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Problem Solving Learning Model Based on Mathematical Communication on Critical Thinking Ability in the Concept of Function Derivatives

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Abstract

This research aims to determine students' mathematical communication skills and critical thinking abilities after being given problem solving lessons in the concept of function derivatives as well as the relationship between students' mathematical communication skills and critical thinking after being given problem solving lessons in the concept of function derivatives. The research method used is quantitative research using a descriptive approach, namely case studies. The problem solving learning treatment was given four times during two class hours and the post-test was given after the treatment also four times. Students' mathematical communication and critical thinking abilities are measured using a description test. The results of data analysis show that students' mathematical communication skills have increased significantly after being given a problem solving learning model on the concept of function derivatives. Likewise, students' critical thinking abilities have increased significantly after being given a problem solving learning model on the concept of function derivatives. This research shows that there is a significant relationship between mathematical communication skills and students' critical thinking abilities. The results of this research can provide an important contribution in providing an effective alternative method for increasing students' understanding and critical thinking in the concept of function derivatives. Helps in developing students' critical thinking skills. Encourage students to communicate effectively and thoroughly in a mathematical context. In order to prepare students for success in mathematics, it is important to develop mathematical communication and critical thinking skills. This ability will help in solving problems, understanding concepts, and applying mathematics in everyday life.

Keywords
Problem solving; mathematical communication; critical thinking.

I. Introduction

Technological changes have had an impact on many sectors, one of which is the field of education which is now known as 21st century learning. In its implementation, learning combines literacy competencies, knowledge capabilities, skills, attitudes and technological skills. By carrying out this learning, it can lead students to train and develop high-level thinking skills. Because in the 21st century learning which is centered on students aims to provide assumption skills such as the ability to think critically, solve problems, metacognition, communicate, collaborate, be productive and innovative, as well as data

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literacy (Mardhiyah et. al., 2021). More precisely, what is explained tends to be 21st century skills that must be mastered.

The efforts made by the government to prepare students for the 21st century are contained in the explanation of PERMENDIKBUD No. 20 of 2016 by the Minister of Education and Culture of the Republic of Indonesia regarding Graduate Competency Standards (SKL) for primary and secondary education. It is stated that the scope of graduation ability qualifications consists of three dimensions, namely attitudes, knowledge and skills at high school level. In the knowledge dimension, it is stated that students must have factual, conceptual, procedural and metacognitive knowledge at a technical, specific, detailed and complex level in relation to science, technology, arts, culture and humanities. As for the skills dimension, they must have expertise in thinking and acting creatively, productively, critically, independently, collaboratively and communicatively. From the description of the dimensions of these skills, they are very appropriate to the skills that students must master in facing changes in the 21st century. These 21st century skills include critical thinking and problem solving, creativity and innovation, communication, and collaboration. So the knowledge and skills that students must master in the 21st century are higher order thinking skills or HOTS (Higher Order Thinking Skills).

But the reality is that in many schools higher order thinking skills or HOTS (Higher Order Thinking Skills) tend to remain at a low level. Wardhani and Pohl (Hartini, 2018) also concluded in their research that PISA (Program for International Student Assessment) and TIMSS (Trends in International Mathematics and Science Study) test students' higher-order thinking abilities, and the test results obtained by Indonesia reflect that they is still unable to reach the High Order Thinking Skills (HOTS) level and the quality of Indonesian education is far behind compared to other countries. According to the results of TIMSS (Trends in International Mathematics and Science Study) in 2015, Indonesia's average mathematics score was 397 points, ranking 69th out of 76 participating countries. With this number of scores, Indonesia is still unable to reach the Low Benchmark level where the score points at this level must be at least 400 points. At this level students only have some basic mathematical knowledge and knowledge of integers and basic graphs. This shows that Indonesian academics are currently unable to discuss material at a level that requires high-level thinking skills from these studies.

According to Brookhart (Hartini, 2018) that high level thinking in this study is thinking that is about problems in the area of thinking by giving reasons. He also revealed that the mathematics questions on TIMSS are in the cognitive reasoning domain which is used as a measure of students' high-level thinking skills. Apart from that, based on research conducted by Hadi and Novaliyosi (2019), the characteristics of the questions used in this study are at a high level of difficulty index. Where the results obtained in the cognitive domain of application and knowledge show that they have not been able to achieve 10% correct answers.

Meanwhile, the results of the 2018 PISA (Program for International Student Assessment) study released by the OECD (Economic Co-operation and Development) show that Indonesia's average mathematics score reached 379 points with an average score of 489 points. Around 28% of students were able to achieve Level 2 or higher in mathematics. At this level, students are able to interpret and recognize, without direct direction, simple conditions that are described mathematically. Then the 1% range scores at Level 5 or above in mathematics. Where the ability you have is being able to model complex situations mathematically, and being able to select, compare and evaluate appropriate problem solving strategies to deal with them. According to Kurniati, et al.

(Hartini, 2018), high-level thinking skills in PISA questions require students to reason, analyze, evaluate and be creative in solving them.

According to Sani (Yuningtyas & Eka, 2022) revealed thathigher order thinking skills (HOTS)consists of skills in mastering critical, logical, reflective, metacognitive and creative thinking. From this opinion it can be concluded that the thinking skills that students must master include analyzing, evaluating and producing new solutions to the problems they face. So it's not just about knowing and remembering a concept. Skills in remembering, understanding, applying, analyzing, evaluating and creating solutions are high levels in the revised taxonomy according to Anderson & Krathwohl (Khadizah, 2022). At this level, you definitely need high-level thinking skills with critical thinking in solving a case.

Someone who has high level thinking skills will be seen from the way that person communicates the results of analysis, evaluation and solutions obtained both verbally and in writing. Communication skills are an important part of learning mathematics. High-level thinking skills with critical thinking can be seen from the activity of providing evaluations, criticism or suggestions that have appropriate reasons. So, someone who is able to communicate and explain their opinions or judgments well and is supported by a strong theoretical basis is also a critical thinking activity.

According to Hodiyanto (2017), mathematical communication skills are skills in expressing or expressing mathematical ideas orally or in writing. Qohar and Sumarmo (Hafifah and Bharata, 2018), state that mathematical communication is an important skill in mathematics, namely the ability to express mathematical ideas coherently to friends, teachers and other people orally and in writing. The development of communication in mathematics is very important because communication is a means of exchanging ideas and a tool for clarifying understanding. Pugalee (Fahiroh, 2020) emphasized that communication habits are very important in learning, providing arguments for each answer and conveying responses based on other people's answers so that what is learned is more meaningful for him. So that mathematical communication skills and critical thinking are related to each other at the HOTS level. Apart from being related to high-level thinking abilities, Kisma and Sutirna (2019) revealed that mathematical communication abilities in various schools are still low. From the research they conducted, it can be concluded that this ability is in the sufficient category with an average percentage of 47.42% of all indicators. Firdaus (Kisma and Sutirna, 2019) also found in his research that students' mathematical communication skills were still relatively low. Students are less involved in teaching and learning activities, so that learning is not student-centered which is the cause of the low response to mathematics lessons.

Apart from that, critical thinking skills have an important role. Because critical thinking skills are skills for carrying out various analyses, assessments, evaluations, reconstructions, decision making that lead to rational and logical actions (Mardhiyah et al., 2021). Khoiriyah, et al. (2018) also revealed that the low quality of human resources is influenced by the quality of education which is still relatively low, so it is necessary to apply learning that helps improve critical thinking skills. Based on the observations of Fitriana et al., (2019), students' critical thinking abilities are still not optimal because there are still some students who still have difficulty if they are given questions at a level that is more difficult than the questions in the example. Students tend to imitate how to do questions exactly the same as the questions being modeled. When working on story questions, students cannot determine what information is needed in working on the questions. Sometimes students use all the information in the question to work on it, even though not all of the information in the question is used directly.

That matterthe same as the researcher found in the school where the researcher taught. As far as researchers have noticed so far, there are still many students who fail to demonstrate their mathematical communication and critical thinking skills when studying mathematics. This can be seen from the completion of the description questions which are completed individually. The results of these answers show that some students are still unable to explain what they know and what the question asks. Then we still don't understand the exact method used to determine the final solution to the problem. For some students who have mathematical communication skills and can think critically, they can show different solution steps in detail.

According to Pratama, et al., (2019) learning that does not involve students actively in learning can hinder students' mathematics learning abilities in solving problems, so it is necessary to choose and apply a learning model to achieve learning goals.

One of the appropriate learning models to use is:abilitymathematical communication and critical thinking can be improved with problem solving learning models. Because according to Hodiyanto (2017), in his learningStudents are required to solve problems, discuss problems to be solved, and write solutions to problems posed by the teacher. Mulyono (Sinanto et. al., 2019) also states that problem solving is a learning model that places greater emphasis on thinking power to acquire cognitive abilities and skills in solving problems rationally, straightforwardly and thoroughly. Sinanto et. al., (2019) also concluded that the treatment in experimental class I using the Problem Solving learning model was more effective in increasing the critical thinking skills of 4th grade elementary school students in mathematics lessons. In this study, researcherswant studentscan solveproblem solving learning model which is bridged by mathematical communication skills so that it can improve students' critical thinking abilities. Activities in this learning model can force students tosolve problems by communicating and emerging critical thinkingto find a solution tothat problemthey get. According to Vinacke (Jannah, 2023) states that problem solving has three stages, namely the first is problem presentation where students are faced with a goal that must be achieved through several obstacles, the second is solving activities where they will experience activity processes, such as observing, remembering things. in the past, asking questions, expressing ideas and thirdly solutions, namely they may or may not succeed in achieving their goals." Apart from that, research results from Hodiyanto (2017) stated that students' mathematical communication skills were better if they were given a problem solving model compared to a direct learning model. Latif and Safitri. (2020) based on research that has been conducted suggests that the application of problem solving learning increases learning activities in the classroom.

So that students are prepared for developments in the 21st century, it is mandatory for them to study mathematics. According to Dede Suratman (2011), learning mathematics is a forum that can facilitate thinking, communication skills and increase self-confidence in mathematics. One of them is studying the concept of algebraic function derivatives. The material on the concept of algebraic function derivatives is material contained in the 2013 curriculum for class XI high school level. The knowledge competency achieved is explaining the properties of algebraic function derivatives and determining algebraic function derivatives using definitions or properties of function derivatives and analyzing the relationship between the first derivative of a function and the maximum value, minimum value, and monotonicity interval of the function, as well as the slope of the tangent line to the curve. The skill competency to be achieved is solving problems related to the derivative of an algebraic function and using the first derivative of the function to determine the maximum, minimum, monotonicity and slope of the tangent line of the

function. The relationship between the tangent line and the normal line of a curve is related to contextual issues.

The importance of basic abilities in the concept of derived algebraic functions implicitly indicates that it solves mathematical problems. When solving problems, it is clear to use the definition of the derivative of an algebraic function or the property of the derivative to solve the given problem. When applying the problem solving learning model to this material. Students will be given a problem related to the material. After observing, they were given an explanationwhich leads to discussions using literature that can help carry out analysis to find solutions. During this discussion process, they are guided to be able to reason about the right solution and write down the appropriate solution. From this activity, critical thinking skills are required to be used in solving problems and communicating the results obtained in writing. Based on this explanation, the researcher conducted research with the title "Problem Solving Model Based on Mathematical Communication to Improve Critical Thinking in the Concept of Derivatives of Algebraic Functions for Class XI SMAN 1 Pinoh Selatan".

II. Review of Literature

2.1 Mathematical Communication Skills

NCTMor National Council of Mathematics (Evriani, 2022), communication is the most basic element in learning mathematics, therefore in practice there needs to be an emphasis on mathematical communication in secondary school mathematics through interaction with other people offering opportunities to exchange and reflect on ideas . NCTM (Kisma & Sutirna, 2019) states that communication has an important role in mathematics and mathematics education. With communication, they can create a two-way relationship, carry out activities such as questions and answers and discussions and are able to explain the insights gained during learning using their own language orally or in painting. NCTM (Evriani, 2022), also states that in secondary school the characteristics of students have mathematical communication skills with substantial growth in the ability to organize logical chains of thought, express themselves coherently and clearly, listen to other people's ideas, and think about the audience them when they write or speak. The relationships to be expressed symbolically and graphically, and the notations and representations to express them must become increasingly sophisticated. Baroody (Hodiyanto, 2017) reveals two essential reasons. First, mathematics is basically a language for mathematics itself. Second, learning and teaching mathematics is a social activity that involves at least two parties, namely teachers and students.

2.2 Critical Thinking Ability

Thinking is an activityallows someone to express it naturally based on their thoughts.According to Wicaksono (2019), thinkingis one of the characteristics that distinguishes a person fromanother.Rahmawati (Wicaksono, 2019) tooshowthatthis matterusedfor collectiondecision,conceptual formulation,logic, careful or critical thinking,determinationresults, thinkinginnovative,and problem solving. Lambertus (Fridanianti et al.,2018)States thatCritical thinking skills exist in everyone and are capable of measuring, training, and improving.

2.3 Problem Solving Learning Model

Problem solving learning is a problem solving activity given to students where at this level they learn to formulate and solve problems, as well as respond to stimuli that describe

or generate problematic situations using various rules that they have mastered (Anggraini & Pramudita, 2022). According to Hamruni (Ernawati et. Al., 2021) problem solving is an individual or group activity in solving problems based on previously possessed knowledge, understanding and skills in order to meet the demands of unusual conditions and situations. Sudjana (Listyani, 2020) states that the problem solving learning model is not only a teaching model, but also a thinking model. Where in its implementation you can use other methods starting from searching for data to drawing conclusions.

The framework of thinking in this research can be seen in Figure 1 below.

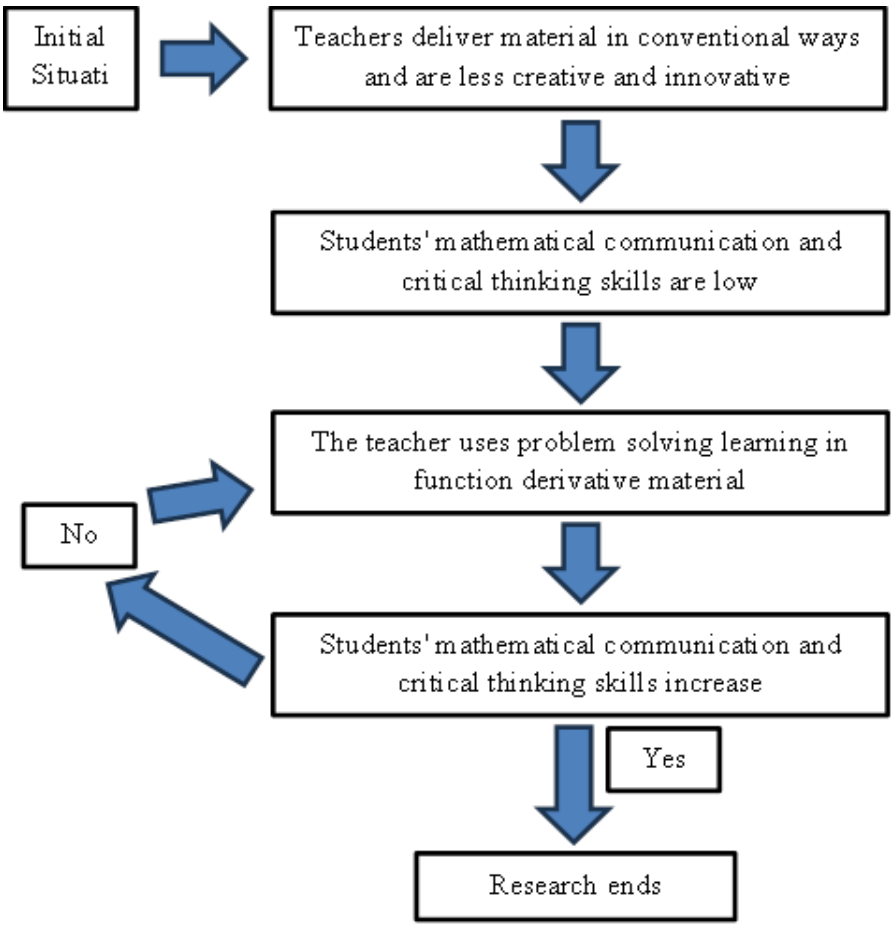

Figure 1. *Research framework*

III. Research Method

This research refers to quantitative research with a descriptive approach, namely case studies. The descriptive approach (Putra, 2018) is a way of researching the status of a group of people, an object, a condition, a system of thought or a class of events in the present. The aim is to systematically, actual and accurately describe, describe or describe the facts, properties and relationships between the phenomena being investigated. Creswell (Rahardjo, 2022) revealed that case studies are carried out by exploring a limited system (case) or several limited systems (cases) over time, through detailed and in-depth data collection involving various sources of information (for example, observation, interviews, audiovisuals, documents and reports), and case description reports and case-based themes.

IV. Result and Discussion

4.1 Posttest Mathematical Communication Skills

To see an increase in mathematical communication skills,Researchers used SPSS 25 to calculate whether the data from the communication skills posttest results were normal or not. The following are the results obtained from the normality test carried out by researchers.

Table 1. Normality Test withShapiro-Wilk

		Kolmogorof-Smirnov			**Shapiro-Wilk**		
	Posttest	Satistic	df	Sig.	Satistic	df	Sig.
Posttest Results for Mathematical Communication Ability	Posttest 1	0.140	27	0.184	0.939	27	0.114
	Posttest 2	0.140	27	0.185	0.956	27	0.305
	Posttest 3	0.126	27	0.200	0.940	27	0.124
	Posttest 4	0.131	27	0.200	0.948	27	0.186

Based on the output table in table 1, it is known that the degree of freedom value is 27, which means the number of samples is below 50. So using the Shapiro-Wilk test is the right test to determine the normality of the data in this study. From posttest 1 to posttest 4, the Sig value is known. all data > 0.05. Based on the basis for decision making in the Shapiro-Wilk test, it can be concluded that the data from the posttest of mathematical communication skills is normally distributed. Once it is known that the data is normally distributed, then proceed with the normalized gain. The results of the normalized gain calculation on the posttest of mathematical communication skills are shown in table 2 below:

Table 2. Normalized Gain from Mathematical Communication Skills

		Mathematical Communication Skills
*Posttest*1 with posttest 2	Average	40.6694%
	Minimal	27.73%
	Maximum	54.55%
*Posttest*2 with posttest 3	Average	50.5621%
	Minimal	9.09%
	Maximum	78 %
*Posttest*3 with posttest 4	Average	71.3977%
	Minimal	9.09%
	Maximum	100%

In the table above it is known thatnormalized gainobtained fromposttest1 with posttest 2 the average value was 40.67%, on posttest 2 with posttest 3 it was 50.56% and from posttest 3 with posttest 4 it was 71.40%.

4.2 Research Results from Posttest Data on Critical Thinking Ability

To see an increase in critical thinking skills, the steps are:The researcher did the same as calculating the normalized gain on posttest data for mathematical communication skills using SPSS 25. So the researcher carried out data analysis using the Shapiro-Wilk test and the following output results were displayed.

Table 3. Test Normality withShapiro-Wilk

		Kolmogorof-Smirnov			**Shapiro-Wilk**		
	Posttest	*Satistic*	df	Sig.	*Satistic*	df	Sig.
Critical Thinking Ability Posttest Results	*Posttest*1	0.145	27	0.154	0.939	27	0.118
	*Posttest*2	0.118	27	0.200	0.936	27	0.100
	*Posttest*3	0.153	27	0.105	0.950	27	0.220
	*Posttest*4	0.151	27	0.118	0.950	27	0.219

Based on the output table in table 3, it is known that the degree of freedom value is 27, which means the number of samples is below 50. So using the Shapiro-Wilk test is the right test to determine the normality of the data in this study. From posttest 1 to posttest 4, the Sig value is known. all data > 0.05. Based on the basis for decision making in the Shapiro-Wilk test, it can be concluded that the data from the posttestcritical thinkingnormally distributed. Once it is known that the data is normally distributed, then proceed with the normalized gain. The results of the normalized gain calculation on the posttest of mathematical communication skills are shown in table 4 below:

Table 4. Normalized Gain of Critical Thinking Ability

		Critical Thinking Ability
*Posttest*1 with posttest 2	Average	41.0707%
	Minimal	13.64%
	Maximum	79.55%
*Posttest*2 with posttest 3	Average	56.0154%
	Minimal	33.33%
	Maximum	70%
*Posttest*3 with posttest 4	Average	71.6965%
	Minimal	23.08%
	Maximum	100%

In the table above it is known thatnormalized gainobtained fromposttest1 with posttest 2 the average value was 41.07%, on posttest 2 with posttest 3 it was 56.02% and from posttest 3 with posttest 4 it was 71.69%.

4.3 Discussion of Research Results

a. Discussion of Research Results on Mathematical Communication Abilities and Critical Thinking Abilities

This research aims to find out how students' mathematical communication and critical thinking abilities are after being given a learning modelproblem solving.The researcher carried out the treatment 4 times and the posttest also 4 times. Students are organized into groups to discuss problems on the LKPD (Student Worksheet).

In the first treatment, students were asked to form groups and discuss Activity 1. In Activity 1, many students with medium and low abilities experienced difficulty in finding the formula for the concept of algebraic function derivatives. They still cannot understand the meaning of the sentences in the explanatory text. So there is difficulty in writing down the steps to solve existing problems using appropriate symbols. Meanwhile, high ability students can understand more quickly to find formulas from the concept of algebraic function derivatives. This can be seen from how they describe the solutions to the problems obtained. Although there are still several steps that are inaccurate due to lack of accuracy. When the researcher asked several supporting questions, the reaction given by low and medium ability students was silence and even though it took more time they were

still unable to convey answers with several parts that were still not correct. Meanwhile, high ability students can answer questions quickly and also verbally.

Then when the students were given a second treatment by discussing activity 2. During the learning process, some students experienced difficulty in finding the final result of the instantaneous speed and still had difficulty writing down the reasons for the answers they had made. For students with low abilities, some have shown improvement through writing symbols in writing problem solving steps, although there are still some who are not quite right. They are still unable to express an explanation of the reasons for the answers they have made. For students with moderate abilities, they are able to write the correct symbols coherently and there are only a few errors in writing at the end of the answer. Some of them were able to write down the reasons for their answers in simple language. For high ability students, they are able to complete the steps to get the final result using the right symbols and can write down the reasons for the answer correctly. When researchers ask questions related to the answers they make. Responses from students with low ability answered for a long time and when giving their answers seemed hesitant. Then the researcher asked why they were impressed like that, the students answered because they did not feel confident in the results of their work. Meanwhile, students with moderate abilities were able to respond more quickly even though there were slight errors in the delivery of reading symbols. Then students with high abilities are able to provide very fast responses in answering questions asked by researchers.

Next, in the third treatment, students discuss with their groups about activity 3. In activity 3, students are asked to create their own questions and find solutions using the Maple calculator or Photomath application. However, unfortunately this cannot be done because conditions in the field are hampered by a power outage and if the power goes out the internet signal will be lost. Both of these applications must be connected to the internet to be used. So students cannot solve the problem in activity 3. So students continue working on questions in activity 4. Where each group creates questionsregarding the material on derivatives of algebraic functions regarding the rate of change. Then design the appropriate solution steps using the known concept of function derivatives. Then present the results of the group discussion to the classrecorded and collected in video form. In the process, students did not experience many obstacles. Students with low ability are able to write down problem solutions regarding the rate of change well. The application of the symbols is correct, and there are only a few errors due to lack of accuracy in the final result. Meanwhile, those with moderate abilities show that the steps they have taken are correct and appropriate. For high ability students, they can finish more quickly.

Next, in the fourth treatment, each group was asked to observe the problem and the steps to solve it. After that, they were asked to check the steps. If there are steps that are not correct, students must provide a more appropriate explanation of the solution.

During the learning process using the problem solving learning model, some students are able to express ideas and ideas that they want to convey in solving problems. The researcher also saw that if one group member mentioned the steps that should be written down, the other members did not immediately agree with the idea. However, what they do is check first whether what their friends say is correct and appropriate. Some students also still experience difficulties in determining the steps that must be written down in solving problems. Some students also said that they were not sure about what they had done, so as to ensure this. They need the help of teachers to provide guidance. So communication is established not only between students but also between teachers and students. As in research by Dahana (2018), it was concluded that one aspectWhat can influence students' critical thinking is interacting with other people.

From the posttest results obtained, there were several student answers which indicated that students' written mathematical communication and critical thinking skills were still weak.

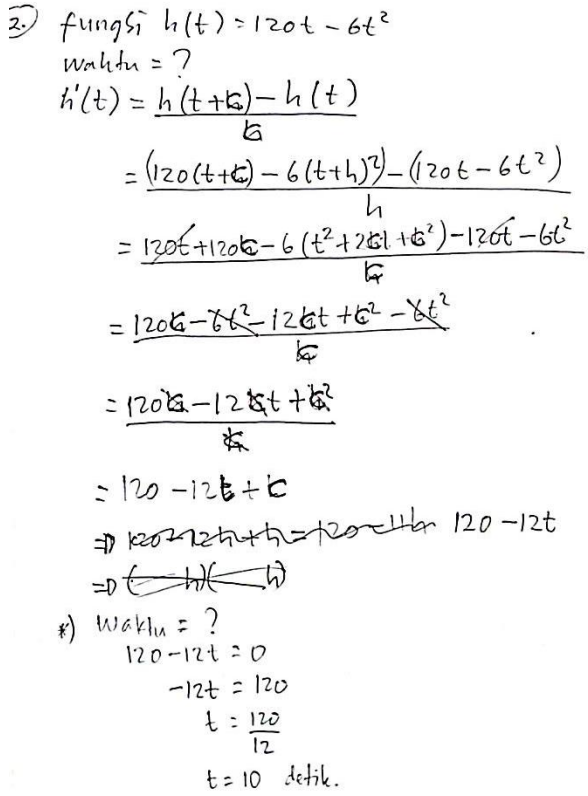

Figure 2. *Students' answers to posttest 1*

From these answers, students did not write the symbols for the concept of function derivatives completely in the initial step. The steps that must be written are: . Even though the final result obtained is correct, it is because of the symbols If it is not included then it is considered wrong. In this question, the researcher asked students to provide an explanation of the answers they had made. However, they did not provide an explanation of the answers they had obtained. After being given the problem solving learning model again. The results obtained by these students are as shown in the picture below.

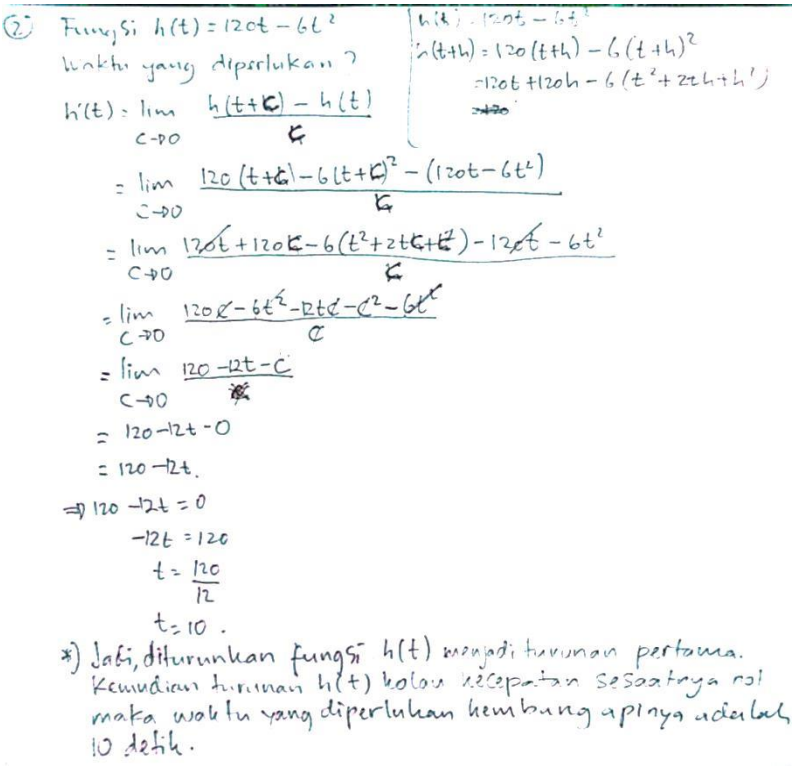

Figure 3. *Students' answers to posttest 2*

From the results of the answers above, in the first step, students have written symbols or formulas for their instantaneous speed correctly. However, if you pay close attention. There was an error in writing the symbol. In the third step, there was an error that the student should have written, namely 6t2, but it was written –6t2 on the answer sheet. Then in the step to determine the t value. In step –12t = 120, it should be –12t = –120 because both sides have been subtracted by 120.

So it can be stated that students' written communication skills have increased, although there are still several steps that are still wrong. Errors in writing these symbols may be because students are not careful and are in a hurry to solve the problem. Then students also write explanations of the answers they have written. Compared with before in posttest 1 without any explanation. In the results of posttest 2 answers, students were able to draw conclusions from the results they had obtained well. So researchers can conclude that good mathematical communication skills can result in students being able to think more critically.

After all the data for mathematical communication and critical thinking skills have been neatly arranged. What the researcher did after tidying up the data was to carry out a normality test. All posttest data is normally distributed. So the next step is to continue with the normalized gain test.

From the results of posttest data on communication skills using descriptive statistical calculations, the average value was obtained consecutively, namely for posttest 1 of 49.19, posttest 2 of 70.07, posttest 3 of 85.56 and posttest 4 of 95.48. If you pay attention to these four data, it shows that there is an increase in the average value, namely between posttest 1 and 2, there was an increase of 20.88. From posttest 2 to posttest 3 it was 15.49 and finally between posttest 3 and posttest 4 it was 9.92. Even though activity 3 failed to be implemented, the average value of posttest 3 data obtained showed an improvement.

In the analysis between posttest 1 and posttest 2, the average normalized gain score was 40.67%, which was included in the quite effective category. This means that the

problem solving learning model is quite effective in improving students' mathematical communication skills. Furthermore, in posttest 2 and posttest 3, the average normalized gain score was 50.56% in the strong effective category. Then in posttest 3 and posttest 4, the average normalized gain score was 71.40%, which indicates a strong and effective criterion. The results of posttest 2 and posttest 3 then posttest 3 and posttest 4 show that the problem solving learning model is strongly effective in improving students' mathematical communication skills.

If we refer to the Minimum Completeness Criteria (KKM) with a minimum score of 75, it can be calculated by counting students who were able to get a score equal to or more than 75. In posttest 1, there were 5 students who were able to get a score equal to or more than the KKM. education or 18.52%. In posttest 2 there were 9 students or 33.33%, while in posttest 3 there were 21 students or 77.78%. Finally, in posttest 4, it was discovered that all 27 students in that class were able to increase their scores above the KKM.

In terms of data analysis using the normalized gain score formula, it can be seen that the use of the problem solving learning model is very effective, meaning that students' mathematical communication skills have increased significantly. However, if you look at the number of students who were able to exceed the KKM from posttest 2 to posttest 4, there has been a good increase. Where the value of mathematical communication skills can be seen in the attachment page. Apart from wanting to see how students' mathematical communication skills improve. Researchers also want to know how students' critical thinking abilities are after being given a learning modelproblem solving.

From the results of the posttest data on critical thinking skills using descriptive statistical calculations, the average value was obtained consecutively, namely for posttest 1 of 44.85, posttest 2 of 69.26, posttest 3 of 85.44 and posttest 4 of 93.41. If you pay attention to these four data, it shows an increase in the average value, namely between posttest 1 and 2 there was an increase of 24.41. From posttest 2 to posttest 3 it was 16.18 and finally between posttest 3 and posttest 4 it was 7.97. Even though activity 3 failed to be implemented, the average value of posttest 3 data obtained showed an improvement.

In the analysis between posttest 1 and posttest 2, the average normalized gain score was 41.07%, which was included in the quite effective category. Which means modellearningproblem solvingquite effective in improving students' critical thinking skills. Furthermore, in posttest 2 and posttest 3, the average normalized gain score was 56.02% in the strong effective category. Then in posttest 3 and posttest 4, the average normalized gain score was 71.70%, which indicates a strong and effective criterion. The results of posttest 2 and posttest 3 then posttest 3 and posttest 4 show that the modellearningproblem solvingstrong and effective can improve students' critical thinking skills.

Based on the Minimum Completeness Criteria (KKM) with a minimum score of 75, you can immediately enumerate students who are able to get a score equal to or more than 75. In posttest 1, there are 2 students who are able to get a score equal to or more than the KKM. or 7.41%. In posttest 2 there were 4 students amounting to 14.81%, while in posttest 3 there were 23 students or 85.19%. Finally, in posttest 4, 26 students, 96.30%, were able to increase their scores above the KKM.

From the analysis side using the normalized gain score formula, it can be seen that the use of the modellearningproblem solvingstrong and effective, meaning that students' critical thinking abilities experience a significant increase. However, if you look at the number of students who are able to exceed the KKM. Starting from posttest 3 to posttest 4 there was quite good improvement. Where the results of critical thinking ability scores can be seen in the attachment page.

V. Conclusion

Based on the discussion of the research results, it can be concluded that there is a relationship to the research entitled "Mathematical Communication-Based Problem Solving Model to Improve Critical Thinking in the Concept of Derivation of Algebraic Functions Class XI SMAN 1 Pinoh Selatan". Based on the data that has been collected and the tests that have been carried out, the following conclusions can be drawn:

1. From the test results using the normalized gain score, mathematical communication skills increased significantly after being given a problem solving learning model on the concept of function derivatives. This is evident from the results obtained during the analysis process which show that the problem solving learning model based on functional derivative concepts is effective in improving mathematical communication skills.
2. Furthermore, from the test results using the normalized gain score, critical thinking abilities increased significantly after being given a problem solving learning model on the concept of function derivatives. This is evident from the results obtained during the analysis process which show that the problem solving learning model on the concept of function derivatives has a strong effect on improving mathematical communication skills.
3. From the results of research hypothesis testing, there is a significant relationship between mathematical communication skills and critical thinking skills. This means that it can be stated that the hypothesis H0 is rejected and Ha is accepted which states that "There is a relationship between students' mathematical communication skills and critical thinking with the problem solving learning model on the concept of algebraic function derivatives".

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