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Analyzing students' mathematical reasoning from the perspective of learning interest

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Abstrak Dalam pembelajaran matematika, banyak ditemukan siswa kurang mampu memahami dan mengaitkan informasi dari soal dengan konsep matematika yang dibutuhkan untuk menyelesaikan soal yang diberikan. Hal ini mungkin berkaitan dengan kemampuan penalaran matematis dan penalaran matematika bisa saja dipengaruhi oleh minat belajar siswa. Penelitian ini berujuan mendeskripsikan kemampuan penalaran matematis siswa berdasarkan perbedaan minat belajar siswa. Untuk mencapai tujuan tersebut, studi kasus digunakan. Penelitian ini melibatkan enam siswa dengan minat belajar tinggi, sedang, dan rendah yang diketahui melalui angket minat belajar. Data dikumpulkan melalui tes dan wawancara kemudian dianalisis secara kualitatif dengan merujuk pada langkah pemecahan masalah yang diintegrasikan dengan indikator penalaran. Hasil penelitian menunjukkan perbedaan pencapaian indikator penalaran matematis oleh siswa dengan tingkat minat belajar berbeda; semakin tinggi minat belajar siswa, lebih banyak indikator penalaran matematis yang dipenuhi. Hal ini menunjukkan minat belajar dan kemampuan penalaran matematis berkaitan.

Kata kunci *Penalaran matematis, Minat belajar, Studi kasus*

Abstract In mathematics teaching and learning, most of the students are not yet able to understand and connect given problems or tasks with mathematics concepts or ideas required to solve the problem. This might relate to their reasoning ability and this ability is likely to be affected by their learning interest. The objective of this study is to describe students' mathematical reasoning based on different learning interests, involving six secondary students with high, medium, and low levels of learning interests, which were identified through a learning interest questionnaire. Data was collected through a reasoning test and interviews. It was qualitatively analyzed by referring to problem-solving stages integrated with aspects of mathematical reasoning. The result shows the different achievements of mathematical reasoning indicators by students who have distinct levels of learning interest; the higher the learning interest students have, the more indicators of reasoning they have. This indicates that students' learning interest relates to their mathematical reasoning ability.

Keywords *Mathematical reasoning, Learning interest, Case study*

Introduction

Mathematical reasoning has a critical role in supporting students' skills to solve a problem, especially non-routine problems (Suparman et al., 2021). Development of problem-solving skills in learning mathematics can be trained with mathematical reasoning. Ball and Bass (2003) explain three central roles that reasoning plays in teaching and learning mathematics: first, it is a basic skill to understand meaningful mathematics; second, it is a basis for using mathematics; and third, it becomes a basis for reconstructing knowledge. Some studies (Aprilianti & Zhanty,

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2019; Sihombing et al., 2021) show that during the Covid-19 pandemic, 60% of students reasoning was in a low category. This was influenced by the decline in student learning interest during online learning (Yunitasari & Hanifah, 2020). Therefore, there might be a correlation between students' mathematical reasoning and learning interests.

Several factors affect students' mathematical reasoning, one of which is interest in learning (Yuliani, 2021). Matrona (2016) explains that learning interest is a feeling of liking, a student's interest in learning activities shown through enthusiasm, participation, and activeness in learning and realizing the importance of these activities to obtain a change in students whether in the form of knowledge or other aspects including attitudes. Students with high learning interests will be more likely to thrive in learning than those who are less interested. The student with less interest is indicated by attitudes that tend to pay less attention to ongoing learning so that learning objectives are not achieved (Oktavia et al., 2020). In a quantitative study, Kadarisma et al. (2019) found that there is a positive correlation between learning interest and mathematical reasoning, where the determination coefficient of the relationship is 0.77. This indicates that students' achievement in mathematical reasoning is mostly influenced by learning interests. To further understand the relationship, this research aims to identify students' mathematical reasoning based on their different levels of learning interest qualitatively. It is expected to extend our understanding of the nature of how they relate each other in a specific mathematics content used in this research.

Mathematical Reasoning Ability

In the literature, the reasoning is often defined as a skill of high deductive-logical quality (Lithner, 2003), which closely associate with the goal of mathematics teaching and learning (Jeannotte & Kieran, 2017; Kaur & Toh, 2012). Moreover, it is a thought process carried out by a person as a way to obtain a conclusion (Gil & Ben-Zvi, 2011). In a similar fashion, reasoning is an activity or thought process that helps students to draw conclusions or make new statements, and build new ideas based on previous statements or proven truths (Niss & Højgaard, 2019). Drawing from the idea of what mathematical reasoning means and referring to Hendriana et al., (2017), this study formulated indicators of mathematical reasoning depicted in Table 1.

Table 1. The indicator and description of mathematical reasoning

Indicator	Description
Presenting mathematical statements orally, in writing, with diagrams, and/or pictures.	○ Identify and write existing information (what is known and asked) in given problems or tasks. ○ Present the information through related representations
Making a conjecture.	○ Make a plan to solve problems.
Performing mathematical manipulation.	○ Connect prior knowledge/information with planned solution steps or actions. ○ Using the formula with correct steps.
Compiling evidence and providing reasons for the solution.	○ Solve the problem with the selected solution step or actions. ○ Make justifications for the solution.
Making a conclusion.	○ Conclude the answer to the given problem or task.
Checking the validity of the conclusion.	○ Examine the suitability of the steps and the answers

Mathematical reasoning is an important topic in mathematics education. Mathematics and reasoning are interrelated. Mathematics topics are understood through reasoning, where reasoning is seen as a learning process itself, and where the learner constructs knowledge through reasoning (Kilpatrick et al., 2003). Meanwhile, reasoning is developed through learning mathematics. Therefore, mathematical reasoning is critical in solving mathematical problems.

Learning Interest

In the context of learning, learning interest is defined as the state of engaging students in learning mathematics while enjoying the learning process (DeLay et al., 2016; Wong & Wong, 2019). Furthermore, Emefa et al. (2020) define it as a psychological state that occurs during the interaction between a student and a specific topic or activity, including the process of formation of the will, attention, concentration, and positive feelings toward a specific topic or activity. This study considers interest as students being confident and free in social interactions in learning mathematics while showing they like and enjoy the learning process.

One aspect of psychology that can encourage students to achieve certain goals in learning is learning interest. Someone who has an interest in an object tends to pay more attention to that object (Dewey, 1975). When students have strong interests, they relatively have high self-efficacy and have more attention, have goals, and use strategies in discipline than students with less interest (Preiss & Sternberg, 2010). Likewise, students' interest in mathematics is an essential factor in determining the success of learning mathematics. It is considered as an important trigger for motivation. Therefore, before a student is motivated to learn, they must first be interested. In their study, Toli and Kallery (2021) provide traits of interest: heightened attention, effort, impact, and experience. They use a developmental model to increase students' interest in learning science. The results show a significant positive correlation between student learning outcomes and interest in learning the subject. In this study, students' interests in learning was categorized as high, medium, and low to see its connection to mathematical reasoning ability. Indicators of learning interest used to develop the questionnaire are the enjoyment of learning, interest in learning, learning attention, and involvement in learning (Friantini & Winata, 2019).

Methods

This study followed a case study as part of a qualitative approach (Merriam & Tisdell, 2015). A case study is an approach that examines a specific phenomenon in greater depth (Creswell, 1998). In this case, this study focused on how students' learning interests relate to their mathematical reasoning.

Participants in this study were thirty secondary students. The selection of the student used purposive sampling following the nature of the case study and the aim of the research. The students were given a 15-item learning interest questionnaire (Table 2). The result of the questionnaire was categorized as three different levels of learning interest (low, medium, and high): 15 students were in a high-interest level, 11 students were at a medium level, and 4 students had low interests level.

After administering the questionnaire, a test comprising two problems was given to determine students' mathematical reasoning in solving problems. The results of the questionnaire and test were analysed and two students were selected for each category for semi-structured interviews. It was conducted to further analyze students' mathematical reasoning and its connection to learning interests. The interview was conducted lasting 30-60 minutes per student. Questions given to the student were, for example, how do you understand the problem? Explain! or what steps did you use to solve the problem? The interview and test data were analyzed through deduction coding (Miles et al., 2018) to understand students' performance in mathematical reasoning. The performance then was related to students' learning interest to draw a conclusion, which is in the form of a summary table and narration.

The percentage of fashion show contestants with their favorite colors is shown in the table below. Determine the percentage of participants who like both red and green!

Color	Percentage
Red	75%
Green	30%
Other colors	10%

Table 2. Sample items used in the questionnaire.

Indicator	Items
Enjoyment of learning	I am happy when I take part in mathematics learning activities
Interest in learning	I read the topic first before studying at school
Learning attention	I pay attention to the teacher when participating in learning activities.
Involvement in learning	I actively participate in learning activities

Results

The following is a description of students' mathematical reasoning in solving problems based on their level of learning interest.

Students' mathematics reasoning with a high level of learning interest

Figure 1 indicates that students were able to answer the question well. They could write down what was known and asked in the question correctly, use notations or symbols and describe the Venn diagram based on the information obtained from the question, and apply mathematical formulas or ideas. Moreover, they performed mathematical manipulations and calculation steps properly and correctly. At the end of the work, they came to a conclusion to the problem-solving. This finding was supported by the result of interviews. The following excerpt of the interview shows how the student justifies his steps in solving the problem.

P : *What steps did you use to solve the problem?*

S_1 : *I solved this problem using the formula I wrote down. In the red color array, the combination of red and green is replaced by 75%-x plus 30%-x plus x and added to those who do not like both, namely 10%. 75%-x are those who only like red, 30%-x are those who only like green.*

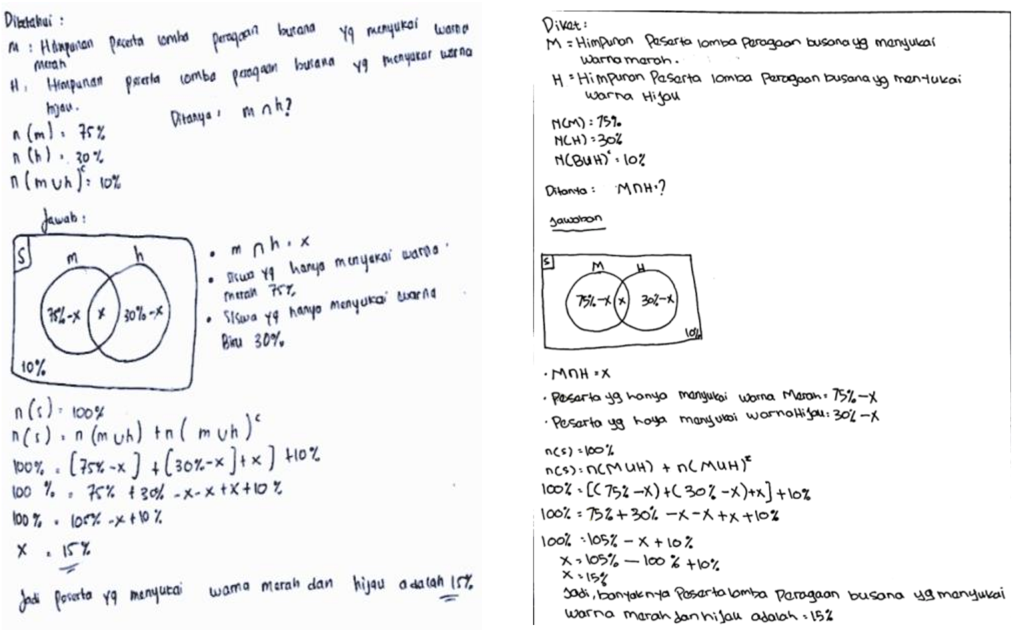

Figure 1. The answer to the first question of students with a high level of learning interest

Figure 2 shows that students could write down what was known and asked, use notations or symbols and draw Venn diagrams based. However, they did not write down the formula or work plan but immediately went through the completion steps. At last, they had the conclusion.

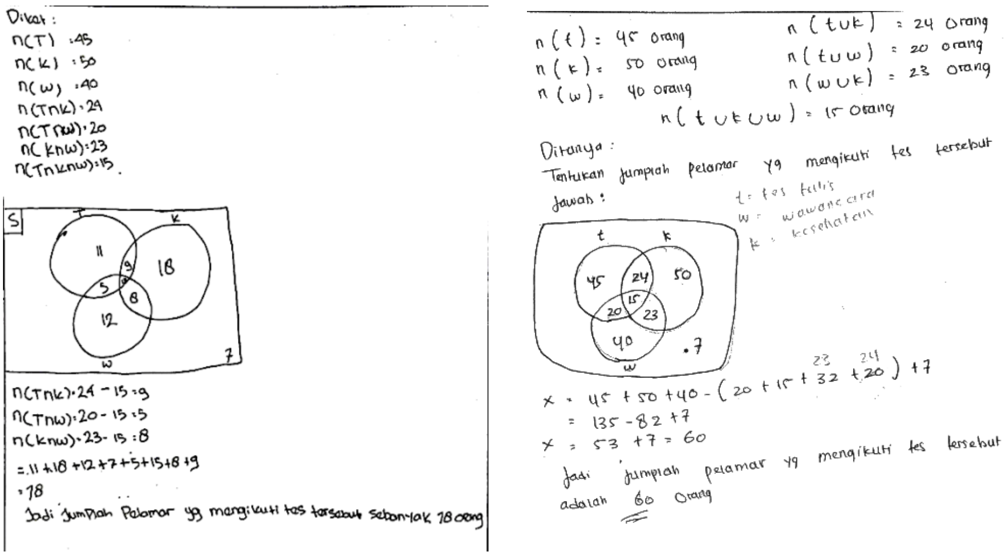

Figure 2. The answer to the second question of students with a high level of interest

P	:	*On the Venn diagram and given information, you wrote down that those who passed the medical test and interview were 23 people, then those who passed the written and health test were 24. Then which one was correct?*
S_1	:	*Oh, I was wrong. It should be 23 and 24 (Seeing his counting again). So, the number of people who took the test is 75 people.*

Referring to the interview, the student immediately completed the solution without writing the formula or mathematical idea first. In this step, he made a mistake in writing the number according to the given information. He was aware of his mistake and tried to correct it. However, the result obtained was still incorrect because the step was also yet correct. He did not perform mathematical manipulation but could provide reasons and evidence in the process. Then, he drew a conclusion based on the obtained answer. This suggests that, although having an error in the manipulation process, the student is considered to have fulfilled most of the mathematical reasoning indicators.

Students' mathematics reasoning with a medium level of learning interest

As seen in Figure 3, students could identify what was known and asked, either use symbols or draw a Venn diagram, work on the plan, utilize the formula, and draw a conclusion. We confirmed some aspects of their answers in the interview as illustrated in the excerpt of the interview, for example, the use of notation.

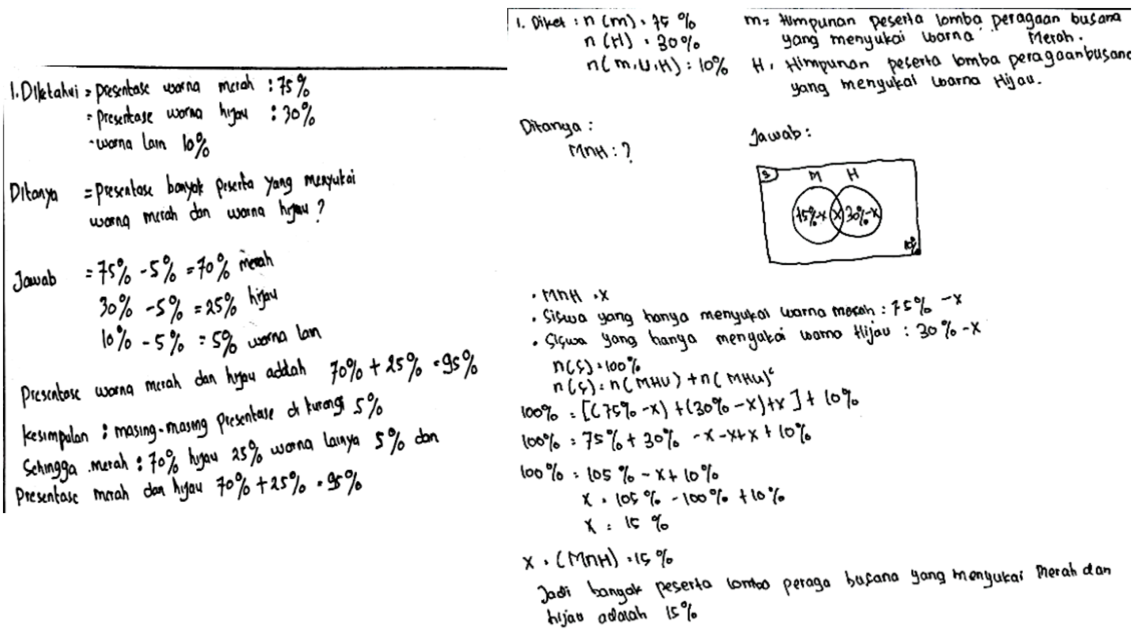

Figure 3. The answer to the first question by students with a medium level of learning interest

P : *Can you write symbols and notations based on the given information from the problem? If yes, please explain!*

S_2 : *Yes, I can. n(M) is the number of percentages that like red. n(H) is the number of percentages that like green and n(MH) is the number of percentages that like other colors.*

Both students could write what was known and asked in the problem. One drew a Venn diagram, but traces of work that have been removed were visible (Figure 4). This indicates that the student was still hesitant in drawing it. Then, he could not write the formula but plan a solution and do completion steps. At the end of the work, he had a conclusion.

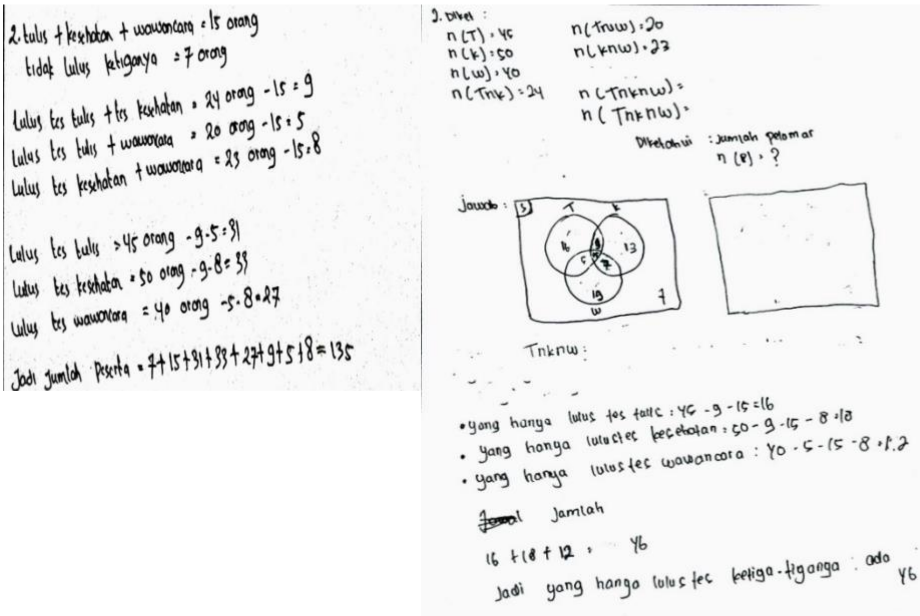

Figure 4. The answer to the second question by students with a medium level of learning interest

P	:	*What steps did you use to solve this problem?*
S_3	:	*Those who only passed the written test were equal to 45-9-15=16, those who only passed the medical test were equal to 50-9-15-8=18, and those who only passed the interview test were equal to 40-5-15-8=12. The number of applicants is 16+18+12=46.*

The interview excerpt shows that one of the students could not write symbols or notations because he did not understand. Furthermore, he could not describe the Venn diagram because he did not know either how. Then, he immediately completed the work by submitting a completion plan. However, the steps written were still incorrect. Thus, the answer obtained was also incorrect.

Students' mathematics reasoning with a low level of interest

Based on Figure 5, the student wrote the information contained in the problem- what was known and asked. However, another student did not write symbols and draw a Venn diagram as shown in the interview. Both students did not write the formula or the solution plan. At the end of the work, one student did not have conclusions.

P	:	*Can you use symbols or notations based on the given information from the problem? If yes, please explain!*
S_5	:	*No, I cannot.*
P	:	*Why not?*
S_5	:	*I do not know.*

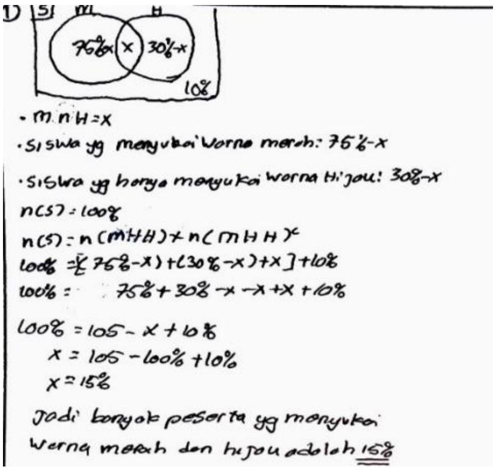

Figure 5. A low-learning interest student's answer for the first problem

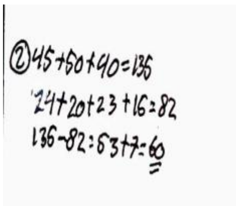

Figure 6. A low-learning interest student's answer for the second problem

Overall, both students in this category of learning interest did not fulfill most of the mathematical reasoning indicators. Figure 6 shows one of the students' answers. They did not have a work plan as is evident in the following interview.

P : *What formula or mathematical idea will you use to solve the problem?*
S_5 : *I do have any idea.*

Findings and Discussion

Table 3 presents a summary of the finding of the current study. Overall, the higher the level of learning interest students have, the more students fulfill the mathematical reasoning indicator. For example, students with a low level of learning interest (H1, H2) fulfilled two different indicators of mathematical reasoning. This study could be a qualitative standpoint to understand the relationship between learning interest and mathematical reasoning, which complement prior quantitative research on the topic (for example, Kadarisma et al., 2019).

Learning is a social, cultural, and internal as well as external process (Shuell, 1996). Internal factors include physical and spiritual conditions, while external factors are environmental conditions around students. Examples of internal factors that affect student learning include attitudes, talents, motivation, intelligence (mathematical reasoning), and interests. Mathematical reasoning is very crucial in supporting students' learning activities (Hjelte et al., 2020). It is influenced by students' interest in learning mathematics and vice versa (Kadarisma et al., 2019). Thus, interest in learning and mathematical reasoning abilities are interrelated as the finding of the study suggests. Another study also reveals that there are differences in mathematical reasoning abilities between students who have different interests in learning (Yuliani, 2021).

Referring to the relationship between learning interest and mathematical reasoning as it is evident in the current study and other studies (for example, Kadarisma et al., 2019), supporting students affective aspect of students' learning such as learning interest is crucial. This could be done through a rich learning design that employs various learning contexts, strategies, and tools. For example, providing students with contextual problems that are familiar and challenging supported by the use of technological tools, such as mobile applications to explore the problem is more likely to elevate students' learning interest and facilitate their reasoning than only asking them to solve problems on paper.

Table 3. The summary of students' performances in mathematical reasoning

Indicator of mathematical reasoning	Level of learning interest					
	H1	H2	M1	M2	L1	L2
Presenting mathematical statements orally, in writing, with diagrams, and/or pictures.	✓	✓	✓	✓	✓	✓
Making a conjecture.		✓				
Performing mathematical manipulation.	✓		✓	✓	✓	
Compiling evidence and providing reasons for the solution.	✓	✓	✓	✓		✓
Making a conclusion.	✓	✓	✓	✓		
Checking the validity of the conclusion.	✓	✓				

Conclusion

This study found that there is a difference in students' fulfillment of mathematical reasoning indicators based on their level of learning interest. Indeed, the higher the level of students' learning interest, the more they accomplish indicators of mathematical reasoning. For instance, students with a high level of learning interest are able to apply five of the six indicators of mathematical reasoning to solve the given problem. Albeit having similar number of accomplished indicators, they have distinct aspects of mathematical reasoning. For example, one student could not make a conjecture while another student was not able to perform mathematical manipulation correctly. This is similar to students with a low level of learning interest. However, students with a medium level of learning interest fulfilled the same indicators. Therefore, students' mathematical reasoning within the same level of learning interest could operate differently.

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