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Mathematical Reasoning Ability as a Tool to Improve Mathematical Literacy

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Abstract

Mathematical reasoning is one of the competencies needed to improve mathematical literacy. Mathematical reasoning is very influential in relation to other sciences and in daily life. This research is a descriptive research with the purpose of describing mathematical reasoning ability of Semester 1 students of Mechanical Engineering Study Program of Balikpapan University. The result of the research shows that there is a good mathematical reasoning in Mechanical Engineering 1st Semester Class A1 Academic Year 2023/2024. With good mathematical reasoning, it can be said that their mathematical literacy is also good enough. Mechanical Engineering students who have good mathematical reasoning will be very supportive in understanding other sciences, especially science in the field of Mechanical Engineering. The problems that arise in the process of mathematical reasoning of Mechanical Engineering Semester 1 students include not understanding the meaning of the problem command, difficulty starting the work steps, lack of accuracy when operating numbers, inability to use certain theories / formulas / rules in solving problems, inability to conclude answers, usually the answer only stops at the calculation result without concluding the results. For students whose achievement of mathematical reasoning ability indicators is still low, it can be helped by often practicing working on problems that require mathematical reasoning. This is one way for teachers to improve their students' mathematical reasoning skills.

***Keywords**: mathematical reasoning, mathematics literacy*

INTRODUCTION

Mathematics is a basic science field supporting other sciences. All aspects of life are inseparable from the role of mathematics {Formatting Citation}. Not infrequently we encounter around, for simple calculations still rely on calculators (calculating machines) without understanding the process of how the calculation can occur. There are also often

errors in the operation of (real) numbers which consequently lead to incorrect solutions. For example, a simple algebraic problem $-2-5\times(-4)=\cdots$ .for this there can be several possible answers from students in different ways. Likewise, for math problems that are packaged in the form of narratives, leading students to think rationally using their reasoning to sort out what is known, what is questioned and how to determine the solution, what kind of solution steps are taken, methods that can be used to obtain the most optimal solution.

In general, mathematical reasoning is a logical thinking process with existing provisions in dealing with problems (Yuliany et al., 2021). Mathematical reasoning includes instrumental understanding and relational understanding. Instrument understanding is the student's reasoning ability in producing the correct solution to the problem given. Meanwhile, relational understanding is the ability of students to link 1 topic with other topics to solve problems.

In the Merdeka curriculum of the Mechanical Engineering undergraduate study program at balikpapan University, mathematics courses are compulsory courses that must be taken by mechanical engineering students. Mathematics courses are presented for 4 semesters from Semester 1 to Semester 4 lectures with a total of 12 credits. This means that mathematics is needed as a basis and companion in learning other mechanical engineering scientific courses. One of the achievements of mathematics courses in the Mechanical Engineering undergraduate study program is that students are able to master the principles and mathematical methods needed to analyze physical phenomena and formulate and be able to use them to solve problems in mechanical engineering. In other words, students must be able to use their reasoning to bring real problems related to mechanical engineering into mathematical statements/modeling and determine solutions using appropriate mathematical methods. Furthermore, it is expected that after finding a solution, they will be able to translate the mathematical language back into everyday language. Many previous studies have discussed mathematical reasoning. As stated Chelsi Ariati (2022) in the results of her research in the period 2015 - 2021, the study of mathematical reasoning ability was most studied in 2020 and 2021. Studies are still dominant in the Java and Bali regions on Geometry and algebra material for grade VIII. Some previous studies on students' reasoning include according to Putra & Idkhan, (2022) in his research on Vocational Students in Mechanical Engineering in Makassar City that

reasoning ability has a significant effect on mastering mechanical technology competencies by 5.0%. Unlike the case with Pandu & Suwarsono, (2021), saying that mathematical reasoning ability is very important as a support for the success of mathematics learning, because the two are related to each other. According to Ridha et al. (2019) explains that in transformation geometry lectures there is an increase in the mathematical reasoning ability of better students whose learning uses GeoGebra software than students whose learning uses conventional learning.

Based on the explanation above, it turns out that mathematical reasoning is one of the competencies needed to improve mathematical literacy. According to Kusumawardani (2018), one of the efforts to improve students' mathematical literacy skills is to improve mathematical reasoning competencies. Indicators of mathematical reasoning according to Hendriana et al., (2016) are (1) students are able to present mathematical statements through writing, pictures, sketches or diagrams; (2) students can make conjectures; (3) students are able to provide reasons for several solutions; (4) students are able to check the validity of an argument; (5) students are able to draw conclusions or generalizations. By giving mathematical problems that directly contain the five indicators, it is expected that this study will be able to provide an overview of the reasoning of Mechanical Engineering students of Semester 1 of Balikpapan University in solving mathematical problems. Furthermore, with good mathematical literacy, it is expected that students will be able to solve mathematical problems in the field of mechanical engineering that require mathematical reasoning.

METHODS

This research is a descriptive study using the entire population as a research sample. Descriptive research method according to Hardani ahyar (2022) is research conducted to determine the value of independent variables, either one or more variables without making comparisons with other variables. In other words, this research is independent research without any influence or relationship to other variables such as correlation or experimental research. The purpose of this study is to describe and examine the reasoning ability of students in terms of choosing how to solve basic mathematical problems related to the basic principles of mathematics. The basic principles of mathematics referred to here are measuring students' ability to solve the given problem according to their basic

mathematical knowledge and their reasoning ability by choosing their own way of determining the solution of a problem.

The research subjects are students of Mechanical Engineering Study Program of University of Balikpapan Class A1 semester 1 academic year 2023/2024 consisting of 28 students. All students will be used as research samples. All students will be given the same opportunity to work on the given problems.

The research instruments are basic math problems involving real number operations. Each student is given the same 2 problems to do. The first problem is an inequality problem that must be solved with mathematical steps involving real number operations. While the second problem is a problem that requires students to use some basic theorems to solve it. The questions asked in the test were as follows:

1. Express the solution sets of the following inequalities in terms of intervals and sketch their graphs $-2 < 1 - 5x \leq 3$
2. Find a triangle ABC with angles $A(-2,-1)$, $B(4,-1)$, and $C(1,3)$.
   Sketch the triangle ABC in cartesian diagram. Find the unit perimeter of the triangle?

The above research instrument will be used to provide an overview of the reasoning ability of mechanical engineering students in solving simple mathematical problems. We divide this instrument into 5 classifications of students' mathematical reasoning abilities which we categorize in 5 steps of work. This work step will indirectly be used to analyze students' reasoning ability from the lowest level (Number 1) to the perfect reasoning level (number 5) which is done sequentially from 1 to 5. It is expected that students will be able to solve these problems with the reasoning they understand about the concept of numbers so far.

To complete the information if the students' answers are considered to need additional explanation, random interviews are conducted with students, for example if there are reasons for students who are unclear about the answer sheet given.

Furthermore, the work of the Mechanical Engineering students was analyzed by classifying their answers into the level of completion in accordance with their respective reasoning. Indicators of mathematical reasoning that will be discussed are (1) the ability of mechanical engineering students to present mathematical statements through writing, drawings, sketches or diagrams; (2) the ability of mechanical engineering students to propose conjectures on how the solution flow will be done; (3) the ability of students to

provide reasons for several solutions; (4) the ability of students to check the validity of an argument; (5) the ability of students to draw conclusions or generalizations from the requested solutions.

RESULTS AND DISCUSSION

The following are the results of the mathematical reasoning ability of mechanical engineering students in working on the given math problems. The results of students' mathematical reasoning ability for the first problem are presented in table 1 below.

Table 1. Indicators of Mathematical Reasoning Ability on Question 1

No.	Indicators	Question 1 Total number of students (percent)
1.	Ability to present mathematical statements through writing	10,71
2.	Ability to make conjectures or determine ways of solving	10,71
3.	Ability to perform calculations based on certain formulas/theorems/rules	21,43
4.	Ability to check the validity of arguments	21,43
5.	Ability to draw conclusions	35,72

In Table 1 above, students' mathematical reasoning skills are divided into 5 indicators. For the first indicator, namely the reasoning ability to present mathematical statements through writing, the number of students is 10.71% or as many as 3 people. This means that they are only able to understand the basic concept of the meaning of number operations in the inequality of problem 1, even though the determination of the solution method is still wrong and they are also unable to determine the correct solution set area on the real number line.

An example of the results of working on problems that achieve indicator 1 is given in Figure 1 below.

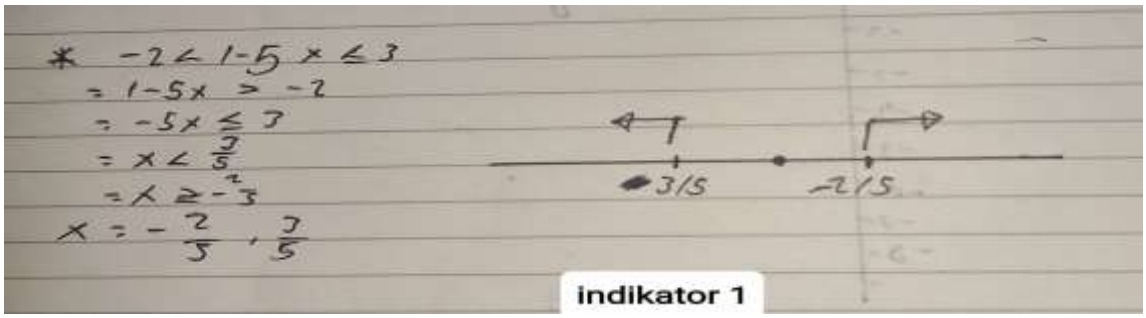

Figure 1. Ability to present mathematical statements through writing

Figure 1 is an example of student work that fulfills indicator 1, namely the reasoning ability to present mathematical statements through writing. It can be seen from the results of the work, students try to determine the steps of solving the problem given, but they have not been able to determine the right way to solve the problem.

Furthermore, students who have the second indicator reasoning ability, namely the ability of students to make conjectures or determine ways of solving are also 10.71% or 3 people. An example of the results of working on problems that achieve indicator 2 is given in Figure 2 below.

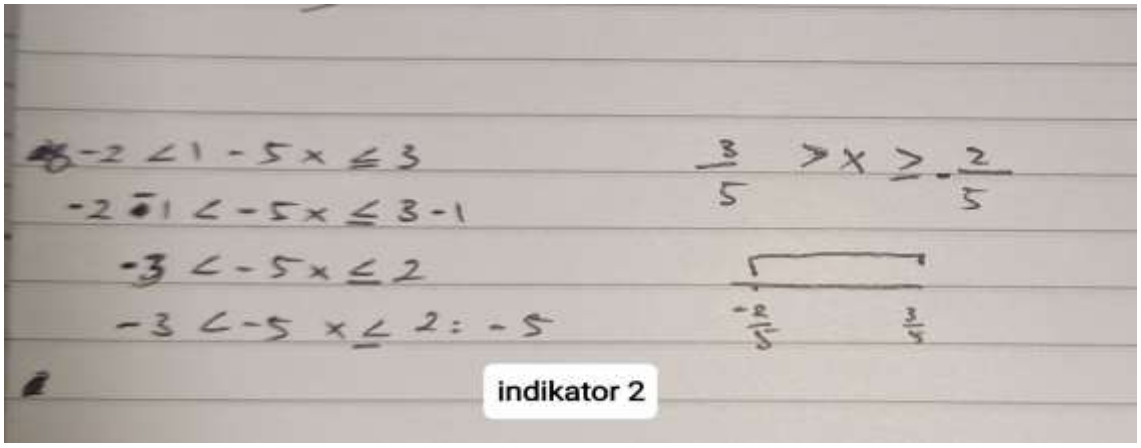

Figure 2. Ability to make conjectures or determine ways of solving

In Figure 2. it can be seen that students have been able to present mathematical statements and try with their reasoning to solve the problem in a way that they are good at. It appears that the results of mathematical calculations are correct, but they are still confused when pouring them in the form of graphical sketches, there is uncertainty about the boundaries of the solution set area.

In the third indicator, namely the reasoning ability to perform calculations based on certain formulas/theorems/rules as much as 21.43%. Which means that there are 6 students who are able to present mathematical statements well, able to determine the method of solution and able to perform calculations using certain mathematical formulas/theorems/rules. An example of the results of working on problems that achieve indicator 3 is given in Figure 3 below.

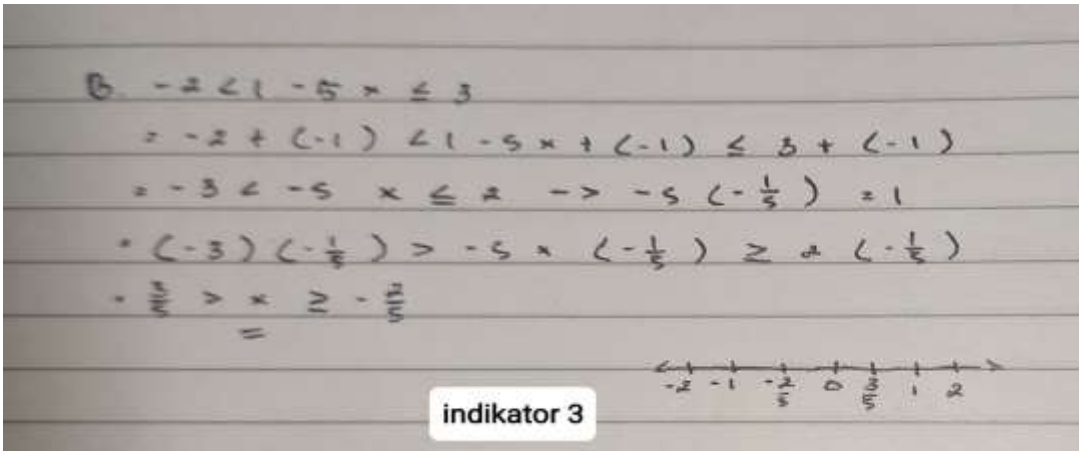

Figure 3. Ability to perform calculations based on certain formulas/theorems/rules

In Figure 3, the student's work steps are organized following the rules in solving an inequality. From the picture, it can be seen that the student explained the steps of the real number operation that he did to determine the solution set. However, the student has not been able to determine the required solution set and unable to put the calculation results into the ability to check the validity of arguments, as many as 21.43% or 6 people. In this fourth reasoning indicator, students have the ability to present mathematical statements through writing, are able to propose conjectures or ways of solving, do calculations based on certain formulas / theorems / rules, so students are also able to check the validity of arguments. The example of student work that fulfills indicator 4 as presented in Figure 4 below.

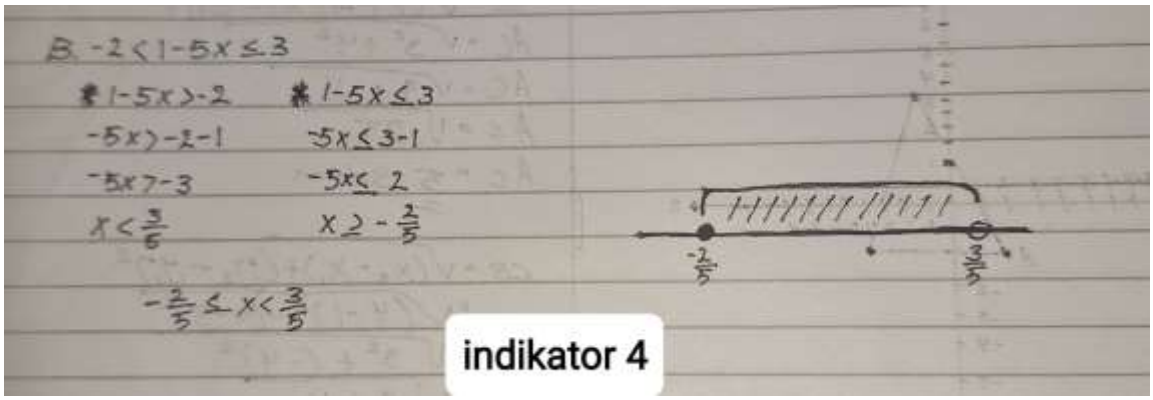

Figure 4. Ability to check the validity of arguments

In Figure 4, in addition to being able to determine the calculation results based on the solution method they mastered, students are also able to check the validity of their arguments. Seen in the real number line graph presented, students are able to determine the interval limit correctly. In addition, students are also able to determine the area of the solution set by shading the area. Next in table 1, the fifth indicator is the ability of students'

reasoning in drawing conclusions. From a total of 28 students, there are 10 people or 35.72% of students who fulfill this indicator 5. Achievement in indicator 5 is the most perfect level of student reasoning compared to the previous indicators that have been discussed. In addition to being able to present mathematical statements in writing, being able to determine the method of solution, determining the results of calculations based on the method of solution they mastered, being able to check the validity of their arguments. Then students are also able to draw conclusions by determining and writing the settlement set area of the problem. Seen on the real number line graph presented, students are able to determine the interval limit correctly. In addition, students are also able to determine the area of the solution set by shading the area. The following Figure 5 gives an example of one of the student answers that fulfills reasoning indicator 5.

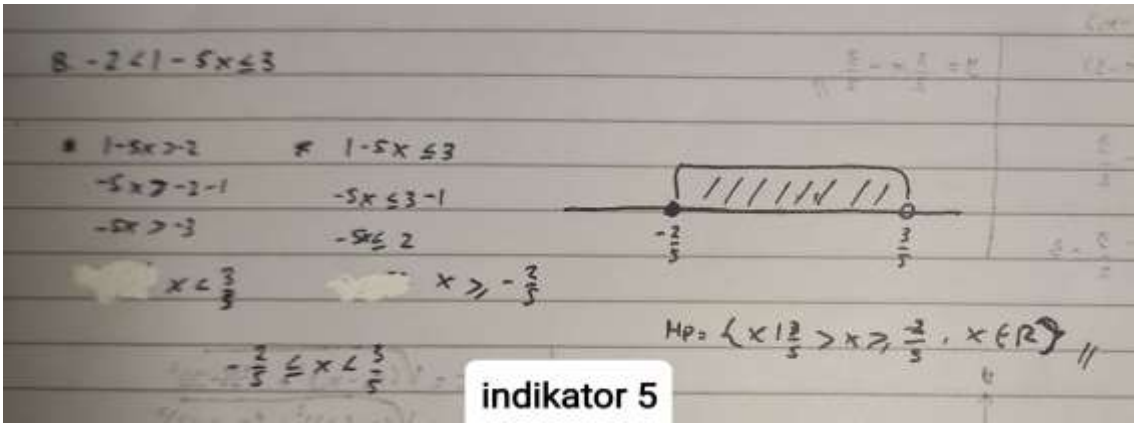

Figure 5. Ability to draw conclusions

In Figure 5 above, students are able to solve problems with the reasoning they have coherently. From the ability to present mathematical statements in writing to writing the solution set with the correct set rules.

Based on the research results with the first question instrument, namely the command to state the solution set of the inequality $-2 < 1-5x \leq 3$ in the interval interval and sketch the graph. Of the 28 students obtained diverse answers even though before working on the problem had been given the same reinforcement material about the learning material of the real number system. There were 10 students whose answers met the five indicators of mathematical reasoning required. Only 3 students seemed to still have difficulty determining the solution to the problem given.

Furthermore, the research results are presented in the form of reasoning ability of mechanical engineering students in the second problem. If the first problem was asked to

determine the solution set first, then asked to sketch the graph on the real number line. For the second problem, students were asked to provide a sketch of the image first, then required to determine the solution according to their own reasoning. The results of the indicators of mathematical reasoning ability of Class A1 mechanical engineering students on question number 2 can be seen in Table 2 below.

Table 2. Indicators of Mathematical Reasoning Ability on Problem number 2

No.	Indicator	Question 2
		Total number of students (Percent)
1.	Ability to present mathematical statements through writing	14,29
2.	Ability to make conjectures or determine ways of solving	35,71
3.	Ability to perform calculations based on certain formulas/theorems/rules	7,14
4.	Ability to check the validity of arguments	0
5.	Ability to draw conclusions	42,86

In Table 2, given the problem of a known triangle ABC with angle points A(-2,-1), B(4,-1) and C(1,3). Students are asked to sketch the ABC triangle in a cartesian diagram and determine the circumference of the ABC triangle. students' reasoning ability in presenting mathematical statements through writing / sketching images is 14.29% or 4 people. In this first indicator of reasoning ability, they were only able to sketch the cartesian diagram but mistakenly determined the corner points of the requested ABC triangle. Furthermore, students who were able to complete up to indicator 2 were 35.71% or 10 people, namely students who were able to draw a sketch of triangle ABC correctly and were able to determine how to calculate the circumference of triangle ABC. In indicator 3, students who are able to do calculations based on the formula are only 2 people or 7.14%. In indicator 3, students have not been able to check the validity of arguments and draw conclusions. Furthermore, in indicator 5, 12 people or 42.86% of students were able to determine the sketch of triangle ABC and were able to solve the problem correctly until the conclusion. The student errors that occur in solving this second problem include not being able to estimate the scale of the image/graphic on the cartesian diagram, the triangle drawing is correct but lacks the writing of the names of the corner points, incorrect number operations in this case there are still many who do not understand addition subtraction or multiplication and division of real numbers. Not understanding

the use of formulas, not completing the work as requested, often missing to write the conclusion / solution set of a problem.

Based on the results of students' answers to questions number 1 and number 2 above, the results of reasoning indicators vary among students. For students who fulfill 5 indicators in the first question as many as 10 people and in question number 2 as many as 12 people. This student achievement implies that mathematical reasoning is also quite good in Mechanical Engineering students Semester 1 Class A1 Academic Year 2023/2024. Thus it can be said that their mathematical literacy is quite good. According to Kusmanto & Marliyana (2014) that mathematical reasoning is very influential on the relationship with other sciences and in everyday life. Mechanical Engineering students who have good mathematical reasoning will be very supportive in understanding other sciences, especially science in the field of Mechanical Engineering.

According to (Astuti et al., n.d.), sometimes subjects are able to determine how to find a solution to a problem, but at the time of calculation there is an error in the algebraic process. It can also happen to subjects who are able to master indicator 2 but when applying the formula/theorem in indicator 3 have difficulty applying the right rhetorem. In the answer sheet of the reasoning test for Mechanical Engineering Semester 1 students, the problems that arise in the process of mathematical reasoning include not understanding the meaning of the problem command, difficulty starting the work steps, lack of accuracy when operating numbers, inability to use certain theories / formulas / rules in solving problems, inability to conclude answers, usually the answer only stops at the calculation result without concluding the results. Furthermore, according to Kusumawardani (2018), giving tasks that require mathematical reasoning is one way for teachers to improve mathematical literacy. For students whose achievement of mathematical reasoning ability indicators is still low, there is still hope for better if they often practice working on problems that hone their mathematical reasoning.

CONCLUSIONS

Based on the research results, it can be concluded that (1) There are 10 students out of 28 students who are able to fulfill 5 indicators of mathematical reasoning in the first problem and 12 students out of 28 students who are able to fulfill 5 indicators of mathematical reasoning in the second problem. This implies that mathematical reasoning is quite good in Mechanical Engineering students Semester 1 Class A1 Academic Year

2023/2024. With good mathematical reasoning, it can be said that their mathematical literacy is quite good too. Mathematical reasoning is very influential on the relationship with other sciences and in everyday life. Mechanical Engineering students who have good mathematical reasoning will be very supportive in understanding other sciences, especially science in the field of Mechanical Engineering; (2) The problems that arise in the process of mathematical reasoning on the answer sheet of the reasoning test of Mechanical Engineering Semester 1 students include not understanding the meaning of the problem command, difficulty starting the work steps, lack of accuracy when operating numbers, inability to use certain theories / formulas / rules in solving problems, inability to conclude answers, usually the answer only stops at the calculation result without concluding the results; (3) Giving assignments that require mathematical reasoning is one way for teachers to improve mathematical literacy. For students whose achievement of mathematical reasoning ability indicators is still low, there is still hope for better if they often practice working on problems that hone their mathematical reasoning.

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