



Reasoning Habits of Students through Realistic Mathematics Problems

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Abstract

A realistic math problem is one of the math problems whose solution requires a reasoning habit. Reasoning ability will increase if students often practice their reasoning habits. By solving realistic math problems, it is expected that students' reasoning habits can be trained well. This study aims to describe the reasoning habits of class VIII students of MTs Sunan Kalijogo Kranding Kediri Regency, East Java, Indonesia in solving realistic math problems in terms of 4 stages of reasoning habits. This study uses a qualitative approach with a descriptive type of research. The data collection technique in this study used a mathematical reasoning ability test sheet and interviews. The subjects in this study were students of class VIII F MTs Sunan Kalijogo Kranding, totaling 28 students, then three students with high, medium, and low categories of reasoning habits were taken to conduct interviews. The results of this study indicate that students with high-category reasoning habits can fulfill the four stages of reasoning habits. Students with reasoning habits in the medium category can fulfill two stages of reasoning habits. Students with low-category reasoning habits are not able to fulfill the four stages of reasoning habits. The results of this study are useful for choosing the right learning method in improving students' reasoning abilities, such as using realistic mathematics learning or Project Based Learning (PBL).

Keywords: *Reasoning Habits; Realistic Mathematics Education*

A. Introduction

The development of the times makes science and technology also change (Yoga, 2018). The availability of very abundant information requires us to have the ability how to process it (Setiani et al., 2015). Critical, systematic, logical, and creative thinking is needed in processing the information ((Fuadi et al., 2016)). These skills can be obtained by learning mathematics (Maryanih et al., 2018). Therefore mathematics is needed to solve various problems including in dealing with technological developments.

Mathematics is taught from elementary school to the university level (Wibowo, 2017). One of the mathematical objectives that have been written in Permendiknas No. 22 of 2006 is to use reasoning on patterns and properties, perform mathematical manipulations in making generalizations, compiling proofs, or explain mathematical ideas and statements so that they are able to solve mathematical problems. Based on the description above, one of the subjects that can improve students' reasoning so that students can communicate well with their environment is mathematics.

Mathematical reasoning is one of the basic mathematical abilities to understand concepts and formulate ideas mathematically (Ball & Bass, 2003). Mathematical reasoning is considered the "adhesive" that can help students understand mathematics (Askew, 2020). (Ario (2015) states that, in addition to the cognitive aspect in the form of reasoning ability, the affective aspect in the form of reasoning habits is also the goal of learning mathematics. It can be said that mathematical reasoning abilities can be developed through reasoning habits in understanding mathematical concepts.

Reasoning habits are productive ways of thinking that are common in the process of mathematical investigation and idea generation (NCTM, 2016). Hima & Anwar (2016) explained that students must make observations, submit conjectures, and experience wrong prefixes and incomplete explanations, before reaching a logical conclusion when involved in the mathematical reasoning process. Therefore, mathematical reasoning habits can be developed after students are involved in the learning process. NCTM (2016) explains that reasoning habits are divided into 4 stages, (1) analyzing problems, (2) applying strategies, (3) finding and connecting between mathematical contexts, and (4) reflecting on solutions. In this study, the reasoning habits of students in working on mathematical problems will be explained using the 4 stages of reasoning habits initiated by the National Council of Teachers of Mathematics.

Based on the 2011 TIMSS study, Indonesian students' math and science abilities are ranked 38 out of 42 countries (Hadi & Novaliyosi, 2019). Cognitive ability at the level of reasoning of class VIII students has the lowest average percentage of 17% (Rosnawati, 2013). Previous research has shown that the mathematical reasoning of students is weak because of the lack of training of students in solving problems that require reasoning (Raharjo et al., 2020). This is following the sresearch of Rizta et al. (2013) that teachers in class more often give questions that emphasize understanding concepts, but also that require higher-order thinking such as reasoning are still rarely given. There are still many students who have not applied the reasoning habit in solving the mathematical problems they face (Fajariyadi, 2016). In connection with these problems, a learning approach that can be an alternative to improve students' mathematical reasoning is a realistic mathematical education (RME) approach.

In RME, context problems are defined as experientially real problem situations for students thus the problem played from the start onwards (Gravemeijer & Doorman, 1999). This realistic mathematical approach uses problems that easily be imagined or real in students' minds, so students will determine and reconstruct the problems themselves given (Fauzan et al., 2016). Therefore, students' mathematical experience and reasoning will increase. Realistic mathematical problems in this study are applied to geometry material. Kusniati (2011) stated one of the mathematical materials that are often a problem for students is geometry. According to Sholihah & Afriansyah (2018), geometry is a branch of mathematics that has a greater chance than other branches of mathematics to be understood by students, because geometric ideas have been known to students since before they entered school, for example, lines, planes, and spaces.

One of the mathematics teachers at MTs Sunan Kalijogo Kediri Regency, East Java stated that there were still many students who did not understand the story problems that required

reasoning on the material of cube and cuboid geometry, so they still had difficulty solving the story problems. According to research by Maryanah et al. (2018) students have difficulty solving cube and cuboid problems because they do not understand the concepts of cube and cuboid. In solving questions of reasoning ability, there are various mistakes made by students, it is included there are various mistakes made by students (Ario, 2016). The student learning difficulties in solving generalization problems are not understanding questions, difficult to determine the strategy to be used, the occurrence of misconceptions in other words lack of prerequisites material (Lestari, 2015). It can be said, students can receive material and solve questions but cannot make it meaningful, namely being able to solve other problems outside the context of the problem. For example, if students are given questions of a different form or given a more difficult level of questions, students can also solve them, but in reality students often still find it difficult and eventually give up if they can't do it.

Mathematical reasoning has been studied by several researchers including, Oktaviana & Aini (2021) and Saragih (2020) regarding the analysis of the mathematical reasoning abilities of junior high school students on social arithmetic material and problem-based problems in junior high school students respectively. Next, Raharjo et al. (2020) and Agustin (2016) examine mathematical reasoning abilities with an open-ended and problem-solving approach. Followed by Fauzan et al. (2016) and Mbagho & Tupen (2020) are about an effort to improve reasoning or learning outcomes with a realistic mathematical approach. However, research on students' reasoning habits through realistic math problems has not been widely studied. By giving realistic problems on cube and cuboid material to students, it is expected to obtain a description of students' reasoning habits in solving them. The role of reasoning in solving problems is so important, and the results of this study can be used to determine the level of students' reasoning habits so that teachers can determine how good learning is used in the classroom so that students' reasoning habits increase. Therefore, this study aims to describe the reasoning habits of students through realistic math problems at MTs Sunan Kalijogo Kranding Kediri Regency, East Java.

B. Methodology

1. Research Design

The approach used in this research is a qualitative approach with a descriptive research type. This type of research is descriptive qualitative research, therefore the presence of the researcher is very important because the researcher is the main instrument. Researchers are present at the research location to collect data needed in research. The data generated in this qualitative approach is descriptive in the form of speech or writing and the behavior of the people being observed, so that the data analyzed is in the form of detailed and careful descriptions of certain symptoms or phenomena in more depth (Rukajat, 2018). Information collection in descriptive research regarding research subjects applies at a certain time (Saragih, 2020). The purpose of this study was to describe the reasoning habits of students in solving realistic mathematical problems on cubes and cuboid based on high, medium, and low level reasoning categories in MTs Sunan Kalijogo Kranding students.

2. Instruments

The instruments used in this study were the students' mathematical reasoning ability test sheets (LTKPMS) and interview guidelines.

This research uses a test to measure the level of students' reasoning habits on cubes and cuboid using realistic math problems. The questions are given in the form of descriptions, this is done so that it is easier for researchers to measure students' reasoning habits according to the correct answer keys at each stage of reasoning habits.

Students' mathematical reasoning ability test sheets are made to measure students' reasoning habits. LTKPMS are arranged in two types, in the form of descriptions. The questions given in the first test aim to categorize subjects based on high, medium and low levels of reasoning. Whereas the second test item was only given to selected subjects with high, medium, and low levels of reasoning and each level had 1 research subject. This second test is intended as a comparison, whether the results of the first and second tests will produce scores in the same

category for the selected subject or not. LTKPMS contains different questions but has the same equivalence. Each question contains 2 questions.

The LTKPMS instrument was developed which refers to the 5 characteristics of Realistic Mathematics Education by (Treffers, 1987) and the 4 stages of reasoning habits adopted from NCTM (2009). Indicator of questions and interviews used to measure students' reasoning habits: (1) Analyze problems; (2) implementing strategy; (3) Finding and connecting between mathematical contexts; and (4) Reflecting on solutions (NCTM, 2016).

The steps taken by the researchers to collect data were to prepare a grid of test questions, create test questions and scoring guidelines, ask for validation from 3 Lecturers of the Mathematics Education Program, and 1 math teacher, then conduct the test. The test questions contain the stages of reasoning habits that will be carried out by students and the results of student answers will be collected and analyzed by researchers.

The reasoning habits test questions can be seen below.

A bathtub is 2 m long, 1 m wide, and 1 m high. The bathtub leaked at the top, so it could only be filled $\frac{3}{4}$ of the way. Determine how many liters of water are needed to fill the tub. (liter= dm^3)

Look at the following illustration (Figure 1).

A house that looks like a cuboid will be painted on the outside with a length of 12 m, a height of 4 m, and a width of 6 m. To make it easier to estimate the paint needed, the handyman ignored the existing windows and doors, in calculating the area. If every 12 m^2 requires $\frac{1}{3}$ can of paint, how many cans are needed to paint the walls of the house?

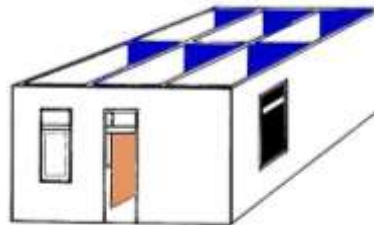


Figure 1. Illustration Problem 2

3. Technique of Data Analysis

The reasoning habits test was given to 28 class VIII F students of MTs Sunan Kalijogo. The results of the reasoning habits test were categorized into three categories which were then used to select research subjects. The data collection technique used purposive sampling, namely students who had good communication skills so that one subject was selected each from the categories of high, medium, and low reasoning habits.

Table 1 is used to determine the categories of students' reasoning habits based on test scores. The scoring technique used in this study is to give a score at each stage of reasoning habits which are presented in Table 2.

Table 1. Reasoning Habits Category

Category	Percentage of Score (x)
High	$x > 70$
Medium	$55 < x \leq 70$
Low	$x \leq 55$

(Suprihatin et al., 2018)

Table 2. Reasoning Habits Test Scoring Techniques

Reasoning Habits Stages (NCTM, 2009)	Score	Indicators
Analyzing the problem	1	Unable to analyze problem
	2	Analyze the problem incorrectly
	3	Analyze the problem correctly, but not according to the mathematical concept
	4	Analyze the problem properly
Implementing the strategy	1	Unable to implement strategy

Finding and connecting between mathematical contexts	2	Implement the strategy wrong
	3	Implement the strategy correctly, but there are answers that are not quite right
	4	Implementing the right strategy
	1	Unable to search and connect between mathematical contexts
Reflecting the solution	2	Find and connect between mathematical contexts incorrectly
	3	Find and connect between mathematical contexts correctly, but there are answers that are not quite right
	4	Find and connect between mathematical contexts appropriately
	1	Unable to reflect the solution
	2	Reflect the solution incorrectly
	3	Reflect the solution correctly, but give the wrong reasons
	4	Reflect the solution correctly
$\text{Percentage Score} = \frac{\text{Student score}}{\text{Maximum score}} \times 100 \%$		

(Nurhayati et al., 2013)

Checking the validity of the data was carried out using triangulation techniques by comparing the results of tests and student interviews, and using member checks which were carried out on interview subjects.

C. Findings and Discussion

1. Findings

The results of this study are presented following the research objectives, namely to describe students' reasoning habits based on 4 stages of reasoning habits adopted from NCTM (2016), namely: (1) Analyzing problems, (2) implementing strategies, (3) finding and connecting between mathematical contexts, and (4) reflecting on the solution.

Based on the test results of 28 students, then an assessment was carried out by the researcher. Based on the results of the assessment, the reasoning habits category was obtained according to Table 1, namely 6 students in the high category, 11 students in the medium category, and 11 students in the low category. From each category, one subject is taken to represent each category of reasoning habits. The following are the research subjects based on test results and recommendations from mathematics teachers.

Table 3. Research Subjects Interviewed

Name	Code	Score	Percentage	Category
TR	S1	31	96,87%	High
LP	S2	22	68,75%	Medium
AM	S3	14	43,75%	Low

The following are the results of the analysis of students' reasoning habits based on 4 stages of reasoning habits which were adapted from NCTM (2016).

Reasoning habits of high category student

Figure 2 shows the answers to the reasoning habits test at number 1 by subjects with high categories.

The first stage of reasoning habits is analyzing the problem. It can be seen in Figure 2 that S1 can identify problems well, by writing coherently and in detail the information that is known and asked, and can write and explain well the plan to solve the problem that will be used. The first step taken by S1 is to write down the information that is known and asked in the question. S1 writes down the methods and formulas that will be used to solve the problem. The formula they

use is the formula for the volume of a cuboid. The volume of the cuboid is multiplied by $\frac{3}{4}$, because the tub can only be filled with $\frac{3}{4}$ of it. The unit is changed to liters according to the request in the problem. So it was concluded that S1 was able to fulfill the stages of analyzing the problem well.

Tentukan jawaban pada kolom yang di berikan sesuai petunjuk yang ada !!!

Diketahui :

(balok) $p = 2 \text{ m}$
 $l = 1 \text{ m}$
 $t = 1 \text{ m}$ Besar bagian atas bisa terisi $\frac{3}{4}$

Ditanya :

berapa liter air yang dibutuhkan untuk mengisi bak mandi tersebut ?

Resolusi kamu memulikan diketahui dan ditanyakan, bagaimana cara kamu memecahkan masalah tersebut ?

- mencari rumus Volume balok
- di soal kita $\frac{3}{4}$ maka sudah menemukan hasil dari Volume balok itu satuannya diganti liter

Langkah penyelesaian :

$$\begin{aligned}
 V &= p \times l \times t \\
 &= 2 \times 1 \times 1 \quad \text{m}^3 \\
 &= 2 \text{ m}^3 \times \frac{3}{4} \\
 &= \frac{6}{4} = \frac{3}{2} = \frac{3}{2} \text{ m}^3 \times 1000 \text{ l} \\
 &= \frac{3000}{2} \text{ l} = 1500 \text{ l}
 \end{aligned}$$

Kesimpulan :

Air yg dibutuhkan untuk mengisi bak mandi sebanyak 1500 liter

Figure 2. S1 reasoning habits test solutions

At the stage of implementing the strategy, S1 can implement the strategy because S1 can implement the plans that have been made with systematic steps and according to what has been planned, S1 is also able to provide reasons why he chose the plan. S1 can fulfill the stages of implementing the strategy well.

In the stage of finding and connecting between mathematical contexts, S1 is also able to fulfill this stage by connecting between the known and asked information, and being able to mention other mathematical concepts related to the given problem. This is shown from the results of the answer S1 (Figure 2) in connecting the known and asked information well so that it can solve the problem correctly. Based on the results of the interview, the subject of S1 is also able to determine other mathematical concepts related to the given problem, namely changing the unit m^3 to liters, by multiplying with 1000 because the unit liter is the same as dm^3 . S1 subjects are also able to make decisions based on the answers they get to draw final conclusions. S1 subjects are able to fulfill the stages of finding and connecting between mathematical contexts well.

S1 can reflect the solution well. This is shown from the results of S1's answer in determining the conclusion correctly, namely the water needed to fill a bathtub with a length of 2m, a width of 1m, a height of 1m, and can only be filled $\frac{3}{4}$ of the way due to a leak of 1500 liters. Based on the results of the interviews before concluding, they re-checked the correctness of the answers at each calculation step that was written.

Reasoning habits of medium category student

Figure 3 shows the answers to the reasoning habits test at number 2 by subjects with medium categories.

Tuliskan Jawabanmu pada kolom yang di sediakan sesuai petunjuk yang ada !!!

Diketahui :

$P = 12 \text{ m}$
 $L = 4 \text{ m}$ Sempat 12 m^2 membutuhkan $\frac{1}{2}$ kaleng cat.
 $L = 6 \text{ m}$

Ditanya :

Berapa kaleng cat yang dibutuhkan untuk mengecat
 di dinding rumah tersebut?

Seolah kamu memiliki data diketahui dan ditanyakan, bagaimana cara untuk memecahkan
 masalah tersebut?

dengan cara membagi dan mengkalikan.

Langkah penyelesaian :

$$\begin{aligned}
 L \cdot P &= (2 \times P \times 1) + (2 \times L \times 1) \\
 &= (2 \times 12 \text{ m} \times 4 \text{ m}) + (2 \times 6 \text{ m} \times 4 \text{ m}) \\
 &= 96 \text{ m}^2 + 48 \text{ m}^2 \\
 &= 144 \text{ m}^2 : 12 \text{ m}^2 \\
 &= 12 \text{ m}^2 \times \frac{1}{2} \\
 &= \frac{12}{2} \\
 &= 6
 \end{aligned}$$

Kesimpulan :

cat yang di butuhkan untuk mengecat dinding
 rumah tersebut adalah 6 kaleng.

Figure 3. S2 reasoning habits test solutions

S2 can fulfill the stages of analyzing problems. S2 writes coherently and in detail the information that is known and asked, and can write and explain well the plans to solve the problems that will be used, although in writing the completion plans are not written step by step, but made into one sentence.

In the stage of implementing the strategy, S2 can implement the plan that has been made with systematic steps and according to what has been planned, S2 is also able to provide reasons why he chose the plan.

The third stage is finding and connecting between mathematical contexts. S2 still does not complete this stage because S2 has not been able to mention other mathematical concepts related to solving the problem. In the S2 interview process, you cannot explain other mathematical concepts related to completing the given test.

The last stage is reflecting the solution. S2 has not been able to reflect on the solution because S2 is only able to write conclusions on the test sheet, but S2 has not checked the correctness of the answers. Based on the results of the interview, S2 has not checked the correctness of the answers obtained before drawing conclusions. This is because S2 already feels confident and reluctant to re-examine the answers he has obtained.

Reasoning habits of low category student

Figure 4 shows the answers to the reasoning habits test at number 2 by subjects with low categories.

The first stage of reasoning habits is to analyzing the problem. It can be seen in Figure 4 that S3 has not been able to identify the problem, because S3 has not been complete in writing down the information that is known and asked, and has not been able to write and explain well the plan to solve the problem that will be used. S3 subjects use the formula for the volume of the cuboid directly, namely by multiplying the length, width, and height of the bath.

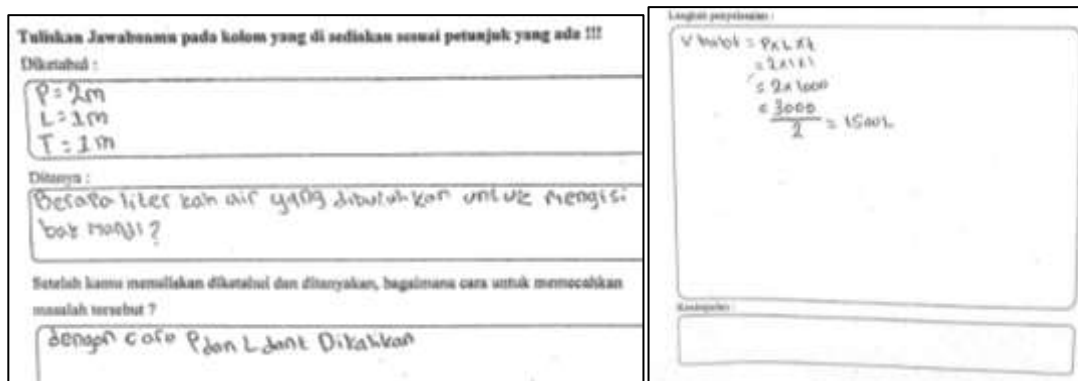


Figure 4. S3 reasoning habits test solutions

S3 has not been able to fulfill the stages of implementing the strategy, because S3 is still wrong in the calculation and planning process carried out. S3 also does not fully understand what plans will be made to solve the problems given. Based on the results of the interviews, it was shown that S3 was still confused about the completion steps they were working on, resulting in incorrect answers. This is probably because he was incomplete in writing down information at the stage of analyzing the problem, thus causing the next stage to produce inaccurate answers.

At the stage of finding and connecting between mathematical contexts, S3 has not been able to fulfill it well. S3 does not know at all other mathematical concepts related to the given problem. Based on the results of the interview, the doctoral subject has not been able to determine other mathematical concepts related to the questions given. S3 also have not been able to make decisions to conclude. This is possible because he did not understand well the problems presented, and did not understand the mathematical concepts in the material of building cubes and cuboids, resulting in the wrong answer.

The last stage, S3 has not been able to reflect on the solution. The S3 subject could not answer at all what the final conclusion was. This is because S3 still finds it difficult to identify the given problem, so S3 cannot solve the given problem.

The results of the research can be presented with findings related to students' reasoning habits through realistic math problems as shown in Figure 5.

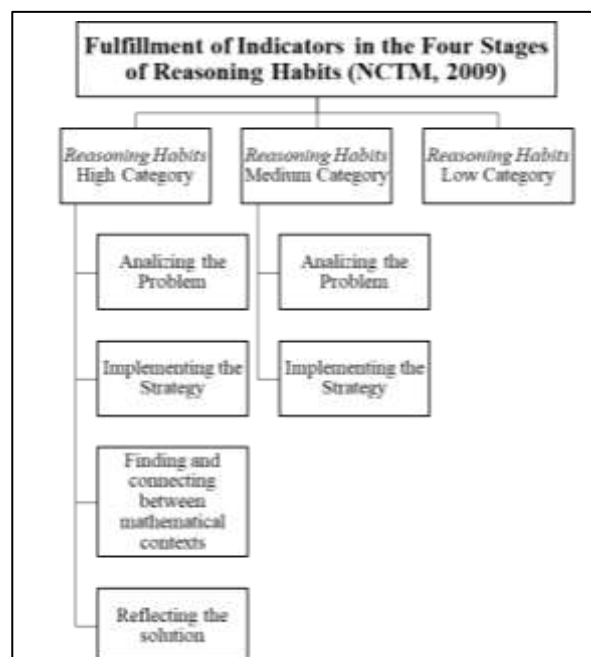


Figure 5. Findings

2. Discussion

Based on the result in the previous description, S1 can fulfill the 4 stages of reasoning habits well. Students with high-category reasoning habits can fulfill the four stages of reasoning habits correctly and completely, namely analyzing problems, implementing strategies, finding and connecting between mathematical contexts, and reflecting on solutions. This is following Safitri (2018) that students who have good thinking habits, then these students can understand the problems found in each lesson well. Raharjo et al. (2020) found that students with high reasoning can identify problems by providing information about known and asked information from the questions, and can make assumptions correctly to solve problems so that students with high reasoning categories can master the four indicators of mathematical reasoning. In line with Hidayati & Widodo (2019), students who have high mathematical reasoning can construct valid arguments using systematic steps.

Students with reasoning habits in the medium category were able to fulfill two stages of reasoning habits, namely at the stage of analyzing problems and implementing strategies, while the other 2 stages of reasoning habits still did not meet. This is following the results of research from Saragih (2020) that students with moderate reasoning can fulfill 2 reasoning indicators from the 4 reasoning indicators analyzed. But not in line with Oktaviana & Aini (2021) who state that students with moderate mathematical reasoning can write and explain what is known and asked correctly. Then the completion steps are still not quite right because of a few mistakes and a lack of understanding in understanding the statements in the questions. Also ended up with the wrong conclusion.

Furthermore, the findings related to students in the moderate category were supported by Nurhayati et al. (2013) that students with moderate mathematical reasoning can write down systematic work steps correctly. Students with moderate mathematical reasoning can find patterns to make generalizations (Afinnas & Kurniasih, 2018). Raharjo et al. (2020) confirm that students with moderate reasoning can identify problems, but are incomplete in providing information at the conclusion. Similarly, Saragih (2020) states that students with moderate mathematical reasoning are quite good at concluding, but are less precise in explaining the reasons for the conclusions obtained.

Students with reasoning habits in the low category are not able to fulfill the four stages of mathematical reasoning skills, namely analyzing problems, applying strategies, finding and connecting between mathematical contexts, and reflecting on solutions. According to research from Ardhiyanti et al. (2019) that students with low mathematical reasoning cannot predict how to solve it because they cannot organize information so they cannot solve problems. The findings in this study by Nurhayati et al. (2013) that subjects with low mathematical reasoning cannot make arguments in answering questions and in compiling the steps for working on questions the subject cannot continue their answers. In addition, it is also in line with Ardhiyanti et al. (2019) that students with low mathematical reasoning are not able to draw logical conclusions and provide appropriate reasons for the completion step. Ario (2015) states that students' lack of understanding of mathematical concepts causes students to have difficulty checking the truth of arguments. So a good understanding of concepts is needed in solving mathematical problems..

D. Conclusion

Based on the results and discussion, it can be concluded that students with reasoning habits in the high-category can answer reasoning questions based on realistic math problems. They fulfill the four stages of reasoning habits, namely analyzing problems, applying strategies, finding and connecting between mathematical contexts, and reflecting on solutions. Students with reasoning habits in the moderate category can answer reasoning questions based on realistic mathematical problems correctly but at the stage of finding and connecting between mathematical contexts, and reflecting on solutions, they are still a bit lacking, because they have not been able to determine other mathematical concepts and have not checked the correctness of each step taken. Students with low-category reasoning habits are not able to fulfill the reasoning habit stages at all. Students with low-category reasoning habits in answering reasoning questions based on realistic math

problems are still wrong because they still find it difficult to analyze problems so they are not able to apply strategies, find and connect between mathematical contexts, and reflect on solutions.

The results showed that in the reasoning habits stage through realistic math problems, the problem analysis stage had a very important role in understanding the given realistic math problems. The stages of analyzing problems relate to students' understanding of mathematical concepts, so in this case, the teacher should emphasize learning to improve students' understanding of concepts. One of the lessons that emphasize understanding students' concepts is PMR (Realistic Mathematics Education), and PBL (Problem Based Learning) or problem-based learning. This learning model requires students to form a problem into an abstract mathematical model so that student's understanding of mathematical concepts will increase. The importance of students' reasoning habits in solving realistic math problems. The results of this study are expected to provide an overview of students' mathematical reasoning habits in solving realistic mathematical problems. Researchers provide recommendations for further researchers who are expected to change the criteria of the research subject under study, for example, the reasoning habits of students in terms of learning styles or gender differences.

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