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Mathematical Problem-solving Ability Viewed from Students' Mathematical Disposition

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Abstract

Mathematics is an instrument for solving problems in life. So, ability to solve mathematical problems is one of the most important skills. Practitioners of education do different approaches to develop the mathematical problem-solving ability of students. Efforts have been made such as an attractive learning model and providing external motivation. Most students, however, were unable to finish and prepare to solve mathematical problems in daily life. This is due to the belief that mathematics is not linked with life, anxiety in solving non-routine problems, and feelings of complacency that contribute to low motivation for students. The aim of this research is to gain an overview of the mathematical problem-solving skills of students in terms of students' mathematical dispositions. This research method is qualitative with a case study approach with questionnaire of students' mathematical dispositions for determining the level of student mathematical dispositions, the mathematical problem-solving skills test, and interviews with group student based on mathematical disposition regarding the questions and answers given. This research was carried out on 35 grade XI students from a high school in the district of Indragiri Hulu. Then, data was analyzed with reduction data aimed at selecting and centralizing data based on research objectives, data presentation, namely structured data descriptions, and draw conclusions. This research showed that students with high mathematical dispositions were able to apply indicators of problem-solving steps well, students with moderate mathematical dispositions were not able to properly apply indicators of mathematical problem-solving steps, and students with low mathematical dispositions found it difficult to understand the given mathematical problems. So, we concluded that students with good mathematical dispositions can well apply indicators of mathematical problem-solving steps.

Keywords: Mathematical Problem-Solving Ability, High Mathematical Disposition, Medium Mathematical Disposition, Low Mathematical Disposition.

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INTRODUCTION

Mathematics has a significant effect on the growth of human self-development and the development of methods to solve everyday problems according to planned procedures (Wu ,2000, Novita et al., 2012, Singer & Voica, 2012, Phonapichat et al., 2014). So, since mathematics is commonly used in every area of life, it makes mathematics is one of the compulsory subjects in the world. The ability to solve mathematical problems is one of the mathematical abilities required. This is because this ability requires increased achievement and the ability to form a scientific and technological society (Jackson, 2000, Rohmah & Sutiarso, 2017).

Most of the difficulties faced by students in general are translating problems that occur in daily life into the form of mathematical language so that many students work on problems on a trial-and-error basis (Sari & Valentino, 2016, Al-Khateeb, 2018). This is motivated by the impression of the students that mathematics itself is not connected to daily life. In addition, students will definitely be confused by the practice of working on routine questions such that student anxiety rises because they can't solve problems solving non-routine mathematical problems solving problems (Sari & Valentino, 2016, Ozcan & Gumus, 2019). Another influencing factor is a sense of satisfaction in solving a problem. Even though it is hoped that students will be able to investigate the extension of potential problems that occur later in solving a mathematical problem (Wedelin et al., 2014, Kilpatrick, 2016).

Various types of initiatives by educational professionals to strengthen the mathematical problem-solving skills of students. The teacher is one of the education professionals who is nearest to students in developing the mathematical problem-solving abilities of students. The teacher applies an attractive model of learning and offers motivation to increase the internal motivation of students (Yildiz, 2016). Learning the problems faced by students in dealing with problem-solving skills is another type of support given (Tambychik & Meerah, 2010, Ozcan, 2015) so that students will be interested in mathematics and be more confident in working on non-routine issues (Ozrecberoglu & Caganaga, 2017). This can result in an improved attitude towards mathematics, and it is hoped that awareness will grow in students' curiosity in learning. There are several factors that influence the mathematical problem-solving skills of students in general, namely persistence in practice, self-motivation, and self-confidence, as well as the meaning that mathematics is useful in daily life. This research therefore aims to analyze the mathematical problem-solving skills of students in terms of the mathematical disposition of students.

Each person has a mathematical disposition and greatly influences the learning process carried out by students (Kilpatrick et al., 2001, Beyers, 2011). Kilpatrick et al. (2001) said productive disposition is one of the mathematical skills, namely the tendency for someone to see mathematics as beneficial, logical and useful, accompanied by the belief in persistence and self-efficacy. In addition, Gainsburg (2007) argued that mathematical disposition is an individual's view of mathematics in which mathematics, the role of mathematics and mathematical motivation are used. Next, McIntosh (1997) points out that dispositions are the usual moods, emotions and habits and Katz (1993) stated that dispositions are trends in conscious behavior patterns that lead to individual goal. So, it can be said that mathematical disposition is a manifestation of a positive appreciation of mathematics among students.

Experts in the field of mathematics education have studied many of the mathematical dispositions contained in students. Various opinions have been put forward by experts on indicators of mathematical disposition such as McIntoch, which states that the indicators of students' mathematical dispositions are attitudes towards mathematics, persistence, self-confidence, and the ability to work together (McIntosh 1997). In addition, Kilpatrick argued that the indicators of mathematical disposition were persistence, desire to learn, attention to mathematics, motivation, self-belief (Kilpatrick et al., 2001). Beyers also argues that the indicators of students' mathematical dispositions are attitudes (feelings and emotions) towards mathematics, belief in mathematics, and commitment but also persistence (Beyers 2011). Thus, from several expert opinions describing indicators of student mathematical dispositions, this study uses mathematical dispositions indicators, namely: 1) Desire for Mathematics Achievement. 2) Independent in the search for mathematical ideas. 3) Diligent and persistent in the resolution of math problems/tasks. 4) Interest and concern in mathematics learning. 5) Appreciate mathematics in other fields.

Problem-solving is a non-routine problem and it takes a lot of time to solve it. This is in line with Polya (1985) and Pretz (2003) view that solving problems is an attempt to find a way out of difficulties and achieve results that are not easy. Educational experts have conducted studies on the ability to solve mathematical problems to develop a number of indicators for solving mathematical problems. Several indicators of problem-solving steps in mathematics have been presented by some of the experts as shown in Table 1.

Table 1. Problem-solving Steps According to Experts

No	Polya (1973)	Krulick and Rudnik (1989)	Pretz et al. (2003)
1	Observe and understand the problem.	Reading and thinking.	Identify the issue.
2	Develop a problem-solving design.	Analysis and planning.	Identify and mentally represent the problem.
3	Carry out problem-solving according to the design.	Determine the settlement strategy.	Develop a strategy for a solution.
4	Correcting again	Make a settlement.	Organize your knowledge of the problem.
5		Confirming the correctness of the answer.	Assign mental and physical resources to solve the problem.
6			Monitor progress toward goals.
7			Evaluate the accuracy of the solution

Broadly speaking, the mathematical problem-solving steps put forward by Krulick & Rudnik (1989), Polya (1973) and Pretz et al. (2003) lead to one goal and have the same meaning. So that, from some of the opinions expressed by these experts on indicators of mathematical problem-solving steps, indicators of the mathematical problem-solving steps used in this study are as follows: 1) Observing and understanding the problem demonstrates what is known and what is asked for. 2) Arrange and solve problems according to the strategy, and 3) Proceed the answers correctly.

METHODS

This research method is a qualitative research method with a descriptive type of case study approach. The design of this study is an embedded single-case design. The embedded single-case design is a qualitative research design with a case study approach where only one unit will be analyzed (Cohen et al., 2018). The school units that can be researched are students, teachers, or parents.

This research was carried out on 35 students of class XI. The principal instrument of this qualitative research method is the researcher himself who is assisted by a research

data collection tool, namely: 1) Questionnaire of students' mathematical dispositions for determining the level of student mathematical dispositions, 2) the mathematical problem-solving skills test; and 3) Interviews with each individual student with the regard to the questions and answers given. Qualitative research data analysis techniques obtained from questionnaires, tests and interviews are: 1) Data reduction aimed at selecting and centralizing data based on research objectives; 2) data presentation, namely structured data descriptions; and 3) conclusions drawn.

The criteria for solving mathematical problems in the research carried out are non-routine issues, problems that arise outside mathematics and well defined. One of the problems that challenge and test students' mathematical problem-solving skills is a non-routine problem because it requires a deeper understanding of how to solve it and has a well-defined social context, which means that it has one solution and that the solution is clear (Pretz et al., 2003).

The data on the mathematical problem-solving abilities of students was taken from one of the high schools in the district of Indragiri Hulu. Indicators of mathematical problem-solving steps can be seen in Table 2 and the mathematical problems of the linear program material tested can be seen in Figure 1.

Table 2. Score Guidelines for Mathematical Problem-solving Step Indicators

No	Step Indicators for Mathematical Problem-solving	Score	Explanation
1	Observing and understanding the problem demonstrates what is known and what is asked for	0	Didn't say what was known and what was asked
		1	Write down what is known without mentioning what has been asked or vice versa
		2	Write down what is known and what is asked, but it is incorrect or incomplete.
		3	Write down exactly what is known and what is asked.
2	Arrange and solve problems according to the strategy	0	No answer
		1	Carry out the plan by writing down the answers, but the wrong answers or just a few correct answers.
		2	Carry out the plan by writing half or most of the correct answers
		3	Carry out the plan by writing the answers completely and correctly
3	Concluded the answers correctly	0	No answer
		1	Interpret the results obtained by drawing conclusions but with less precision
		2	Interpret the results obtained by drawing appropriate conclusions

Mathematical Problem-solving Ability Test Questions

1. Mr. Djuna has a parking area of 1.960 m^2. The parking area for a small car is 4 m^2 and big car is 20 m^2. Maximum capacity is only 220 vehicles, parking fees for small car is Rp 5.000/hour and big car is Rp 10.000/hour. If within 1 hour the parking area of Pak Djuna is fully occupied and there are no vehicles coming and going, then what is the maximum yield for the parking space??
2. A farmer owns no less than 10 hectares of land. He plans to plant rice in an area around of 2 ha to 6 ha and plant corn in an area around of 4 ha to 6 ha. To plant rice per hectare, it costs Rp. 400,000 meanwhile to plant corn per hectare it takes Rp. 200,000. To minimize planting costs, determine how many hectares and lots of rice and maize each should be planted?

Figure 1. Test of mathematical problem-solving abilities

In this study, 35 students completed the mathematical disposition questionnaire and took the test. The results of the 35 students mathematical disposition questionnaire were adapted from the highest to the lowest scores then divided into three groups, high, medium, and low, based on Arikunto (2012). 27% of the highest questionnaire scores are called students who have high mathematical dispositions and 27% of the lowest questionnaire scores are called students who have low mathematical dispositions and between the two are students who have moderate mathematical dispositions. The result of questionnaire for students who have high mathematical disposition the points between 112 and 109 with 10 students, students who have low mathematical disposition the points between 99 and 90 with 10 students and students who have medium mathematical disposition the points between 108 and 100 with 15 students.

RESULTS & DISCUSSION

Results

The following is the answer to the problem of the mathematical problem-solving ability of one of the students with a high mathematical disposition, the answer to the mathematical problem-solving ability of one of the students with a moderate mathematical disposition and the answer to the mathematical problem-solving capability of one of the students with a low mathematical disposition.

1. Responses to students with high mathematical disposition

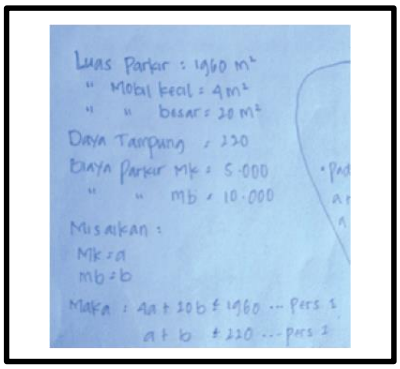

Figure 2a. Student answer with high mathematical disposition on question number one and the first indicator.

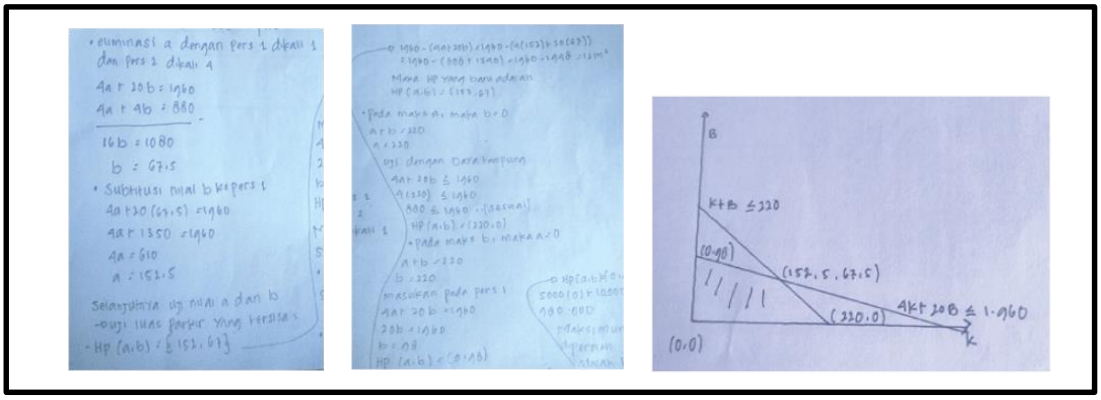

Figure 2b. Student answer with high mathematical disposition on question number one and the second indicator

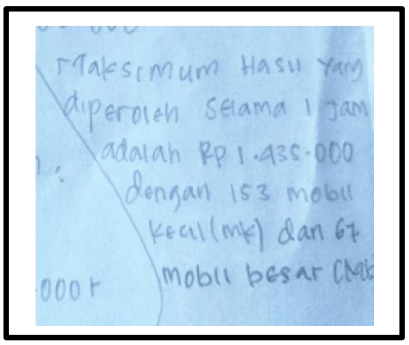

Figure 2c. Student answer with high mathematical disposition on question number one and the third indicator.

In the first question, students with a high mathematical disposition are able to observe and understand the problem (Figure 2a) even though they state what is being asked at the end of the answer and are also able to write and solve mathematical problems both geometrically and algebraically (Figure 2b). This result from interview between student with high mathematical disposition (R1) and researcher (T)

"*T : What is the best way to write the problem in the question?*
R1 : I carefully read and wrote Back, sir.
T : What about the equation you get at? Why do we use inequality?

R1 : Because the problem can be reduced to equations, I use analogy to obtain a simpler equation.
T : What is the next step?
R1 : With the help of the image, I can derive that there are three sites where two lines intersect, namely the point where the x-axis and y-axis connect, and the intersection of the two lines by substitution and elimination.
T : And why is this point test used?
R1 : to ensure the maximum score Sir"

In addition, students with a high mathematical disposition will correctly interpret the results obtained (Figure 2c) and it is seen that they have made rounds. Based on student interviews, they did rounds so there couldn't be a car worth half a car (Figure 2b).

"T : Why is the conclusion different from the point test result?
R1 : Because a comma cannot be attached to an object, sir, simply round it so that cars and motorcycles may fit in the parking lot."

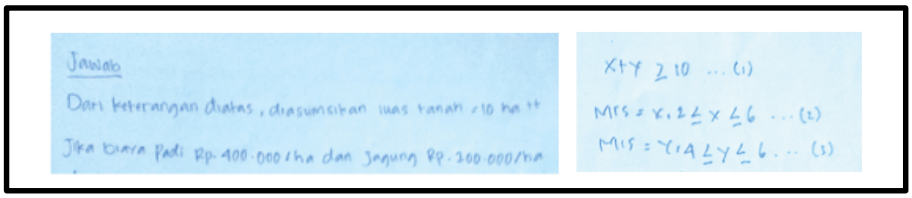

Figure 3a. Student answer with high mathematical disposition on question number two and the first indicator.

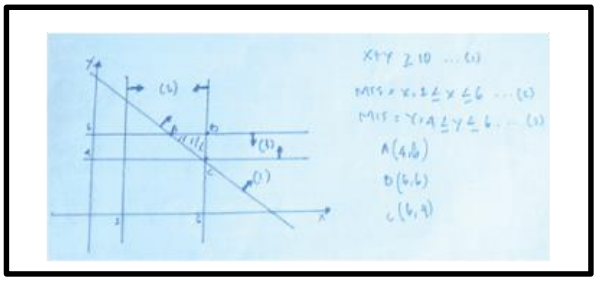

Figure 3b. Student answer with high mathematical disposition on question number two and the second indicator.

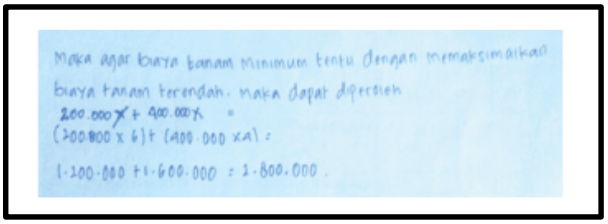

Figure 3c. Student answer with high mathematical disposition on question number two and the third indicator.

On the basis of the second question interview, students who have a high mathematical disposition are able to observe and understand the problem but are not able

to write accurately and fully on the topic of the mathematical problem (Figure 3a) even though students have been able to solve the problem geometrically, although the critical point in the image is obtained without writing the procedure since it only requires the value of x. (Figure 3b). This result from interview between student with high mathematical disposition (R1) and researcher (T)

"R1 : What is the best way to write the problem in the question?
T : I carefully read and wrote Back, sir.
R1 : What about the equation you get at?
T : I utilize the analogy to simplify the equation.
R1 : Why is the question being posed for no reason?
T : Sir, it's already in the conclusion."

In addition, students with a high mathematical disposition are able to interpret the results obtained correctly, even though they have not checked other points on the grounds that they have looked at opaque paper (Figure 3c) based on student interviews.

"R1 : So, how do we go about get conclusion?
T : Just use images, sir.
R1 : Why are test points not used?
T : No, sir, because the only potential answers are in points (4,6) or (6,4), I search in the paper sir."

So, if the student has a high mathematical position, the student may already use the mathematical problem-solving step indicators.

2. Responses to students with medium mathematical disposition

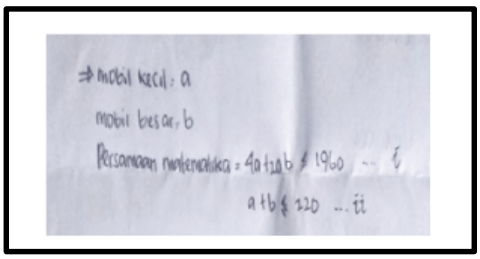

Figure 4a. Student answer with medium mathematical disposition on question number one and the first indicator.

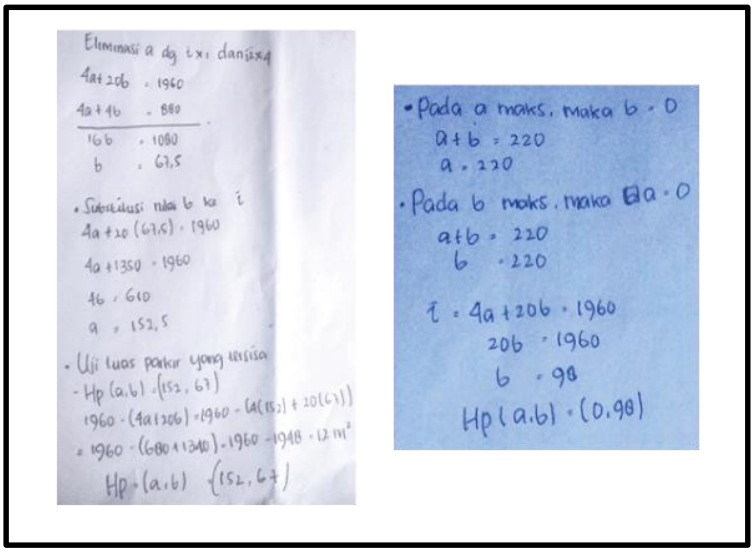

Figure 4b. Student answer with medium mathematical disposition on question number one and the second indicator.

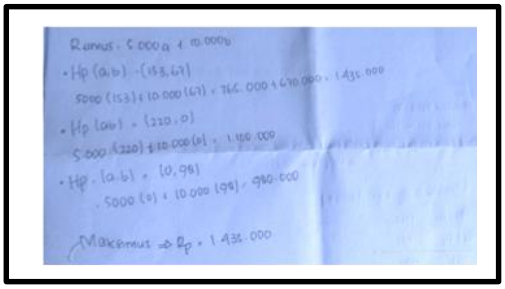

Figure 4c. Student answer with medium mathematical disposition on question number one and the third indicator.

In the first question, students with a medium mathematical disposition are able to observe and understand the problem well (Figure 4a). Students who have a mathematical disposition solve problems on an algebraic basis and do not solve problems with geometry, but during problem-solving interviews using algebra, students cannot state the reasons for rounding off the number of small cars and large cars, so they only estimate the value of x and y for full profits (Figure 4b). based on student interview between student with medium mathematical disposition (R2) and researcher (T)

"T : What is the best way to write the problem in the question?
R2 : Sir, I just notice the number of small and big cars.
T : What about the equation you get at?
R2 : Sir, can you use the separation of two variables?
T : What is the next step?
R2 : with only elimination, sir.
T : That is, the maximal point is directly at the intersection, correct? Is it possible that at some point in the future, this will not be the case?
R2 : Yes, sir, there is a point test; perhaps it can also be done at the intersection of the x and y - axis."

In addition, students who have a medium mathematical disposition are able to interpret the results obtained correctly even though they obtain x and y values on the basis of a rounding calculation (Figure 4c). Based interview

"T : Why is the conclusion different from the point test result?
R2 : I just guest and I see its maximum sir"

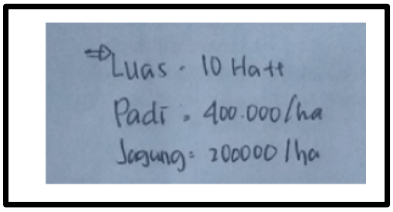

Figure 5a. Student answer with medium mathematical disposition on question number two and the first indicator.

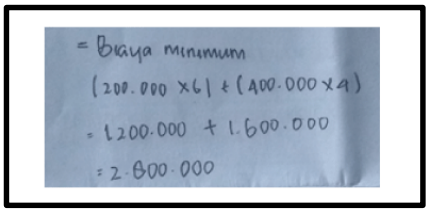

Figure 5b. Student answer with medium mathematical disposition on question number two and the second indicator.

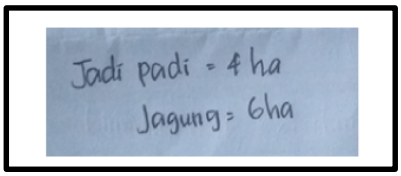

Figure 5c. Student answer with medium mathematical disposition on question number two and the third indicator.

In the second question, when conducting interviews with students who have a mathematical disposition, it was clarified that they were able to understand the mathematical problem but had trouble writing down what was understood and questioned (Figure 5a). This led them to establish a settlement strategy by estimating the potential area of rice-planted land and the area of corn planted land (Figure 5b). Based on interview

"T : What is the best way to write the problem in the question?
R2 : Sir, I only read the stats. The sum two farm is 10 and corn farm between 4 and 6, rice farm between 2 and 6
T : What about the equation you find at?
R2 : Sir, I'm only guessing on a solution.
T : How should the conclusion be written?
R2 : I guess the answer can only be found in point (4,6)"

Based on that assumption, the last conclusion was made on the minimum cost (figure 5c). So, if the student has a medium mathematical disposition, the student has not been able to properly apply mathematical problem-solving indicators.

3. Responses to students with low mathematical disposition

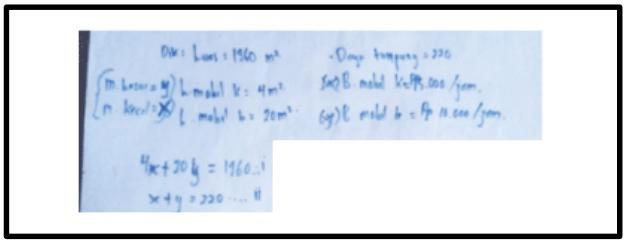

Figure 6a. Student answer with low mathematical disposition on question number one and the first indicator.

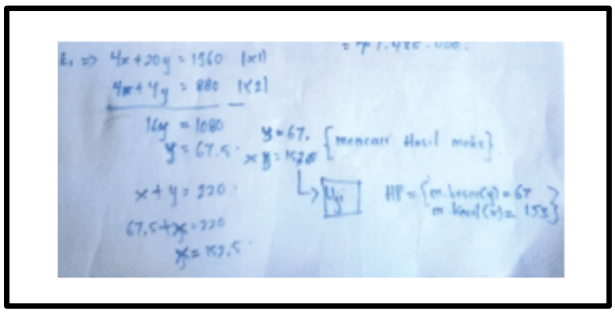

Figure 6b. Student answer with low mathematical disposition on question number one and the second indicator.

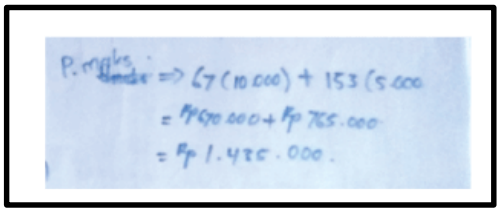

Figure 6c. Student answer with low mathematical disposition on question number one and the third indicator.

In the first question, students with a low mathematical disposition are able to identify what is known but with an incorrect interpretation (Figure 6a), based on interview performed from student with low mathematical disposition (R3), they do not understand that the problem is related to the linear inequality of the two variables.

"T : What is the best way to write the problem in the question?
R3 : Sir, I only read the stats.
T : What about the equation you find at?
R3 : use a two-variable system of equations sir
T : So x and y have to satisfy both equations, right?
R3 : no sir
T : so, how?
R3 : The maximum result, sir, is clear.
T : just use elimination?
R3 : Yes, sir, just take note out on that one right immediately."

However, during the problem-solving interview written by students with a low mathematical disposition, it was noticed that they solved the problem by using only algebra

without the support of geometry, students could state the reasons for rounding up the number of small cars and large cars, but got the results by guessing (Figure 6b). In addition, students with a low mathematical disposition only write the results in algebraic form without being able to write the interpretation of the results obtained (Figure 6c).

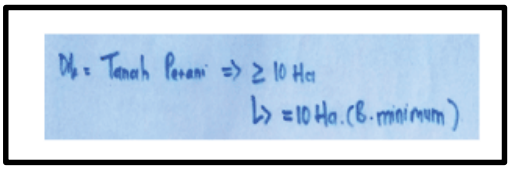

Figure 7a. Student answer with low mathematical disposition on question number two and the first indicator.

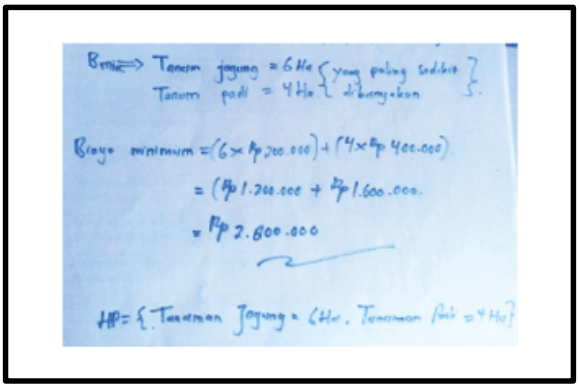

Figure 7b. Student answer with low mathematical disposition on question number two, the second and the third indicator.

In the second question, students with a low mathematical disposition write what is known, but not quite right, and do not write what is asked in the question (Figure 7a). Based on interviews with low mathematical disposition students, they considered the possibility of land planted with rice and land planted with corn to achieve a minimum cost without considering other possibilities (Figure 7b) and did not draw any conclusions that had been developed in writing. Based on interview

"T : What is the best way to write the problem in the question?
R3 : Sir, I only read the stats.
T : So, how about what you wrote?
R3 : Yes, sir, just like that 10 hectares of land.
T : how to get the result?
R3 : Look at the smallest and the largest, only the land area, sir"

So, if students have a low mathematical disposition, they would find it difficult to understand the mathematical problems they face.

Discussion

The following in Table 3 is the conclusion of students' mathematical ability to solve mathematical problems in general in terms of student mathematical disposition. It was achieved after taking a problem-solving abilities test to 35 students and holding group interviews based on mathematical dispositions.

Table 3. Results of evaluations for the ability to solve mathematical problems.

No	Ques-tion	Step Indicators For Mathematical Problem - Solving	Students with Low Mathematical Disposition	Students with Medium Mathematical Disposition	Students with High Mathematical Disposition
1	1	Observing and understanding the problem demonstrates what is known and what is asked for	Write down what is understood and what is asked, but it is incorrect or incomplete.	Write down exactly what is understood and what is asked.	Write down exactly what is understood and what is asked.
		Arrange and solve problems according to the strategy	Carry out the strategy by writing down the answers, but the wrong answers or only a few correct answers.	Carry out the plan by writing down half or most of the correct answers	Carry out the plan by writing down the answers completely and correctly
		Concluded the answers correctly	Interpret the results obtained by making conclusions but less precise	Interpret the results obtained by drawing appropriate conclusions	Interpret the results obtained by drawing appropriate conclusions
2	2	Observing and understanding the problem demonstrates what is known and what is asked for	Write down what is known without mentioning what has been asked or vice versa	Write down what is known and what is asked but not quite right	Write down what is known and what is asked but is inaccurate or incomplete.
		Arrange and solve problems according to the strategy	No answer	No answer	Carry out the plan by writing down the answers completely and correctly
		Concluded the answers correctly	Interpret the results obtained by drawing conclusions but with less precision	Interpret the results obtained by drawing conclusions but with less precision	Interpret the results obtained by drawing appropriate conclusions

From the data obtained, students with high mathematical disposition are usually able to write what is known and what is asked correctly because students with a high mathematical disposition are able to observe and understand the problem even though they state what is being asked at the end of the answer. Carry out the completion plan and interpret what is obtained by drawing the right conclusions because students with high mathematical disposition able to write and solve mathematical problems both geometrically and algebraically. Students who have medium mathematical disposition cannot write what is known and asked completely but interpret conclusions well and carry out the completion plan well Students who have a mathematical disposition solve problems on an algebraic basis and do not solve problems with geometry, but students cannot state the reasons for rounding off the number of small cars and large cars, so they only estimate the value of x and y for full profits. In the meantime, students who have a low disposition do not understand the mathematical problems that occur because they do not understand that the problem is related to the linear inequality of the two variables. This is because the mathematical disposition strongly affects the learning process of students (Kilpatrick et al., 2001, Beyers, 2011) And student mathematical disposition is positively associated with student mathematical problem-solving abilities (Hutajulu et al., 2019) and student achievement (Grootenboer & Hemmings, 2007). Students with a high mathematical disposition have a high sense of interest and curiosity in mathematics to try, understand, solve, and interpret mathematical problems well. (Claudia et al., 2020). In addition, the results discussed in this study are affected by numerous variables, such as learning during the Covid-19 pandemic, which have effect on the student learning process and this analysis is limited to students who are research samples, which also has a major impact on the findings and discussion of the research.

CONCLUSION

Based on the findings and discussion of this study, a conclusion can be drawn that can be used as a consideration by field educators which features a school with the same student character as the study design in which only one unit is investigated. Students with high mathematical disposition in general can use step indicator of mathematical problem-solving in contrast to students with medium mathematical disposition and students with a low mathematical disposition. Meanwhile, students with a medium mathematical disposition have not been able to accurately apply mathematical problem-solving indicators. In addition, students with a low mathematical disposition find it difficult to understand the mathematical problems presented.

CONFLICT OF INTEREST

Although the results of this study indicate that students who are well disposition will be able to apply mathematical problem-solving indicators well, these findings are only available on linear program content and limited to some research samples during the Covid-19 pandemic. It is therefore proposed that future research on various research materials and samples be supported by optimal learning.

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