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THE EFFECT OF THE ONLINE-BASED M-APOS MODEL ON MATHEMATICS PROBLEM-SOLVING ABILITY REVIEWED FROM STUDENTS' SELF-ESTEEM

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ABSTRACT

Mathematics is a difficult subject for most students, where students tend not to be able to solve problems on questions in the form of problem-solving such as description questions. Efforts can be made to increase student learning outcomes by applying the M-APOS learning model. This study investigates whether or not there is a significant effect of the M-APOS learning model on mathematical problem-solving abilities in terms of the self-esteem of East Jakarta Vocational School students Region II, 2021-2022 academic year. This study is an experimental study that compares the value of the experimental class using the M-APOS model with the value of the control class using the conventional model. The values are analyzed using the t-test, where the results of the t-test indicate that $t$count = 15.736 and df= 82. Besides it was found that $ttab$e = 1.989. The test criteria are that the $H0$ is rejected if $t$count > $ttab$e and it was found that 15.736 > 0.165. Based on the test results, the $H0$ is rejected. This means that there are differences in the mathematical problem-solving abilities of students who receive the M-APOS learning model and those who receive conventional learning models.

Introduction

The deadly and contagious disease Corona Virus also known as Covid-19 has greatly affected the global economy. This tragedy has also shaken the education sector, and these fears are likely to reverberate across the education sector globally. The Covid-19 outbreak has forced many schools and colleges to temporarily close. Several areas are affected worldwide and there is a fear of missing the entire current semester or even more in the future. Various schools, colleges, and universities have stopped face-to-face teaching. As per the researchers'

assessment, it is not certain to return to normal teaching any time soon. Education units are struggling to find options to deal with this challenging situation. This situation makes us realize that scenario planning is an urgent need for academic institutions (Rieley, 2020).

As a step to anticipate the transmission of the virus, the Indonesian government issued policies such as social distancing, physical distancing, to large-scale social restrictions or commonly known as PSBB. This condition requires people to stay at home, study, work, and worship at home. As a result of this policy, the education sector such as schools and universities stopped the face-to-face learning process and online learning that could be carried out from their respective homes.

With the implementation of online learning from home, teachers are required to be more innovative in compiling learning steps. This change in teaching methods certainly makes teachers and students adapt from face-to-face learning in class to online learning (Mastuti, et al., 2020). Several previous studies stated that online learning outcomes were better than face-to-face learning (Nira Radita, et al., 2018; Means, et al., 2013, while other studies stated that learning outcomes using face-to-face learning were better than face-to-face learning). who use online learning (Al-Qahtani & Higgins, 2013). Technically in online learning, supporting devices such as gadgets and internet connections must be available for teachers and students (Simanihuruk, et al., 2019). The help of these supporting devices can make it easier for teachers to prepare learning media and arrange learning steps that will be applied.

Students also have a unique set of challenges that are specific to them. Students should try to maintain their concentration on learning even though it is difficult to do. Students' learning and achievement are usually underscored by their goals and goal orientation, but it is not easy to maintain their concentration on achievement goals when life's problems become dominant. Another important challenge for students is that because they now have to engage in online distance learning, the daily routines of students' lives have now been completely changed. Anxious students who try to calm themselves through affiliation with their peers now have limited opportunities to do so (Mendadak et al., 2020)

Learning media available online are very diverse and constantly evolving. The existence of these media is very helpful for teachers in the learning process in the classroom without being preoccupied with the activities of making the media itself. Teachers can provide material through Google Classroom, Edmodo, whats app, zoom meeting, making videos, where teachers can take advantage of teacher video applications that display the teacher's face so that it is more effective in delivering information to students than just narrating information. For instance, the

use of the Zoom meeting application has been used as a substitute for face-to-face meetings. Zoom meetings are very helpful for learning such as math subjects that must be explained face-to-face.

According to NCTM (2000, p.29), Mathematics is one of the subjects that must be studied by students at every level of education. The importance of mathematics is not only learned in the classroom, but mathematics is close to the activities of daily life. As stated in Permendikbud Number 58 of 2014 that mathematics is a universal science that is useful for human life and also underlies the development of modern technology, and has an important role in various disciplines and advances human thinking. One of the mathematical abilities of students is the ability to solve mathematical problems.

Problem-solving ability is one of the goals of learning mathematics that must be achieved by students. In everyday life, consciously or unconsciously, every day we are faced with various problems that require problem-solving skills. Problem-solving is an attempt to achieve the desired goal and it is not automatically known the right way for that goal (Nitko, 2011, p. 231). With problem-solving ability, students will learn to develop appropriate strategies to solve the problems they face (Utami & Wutsqa,2017)

They need mathematics to face the challenges of everyday life because mathematics provides problem-solving skills and thinking skills for various aspects. The National Council of Teachers of Mathematics (NCTM, 2000, p.5) states that in this changing world, people who understand and apply mathematics will have significant opportunities to improve and choose the shape of their future. Lack of mathematical competence will close the opportunity to reach the future. The need for understanding and using mathematics in everyday life and the world of work is getting bigger and bigger. Therefore, learning mathematics in schools is expected to allow all students to understand and even do mathematics in life

The government answers this need by making students' mathematical problem solving the focus of learning mathematics in schools. Mathematical problem solving plays an important role in schools, where this ability is an ability that requires students to solve mathematical problems.

The ideal conditions to be achieved in learning mathematics specifically in Indonesia are contained in the objectives of learning mathematics. The objectives are (a) understanding mathematical concepts, (b) using reasoning, (c) problem-solving skills, (d) communicating ideas with symbols, and (e) having an attitude of appreciating the usefulness of mathematics in

life (Depdiknas, 2006, p. 346). Of the five goals that must be achieved by all students, the problem-solving ability is one of the goals of learning mathematics. (Lahinda & Jailani, 2015)

This is an important problem-solving in mathematics because, in the learning and completion process, students are possible to gain experience using the knowledge and skills they already have to apply it to problem-solving in new situations. Problem-solving means engaging in a task for which the method or solution is not known beforehand. Therefore, to find solutions, students must explore their knowledge, and through this process, they will often develop new mathematical understandings.

Students should have frequent opportunities to formulate, interact with mathematics, and solve complex problems that require a large amount of effort and should then be encouraged to reflect on their thinking. Thus, solving problems is not only the goal of learning mathematics but which is the main goal is to do it. Problem-solving requires students to cultivate and develop knowledge, which allows them to work with a variety of processes and concepts. Problem-solving can be a way for students to make independent decisions, about how to solve problems and gain confidence in their thoughts and actions.

According to Siswono (Ana Ari Wahyu Suci & Abdul Haris Rosyidi, 2012), problem-solving is a process or individual effort to respond to or overcome problems or obstacles when an answer or answer method has not been solved. Meanwhile, according to (Anwar & Amin, 2013), problem-solving is defined as an attempt to find a way out of a difficulty. When someone solves a problem, he not only learns to apply the various knowledge and rules he already has but also finds the right combination of concepts and rules and controls his thinking process.

Branca (Husna, Ikhsan, & Fatimah, 2013) suggests that problem-solving has three interpretations, namely: problem-solving (1) as the main goal; (2) as a process, and (3) as a basic skill. These three things have implications for learning mathematics. First, if problem-solving is a goal, then it is independent of the specific problem or procedure, also apart from the mathematical material, the most important thing is how to solve the problem until it is successful. In this case, problem-solving is the main reason for learning mathematics. Second, if problem-solving is viewed as a process, the emphasis is not solely on results, but on how the methods, procedures, strategies, and steps are developed through reasoning and communication to solve problems. Third, problem-solving is a basic skill or life skill, because every human being must be able to solve his problems. So problem solving is a basic skill that every student must-have. (Netriwati, 2016)

Based on the results of the questionnaire at SMK East Jakarta Region II, most students think mathematics is difficult so students do not like mathematics, which is the cause of students not liking mathematics 43.5% of students do not like calculating 38.8% do not memorize formulas, delivery of teachers in teaching mathematics and other influences. So that it becomes an obstacle for students in working on math problems, as for the penalties faced by East Jakarta Region II Vocational School students in solving problems, namely the students' lack of thoroughness in working on math problems, unable to understand the problems presented and unable to convert story questions into questions. mathematics, so that it becomes a very obstacle for students in solving maths problem solving problems. The diversity of student backgrounds and the lack of learning media are the main problems in the mathematics learning process at SMK East Jakarta Region II.

The process of solving mathematical problems is different from the process of solving ordinary mathematical problems, the difference is in terms of problems and problems. If a mathematical problem can be immediately found a way to solve, then the problem is not a problem but only a regular or routine question. In the process of learning mathematics, the material studied is always related to relevant concepts and information that has been studied previously which is relevant. Mastery of students' concepts in mathematics can be seen through students' ability to work on math problems. Mastery of mathematical concepts is necessary and must be understood correctly and correctly from an early age. This is because the concepts in mathematics are a series of causes and effects so a wrong understanding of a concept will result in a misunderstanding of the following concepts.

One indicator of the success of the educational process can be seen from the learning outcomes obtained by students, to achieve educational success, many factors can influence it such as the teaching and learning process as well as internal factors from the students themselves (Yasdiananda: 103). One of these internal factors is self-esteem. Self-esteem is an integral part of human needs. The importance of fulfilling individual self-esteem needs is closely related to the negative impact if they do not have strong self-esteem.

In learning activities, various problems can arise for students, for example, setting study times, choosing learning methods, using textbooks, studying in groups, and learning motivation (Fitri, E., Ifdil, I., & Neviyarni, S., 2016). Other problems that arise in adolescents are lack of interest in education, and low achievement motivation (Zola, N., Ilyas, A., & Yusri, Y., 2017). First, teenagers whose parents have unrealistically high aspirations for academic achievement or social achievements are constantly pressing to achieve the desired goals. Second, teenagers

who are less accepted by their classmates, do not experience the excitement of classmates in various activities. Third, adolescents who mature early are physically much larger than their classmates, because their appearance is older than their actual age, they are often expected to perform better than their abilities. The three types of adolescents who are less interested in education usually show signs of displeasure. For example, low achievers, work below their abilities in every subject or in subjects they do not like, truant. Symptoms like this are often seen in those with low self-esteem**.**

According to (Owens, Stryker, & Goodman, 2006), to be able to solve mathematical problems solving, students need to have high self-esteem. Having high self-esteem can prevent students from doing negative things in achieving learning achievement. High self-esteem will make a person feel valued, respect himself, see himself as equal to others and always want to progress and develop. While low self-esteem makes people will be faced with various social and psychological problems because people with low self-esteem are considered more vulnerable to negative influences from the social and psychological environment.(Refnadi, 2018).

Bloom states that learning objectives are divided into 3 domains, namely cognitive aspects, affective aspects, and psychomotor aspects (Randall, 2011). Due to this, learning should not only facilitate students in the cognitive function but also the effective function. The phenomenon in today's adolescent affective shows an increase in aspects of juvenile delinquency. According to Burton (2015), Teenage behavior like this shows the characteristics of low self-esteem. Meaningful learning is a condition in which students not only memorize and can do their work correctly, but students are aware and know why they are using the formulas, rules, or mathematical principles (Sumarmo, 2004). One of the learning approaches that are deemed appropriate to achieve meaningful learning is the M-APOS approach.

The APOS theory was originally developed by Dubinsky in 1985 (Arnon et al., 2014). APOS theory itself uses elements from Piaget's genetic epistemology which are considered indispensable for building mathematical knowledge and defining the concepts that make up the theory (Dubinsky & McDonald, 2001). This theory was developed as part of an attempt to understand how mathematics is to be studied. It tries to understand how students construct different mathematical concepts, and from this suggests pedagogic actions that can stimulate the learning process. According to Vygotsky in the view of Constructivism, knowledge must be built by individuals. The construction in this research is a mental construction. Dubinsky

found that mental constructs consist of actions, processes, objects, and schemas, which is abbreviated in APOS. (Hartati, 2014)

The APOS learning model is one of the learning models that allow students to build their knowledge, encourage prior knowledge, solve structured math problems, repeat them and evaluate work independently. APOS is an acronym for actions, processes, objects, and schemas. APOS theory is a model to describe how mathematical concepts can be learned. Asiala (1997: 3) says that the characteristics of the APOS learning model are learning using (1) knowledge built by students through APOS mental construction, (2) using computers, (3) learning students in small groups, and (4) using ACE cycle. (Mandasari et al., 2018).

Based on some of the theories above, it can be concluded that the implementation of M-APOS learning is a modified APOS theory, which has three phases, namely the activity phase, class discussion phase, and practice questions. With the development of the ability to solve mathematical problems, in addition to providing effective learning, students can build their knowledge, encourage prior knowledge, solve structured math problems, repeat them and evaluate work independently, also increase self-esteem because with high self-esteem students can be more confident in solving problems. Based on the things described above, the learning outcomes of M-APOS are needed to influence students' mathematical problem solving abilities and self-esteem. Based on this background, researchers are interested in conducting research with "The Influence of the M-APOS Learning Model on Mathematical Problem Solving Ability Reviewed from Self Esteem of Vocational High School Students in East Jakarta Region II".

Research Method

The research data used for analysis are in the form of mathematical problem solving ability test data and the results of students' self-esteem tests in learning mathematics that is treated with the M-APOS learning model and conventional learning models. The data was obtained from the results of the mathematical problem-solving ability test from the results of students' self-esteem in three classes, namely, those selected as the experimental class, namely X-A SMKS Mardhika and X-C SMKS Adi Luhur while the control class was X-C SMKS Mardhika and X-B SMKS Adi Luhur, 2021/2022 academic year. The number of samples for each study group is presented in Table 1 below.

Table 1 The number of research samples

***Self-Esteem* (B)**	**Learning model related to the ability of mathematics problem solving (A)**	
	Model *M-APOS* (A_1)	**Conventional (A_2)**
High (B_1)	42	42
Low (B_2)	42	42

The post-test scores for the mathematical problem-solving abilities of students who received the M-APOS model treatment and students who were treated with conventional models on the material of sequences and series had measures of central tendency including the mean ($\bar{X}$), mode ($M0$), median (Me) and the size of The dispersion is the range (J) and standard deviation (S) as shown in Table 4.2 below.

Table 2 Description of Mathematical Problem Solving Ability Data for Experiment Class and Control Class

Data	Maks	Min	Central Tendency Measure			Dispersion Size	
			$\bar{X}$	M_0	M_e	J	S
M-APOS	100	55	79.22	80	80	45	12.855
Conventional	70	10	32.88	20	33	60	13.558

Based on the table above, it can be seen that the two classes have quite different average scores, where the average in the M-APOS learning model is higher than the conventional learning model class. The average M-APOS learning model is 79.22 and the average conventional learning model is 32.88.

Testing Requirements Analysis

The prerequisite analysis test was carried out before starting the hypothesis test which included the normality test using the Lilliefors test and the homogeneity test using the Levene test. The research data were obtained from 128 students consisting of 64 students from the experimental class and 64 students from the control class.

a. Normality Test

The normality test was used to determine whether the data from the two research groups were normally distributed or not. The normality test was carried out using SPSS 26 at a significant

level α = 0.05. The normality test was used to determine whether the value of the mathematical problem solving ability of the experimental class that received the treatment of the M-APOS learning model and the conventional learning model was normally distributed. The results of the calculations for the two groups of data are presented in the following table.

Table 3 Normality Test of Mathematical Problem Solving Ability Values in the Experiment Class and Control Class

	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
MAPOS	.106	64	.073
CONVENSIONAL	.081	64	.200*

The results of the calculation of the value of mathematical problem solving abilities in the experimental and conventional classes have Sig. α > 0.05, it can be concluded that H_0 is accepted. This shows the value data from each group comes from a normally distributed population.

b. Homogeneity Test

A homogeneity test is used to determine whether the study population is normally distributed or not. A homogeneity test was carried out using SPSS 26 at a significant level α = 0.05. The homogeneity test was used to determine whether the variance in the value of students' mathematical problem-solving abilities in the class that received the treatment of the M-APOS learning model and the conventional learning model was homogeneous.

Table 4 Test of Homogeneity of Mathematical Problem Solving Ability Values in Experiment Class and Control Class

Test of Homogeneity of Variances			
SCORE			
Levene Statistic	df1	df2	Sig.
.164	1	126	.686

The results of the calculations for the two groups can be seen in the table above. Based on the calculation results obtained Sig. α = 0,65 > 0.05, then H_0 is accepted. This shows that the four groups are homogeneous.

c. Hypothesis Testing

Based on the analysis prerequisite test, namely the normality test and homogeneity test, to obtain data that has a normal distribution and has a homogeneous variance. Test the hypothesis with a two-way analysis of variance (ANOVA). If the results of the two-way ANOVA test have interactions, then the further test will be continued, namely the t-test.

This study aims to determine the effect of the M-APOS learning model on mathematical problem solving abilities when viewed from students' self-esteem. Based on the results of the data analysis, the following can be described:

1. A two-way ANOVA test was conducted to determine the difference in the value of mathematical problem solving abilities of experimental class and control class students. Two-way ANOVA test assisted by SPSS 26 at the level sig $\alpha = 0.05$

Table 5 Two-way ANOVA Test Results Influence of the M-APOS Learning Model

Tests of Between-Subjects Effects					
Dependent Variable: SCORE					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	44394.190[a]	3	14798.063	74.118	.000
Intercept	299049.333	1	299049.333	1497.823	.000
CLASS	41986.714	1	41986.714	210.295	.000
SE	1015.048	1	1015.048	5.084	.027
CLASS * SE	1392.429	1	1392.429	6.974	.010
Error	15972.476	80	199.656		
Total	359416.000	84			
Corrected Total	60366.667	83			

Based on the data above, the results of the two-way ANOVA calculation with SPSS 26 indicate that in the M-APOS learning model the value of Sig. = 0.000 < 0.05 then the conclusion is 0 is rejected, which means that there is a significant difference in increasing the mathematical

problem-solving ability of students who receive the treatment of the M-APOS learning model and those who receive the treatment of the conventional learning model.

The results showed that overall there was a difference in the average mathematical problem-solving ability between students who received the treatment of the M-APOS learning model and students who received the treatment of the conventional learning model. The difference in average mathematical problem solving abilities that received the M-APOS learning model and those who received the conventional learning model treatment as a whole could be further tested with the t-test. The calculation results are presented in the following Table 4.10:

Table 6 T-Test Results Differences in Problem Solving Ability Mathematics in Experiment Class and Control Class

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig.(2-tailed)	Mean Difference
NILAI	Equal variances assumed	.488	.487	15.736	82	.000	49.405
	Equal variances not assumed			15.736	81.018	.000	49.405

In the table above it can be seen that t_{count} = 15.736 and df= 82. Selain itu diperoleh t_{table} = 1.989 . Test criteria, H_0 is rejected if $t_{\text{count}} > t_{table}$ and it was found 15.736 > 0.165. Based on the test, the H_0 is rejected. This means that there are differences in the mathematical problem solving abilities of students who receive the M-APOS learning model and those who receive conventional learning models.

2. Interaction between Learning Models and Mathematics Self-Esteem on Mathematical Problem Solving Ability

Based on Table 4.9, the significant value of the interaction between the learning model and mathematical problem solving ability is 0.010 $< \alpha$ = 0.05, then H_0 is rejected. This means that there is an interaction of learning models with mathematical problem solving abilities. This means that there is a significant interaction between the learning model and self-esteem in mathematical problem solving abilities.

The learning model and self-esteem together have a significant effect on increasing mathematical problem solving abilities. This illustrates that the ability to solve mathematical problems is influenced by the students' self-esteem and the treatment given by the teacher, namely the M-APOS learning model. The interaction between learning models and self-esteem on mathematical problem-solving abilities is presented in the following figure:

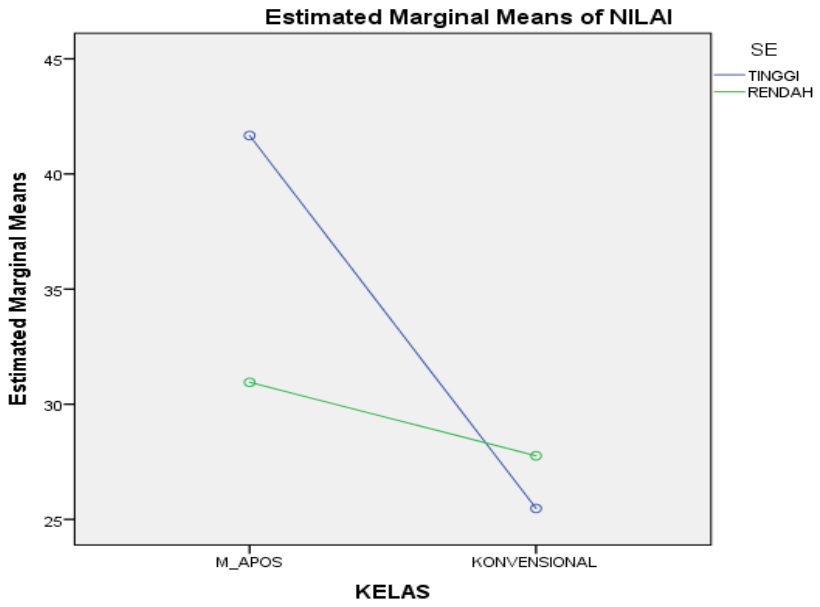

Figure 1 Interaction Between Learning Models and Self Esteem on Mathematical Problem Solving Ability

Based on Figure 1, the figure shows that there is a graph of the interaction between self-esteem and the learning model on mathematical problem-solving abilities. The graph shows that the two lines connecting the learning model and self-esteem do not form two parallel lines, this indicates that there is a wedge between the two lines. The slice shown shows the interaction between the learning model and self-esteem. The self-esteem possessed by students affects students' mathematical problem-solving abilities, and if given a different learning model treatment, namely the M-APOS model and the conventional model, it also affects the students' mathematical problem-solving abilities.

1. Mathematical Problem Solving Ability in Groups of Students With High Self Esteem

The results of the calculation of the third research hypothesis testing are presented in the table below:

Table 7 T-Test Results Differences in Mathematical Problem Solving Ability in Groups of Students with High Self Esteem

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
NILAI	Equal variances assumed	,214	,646	11,359	40	,000	50,095
	Equal variances not assumed			11,359	39,402	,000	50,095

The table above shows that the significant value is 0,000 < α = 0.05. Based on the test results, then H_0 is rejected. This means that there are differences in the mathematical problem-solving abilities of students who receive the M-APOS learning model treatment in the experimental class, which is higher than students who receive the conventional model treatment in the control class.

1. Mathematical Problem Solving Ability in Groups of Students with Low Self Esteem

Hypothesis testing was then carried out with a t-test to see which group of students had lower mathematical problem solving abilities. Here are the results of the t-test test:

Table 8 T-Test Results Differences in Problem Solving Ability Mathematics in a group of students with low self-esteem

Independent Samples Test

	Levene's Test for Equality of Variances		t-test for Equality of Means			
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference

SCORE	Equal variances assumed	,313	,579	10,648	40	,000	48,714
	Equal variances not assumed			10,648	39,606	,000	48,714

In the table above, the significant value is 0,000 < α = 0.05 . Based on the test results then H_0 is rejected, this means that there is no difference in the mathematical problem-solving ability of students who received the treatment of the M-APOS learning model in the experimental class lower than students who received the treatment of the conventional model in the control class.

Discussion

1. Differences in Mathematical Problem Solving Ability Based on Learning Model

In testing the first hypothesis, it has been proven that there is a difference between the mathematical problem solving abilities of students who are given M-APOS learning and students who are given conventional learning. The results of the analysis descriptively and using the t-test showed that there were differences between students who were given M-APOS learning and students who were given conventional learning. Based on the results of data analysis and data processing, students who are given M-APOS learning tend to have high mathematical problem solving abilities compared to students with conventional learning.

a. The interaction between learning and self-esteem on mathematical problem solving skills

Based on the results of data analysis, the analysis shows that there is an interaction between the learning model and self-esteem which affects the ability to solve mathematical problems. This means that the learning model and self-esteem together have a significant influence on students' mathematical problem solving abilities. The interaction proves that each learning has a different effect on mathematical problem solving abilities when applied to groups of students with high and low self-esteem.

b. Mathematical Problem Solving Ability in Groups of Students With High Self Esteem

The results showed that the mathematical problem-solving ability of students who were treated with the M-APOS model on students who had high self-esteem would be higher when compared to students who were treated with the conventional model and had high self-esteem. This happens because students with high self-esteem and who are treated with the M-APOS

model can develop their mathematical problem solving abilities.

Conclusion

Based on the results of hypothesis testing and research discussion, it can be concluded that the M-APOS learning model has a positive influence on improving students' mathematical problem solving abilities. This can be seen from the mathematical problem solving ability taught using the M-APOS model is higher than students who use conventional learning models at SMK East Jakarta Region II schools.

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