solving skills.

CONCLUSION

Based on the results of research, discussion, and reflection, several conclusions can be drawn: (1) The application of problem-based learning models improves problem-solving abilities in class VIIIB students of SMP Muhammadiyah 3 Depok. (2) The application of the problem-based learning model increases the problem-solving ability score of class VIIIB students of SMP Muhammadiyah 3 Depok. This can be seen from the increase in the percentage of students who have a problem-solving ability score of less than 50% who reach the KKM, then in the first cycle it becomes 77.33% who achieves the KKM.

Based on the final results of this study, the researcher suggests to the teacher that the problem-based learning model can be redeveloped so that problem solving abilities are increasing and the teacher must be more assertive in giving sanctions to students who are less disciplined. In addition, further research suggestions are to add independent variables that are measured so that not only problem solving abilities but also relevant variables related to problem-based learning models and the application of problem-based learning models can also develop or increase. other aspects, such as the ability to ask questions, learning achievement, student motivation, attitudes towards mathematics and thinking skills and student interests.

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