

Students' Mathematical Reasoning Ability in Data Presentation and Processing Material Reviewed from Gender

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Abstract

Purpose: The objectives of this study are twofold. 1) To describe the mathematical reasoning abilities of male students, 2) To describe the mathematical reasoning abilities of students.

Methodology: The type and design of the research in this article are qualitative ethnography. The subjects of this study were the principal, teachers, and 23 fifth grade students of Muhammadiyah Elementary School 1 Surakarta. Data collection techniques through interviews, observations, and documentation from test result archives. The data analysis process goes through the stage of data collection from several sources, namely the principal, teachers, students, and supporting documentation. The validity of the data in this study uses triangulation of sources and methods.

Results: The results of the research in this article are two. 1) Male students with high category mathematical reasoning ability meet indicators 1, 2, and 3, the medium category meet indicators 1 and 3, and the low category only meet indicator 1. 2) Female students with high category mathematical reasoning ability meet all five indicators, the medium category meet indicators 1, 3, 4 and 5, and the low category only meet one indicator, namely the first indicator.

Applications/Originality/Value: The findings provide valuable insights for teachers to design differentiated learning strategies that consider gender-specific patterns in mathematical reasoning abilities, supporting more effective development of students' critical thinking skills

Introduction

21st century education is now marked by the need to provide educational experiences to meet 21st century learning competencies. According to (Mukuka et al., 2023) Mathematical reasoning as one of the skills that has an essential contribution to children's cognitive development. This means that it allows students to reason logically when solving problems. According to Mata-Pereira and da Ponte (Mata-Pereira & da Ponte, 2017) Mathematical reasoning is a way of thinking that allows students to be able to make maximum efforts in learning concepts, properties, and procedures as logical, interrelated, and coherent aspects of mathematics. Students are given the opportunity to be able to explore in the problem-solving process. The goal of mathematics education in the 21st century has changed from simply teaching individuals to apply mathematical rules to teaching them how to apply knowledge as a solution to solving problems, transferring skills, and developing strategies. In line with (Australian Curriculum and Assessment Reporting Authority) mathematical reasoning is not limited to processes that describe mathematical thinking but includes strategies for learning mathematics.

Reasoning ability is part of the skills that students must master carefully (Saleh et al., 2018). Based on the results of previous research in Africa, several efforts have been implemented to develop practice-based mathematical reasoning skills, including involving students in solving challenging problems, creating mathematical models, examining mathematical structures, using various representations, and collaboration (Davidson et al., 2019). In line with the curriculum in Australia, in learning activities students explain their thoughts, then conclude based on logical thinking, transmit learning knowledge from one context to another, compare and criticize their decisions (Australian Curriculum and Assessment Reporting Authority). This shows the involvement of students in mathematical reasoning that leads to increased conceptual understanding. In Switzerland, the standard for students at the end of primary school education (grade six) is able to have reasoning skills to verify statements based on data (Smit et al., 2023). This means that a student must be able to justify whether a mathematical claim is stated to be true in general or true only under certain conditions.

The facts show that there are obstacles in schools, namely that students have difficulty understanding the questions given by teachers (Mediyani & Mahtuum, 2020). Referring to PISA data in 2018, Indonesia's score did not show

any significant development, which was always below 400 (Patriana, 2021). Apart from the survey conducted by PISA, it is also conducted by the TIMSS institute which is held every four years (Latif et al., 2022). The results of the 2015 survey showed that Indonesia was in the bottom 10 with a score of 397 below the international average score of 500 (Hadi & Novaliyosi, 2019). In general, in Indonesia, the cognitive level of students at the theory stage is only 17%, lower than in Singapore, Malaysia and Thailand (Rosnawati, 2013). This means that the level of mathematical reasoning of students in Indonesia is still very worrying. In line with the data from teacher interviews at Muhammadiyah Elementary School 1 Surakarta which stated that the mathematical reasoning ability of 23 students was classified as low to moderate. Referring to the existing obstacles, it can be concluded that education in Indonesia really needs system improvements, especially in the aspect of mathematical reasoning.

Another factor in students' low mathematical reasoning abilities is gender differences (Prajono et al., 2021). Men and women have different learning performance orientations. This is reinforced by Gender differences are one of the main factors that influence mathematics performance, this has attracted a lot of attention from researchers. Research result di Amerika Serikat concluded that of the 43% of girls taking the American Mathematics Competitions (AMC) test, boys were six times more likely to achieve top scores (Lubienski, 2020). This means that girls' mathematical reasoning ability is considered lower than boys. This is in contrast to research findings in Southeast America, which show that girls have greater ability to visualize various objects, so they have superior mathematical reasoning than boys (Mainali, 2019). In line with the results of research in Türkiye which stated that in the research, women obtained an average problem solving score that significantly exceeded men (Çakır, 2017). This is certainly closely related to mathematical reasoning ability, so it can be concluded that girls have better mathematical reasoning ability than boys in Turkey. On the other hand, in research in England there is only a little or almost no significant difference between mathematical reasoning and gender differences of students (Gallagher & Kaufman, 2004).

Referring to several previous literatures, the researcher conducted this study with the aim of 1) Describing the mathematical reasoning abilities of male students, 2) Describing the mathematical reasoning abilities of female students. The materials applied in this study are data presentation and processing (mean, median, mode) because the material is closely related to the mathematical reasoning process in the form of tables, graphs, story problems, and number sequences.

Research methods

This research is a qualitative research with an ethnographic approach. Qualitative research methods are used to study and describe a phenomenon in terms of understanding the meaning, interpretation, and social context of the data (Sutama et al., 2022). Ethnographic design is an approach to interpreting an activity that students face and that we want to understand systematically through direct observation and interaction with research subjects (Sutama et al., 2020). This research was conducted at SD Muhammadiyah 1 Surakarta. The subjects of the research were the principal, a fifth grade mathematics teacher. The respondents in this study were 23 students consisting of 10 boys and 13 girls. All respondents were given a mathematics problem which was a mathematical reasoning ability test instrument in the form of two descriptive questions with the topic of mean, median, and mode. After that, the results of the students' work were corrected until they met the indicators of mathematical reasoning. Then the students were divided into three categories of high, medium, and low mathematical reasoning abilities.

Data collection techniques with interviews, participant observation, and test result documents. Interviews were conducted to obtain in-depth information directly from the research subjects, the principal, grade V teachers, and students. Observations were conducted to observe the phenomena that occurred in the research subjects. Documents are needed to support the information obtained. Documents in the form of test instruments, test results, and other relevant documentation.

The validity of the data in this study uses triangulation of sources and methods. The data analysis technique uses an interactive flow method. The data analysis process goes through the stage of collecting data from several sources, namely the principal, teachers, students, and supporting documentation. Data reduction is carried out by correcting and assessing the test results which will then be considered to determine the subjects and interview guidelines. Furthermore, data presentation begins by presenting data in the form of student test results and in-depth interviews. Data verification aims to describe in more detail the data displayed and conclusions are drawn based on factual findings and then linked to the underlying theory.

Results and Discussion

The results of the mathematical reasoning ability test are assessed based on mathematical reasoning

indicators. Mathematical reasoning indicators consist of five stages. First, presenting statements orally and in writing. Second, using mathematical concepts. Third, compiling evidence of problem solutions. Fourth, drawing conclusions from problem solutions. Fifth, reviewing problem solutions, this is in line with the mathematical reasoning indicators.

The results of the mathematical reasoning ability test on the material of mean, median, mode are classified into 3 categories, namely high, medium, and low categories. This test is in the form of a mathematical reasoning ability assessment instrument consisting of 2 questions worked on by 28 students consisting of 13 boys and 15 girls. The results of the students' answers were then analyzed based on indicators of mathematical reasoning skills. The achievement of mathematical reasoning ability comes from the results of written tests worked on by students based on the scores obtained. The criteria for students' mathematical reasoning ability based on scores can be seen in table 1.

Table 1. The criteria for students' mathematical reasoning ability based on scores

No	Percentage of achievement of students' reasoning abilities	Categori
1.	> 70%	Tinggi
2.	55% ≥ 70%	Sedang
3.	≤ 55%	Rendah

The results of the mathematical reasoning ability test of students on the material mean, median, mode are presented in table 2 and table 3 below.

Table 2. Results of the mathematical reasoning ability test of students (male) after being sorted

No	Code	Score		Score Total	Max Score	Value	Category
		1	2				
1	LK4	8	10	18	20	90	High
2	LK8	8	10	18	20	90	High
3	LK7	10	7	17	20	85	High
4	LK5	8	7	15	20	75	Medium
5	LK2	10	5	15	20	75	Medium
6	LK9	9	5	14	20	70	Medium
7	LK3	8	5	13	20	65	Low
8	LK6	8	3	11	20	65	Low
9	LK10	3	5	8	20	40	Low
10.	LK1	3	5	8	20	40	Low

Based on table 2, the average result of the mathematical reasoning ability test of students (male) is 69.5.

Table 3. Results of the mathematical reasoning ability test of students (female) after being sorted

No.	Code	Score		Total Score	Max Score	Value	Category
		1	2				
1	PR8	10	10	20	20	100	High
2	PR5	10	10	20	20	100	High
3	PR6	10	9	19	20	95	High
4	PR1	10	8	18	20	90	High
5	PR10	10	8	18	20	90	High
6	PR9	10	8	18	20	90	High
7	PR2	10	5	15	20	75	Medium
8	PR3	10	5	15	20	75	Medium
9	PR7	8	7	15	20	75	Medium
10	PR13	8	3	11	20	55	Low
11	PR12	8	3	11	20	55	Low
12	PR4	5	3	8	20	40	Low
13	PR11	5	3	8	20	40	Low

Based on table 2, the average result of the mathematical reasoning ability test of students (female) was 75.3.

Based on tables 2 and 3, the results of the mathematical reasoning ability test on the material mean, media, mode. It was concluded that there were 3 male students with a high mathematical reasoning ability category. 3 medium category, and 4 low category. While there were 6 female students with a high category. 3 medium category, and 4 low category. Furthermore, in-depth interviews were conducted to explore the problems experienced by students more openly. Students were asked to convey problems, ideas and opinions related to the material eman, median, mode. In-depth interviews were conducted with 6 students consisting of 3 boys with high, medium, and low reasoning ability categories (LK4, LK5, LK1). Followed by 3 girls with high, medium, and low reasoning ability

categories (PR8, PR7, PR4).

Students' mathematical reasoning ability (Male)

Students with a high mathematical reasoning ability category can generally carry out several indicators. This is evidenced by the results of the tests given. They can work on test questions with the right steps and answers, although there are a few shortcomings. The following is one of the answer sheets for subject LK4 in working on test question no. 1 presented in Figure 1.

$D_1 = 75, 80, 85, 70, 90, 65, 95$
 $D_2 = \text{mean, median, modus}$
 $\rightarrow \text{mean} = \frac{75+80+85+70+90+65+90}{7}$
 $= 80$
 $\rightarrow \text{median} = 65, 70, 75, 80, 85, 90, 95$
 $= 80$
 $\rightarrow \text{modus} = \text{tidak ada}$

Figure 1. Answer Number 1 Subject LK4

Based on figure 1, it can be seen that (LK4) is able to understand the solution to both mathematical reasoning test questions. Overall, students with a high reasoning category can complete the test correctly based on the mathematical reasoning indicator, although it is not perfect. There are shortcomings in the fourth and fifth indicators. LK4 students do not rewrite the conclusions from the answer results. Based on the answer sheet test result document, it can be seen that LK4 students have achieved indicators 1, 2, and 3. Strengthened by the results of in-depth interviews that they understand the intent of the two questions presented. The first indicator, the subject is able to explain mathematical statements verbally and in writing. The second indicator, the subject is able to use the right mathematical concept in solving the test questions. The third indicator, the subject is able to compile evidence of the problem solution verbally. The fourth indicator, the subject is able to explain the conclusion of the question asked verbally, but in writing the subject tends to ignore rechecking the results of the answers obtained and the fifth indicator, the subject has not been able to review the problem solution optimally. This is because the subject tends to stop immediately when they have found the final answer they are looking for.

Students with moderate mathematical reasoning category are not as good as those with high mathematical reasoning category. This can be proven based on the document of mathematical reasoning test result and in-depth interview. Here is one of the test result of subject LK5 on question number 1 presented in figure 2.

$Dik = 75, 80, 85, 70, 90, 65, 95$
 $Dit = \text{Mean, Median, Modus?}$
 $\text{Jawab} =$
 $\text{Mean} = \frac{75+80+85+70+90+65+95}{7} = 80$
 $\text{Median} = 70$
 $\text{Modus} = -$

Figure 2. Answer Number 1 Subject LK5

Based on Figure 2, it can be seen that students (LK5) have completed the questions well even though the final answer obtained is not quite right. According to the answer sheet test result document, it can be seen that students LK5 are able to carry out indicators 1 and 3, but are less than perfect in indicators 2, 4, and 5. Strengthened by the results of the interview that in the first indicator, the subject is able to explain statements verbally and in writing. The second indicator, the subject is able to use the right mathematical concept in solving the test questions for the mean and mode sections, but is less than perfect in the median section because it is not sorted first so that errors occur. The third indicator, the subject is able to compile evidence of the solution to the problem. The fourth indicator, the subject is able to explain the conclusion of the question asked verbally, but in writing the subject

tends to ignore rechecking the results of the answers obtained. The fifth indicator, the subject has not been able to review the solution to the problem optimally. This is because the subject tends to stop immediately when they have found the final answer they are looking for.

Students with a low mathematical reasoning category are only able to meet indicator 1. This can be proven based on the document of mathematical reasoning test results and in-depth interviews. Here is one of the test results for subject LK11 on question number 1 presented in figure 3.

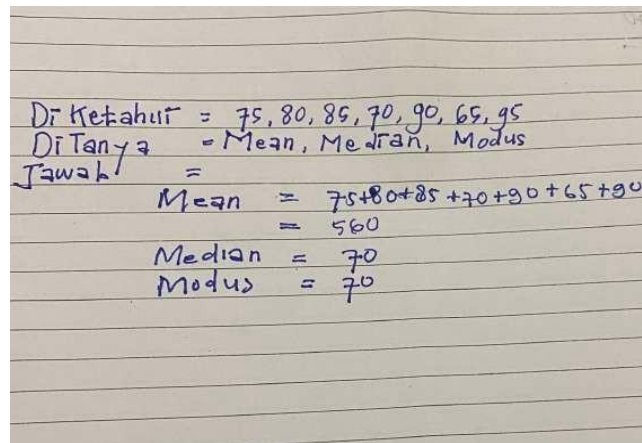


Figure 3. Answer Number 1 Subject LK1

Based on figure 3, it can be seen that students (LK1) cannot solve the problem smoothly. According to the answer sheet test result document, it can be seen that students LK1 seem to have a poor understanding of the concept of the problem and have difficulty in working on the questions presented. Strengthened by the results of in-depth interviews in the first indicator, the subject can write down known statements. The second indicator, the subject has not been able to use the right mathematical concept in solving the test questions. The third indicator, the subject has not been able to compile evidence of the right problem solution so that the subject cannot find the right final result of the questions given. The fourth indicator, the subject has not been able to explain the conclusion of the questions asked either verbally or in writing. The fifth indicator, the subject has not been able to review the problem solution optimally.

1. Students' mathematical reasoning ability (female)

Students with a high mathematical reasoning ability category are generally able to meet all five. This can be proven from the results of the tests they have completed. They can work on test questions with the right steps and answers according to the mathematical reasoning indicators, without any deficiencies. The following is one of the answer sheets for subject PR8 in working on test question no. 1 presented in Figure.

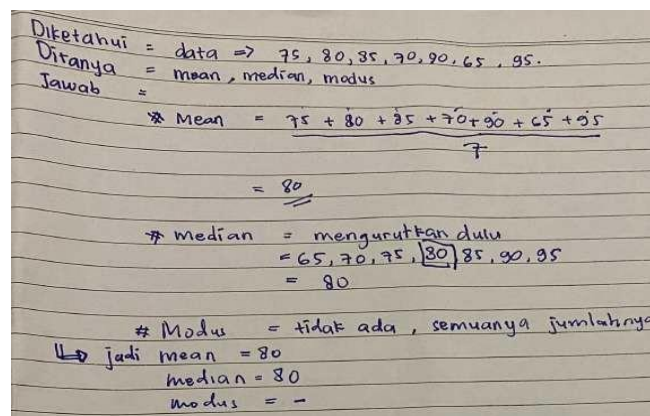


Figure 4. Answer Number 1 Subject PR8

Based on figure 4, students (PR8) are able to understand the solution to the problems given in the

mathematical reasoning test questions and can solve both questions. Overall, female students with a high reasoning category are able to solve the test questions given correctly based on the mathematical reasoning indicators perfectly. Based on the document and reinforced by the results of in-depth interviews with the results of the answer sheet test, PR8 has fulfilled the five indicators of mathematical reasoning.

Female students in the medium category are not as good as those in the high mathematical reasoning category. This can be proven based on the documents of the results of the mathematical reasoning test and in-depth interviews. The following is one of the answers of subject PR7 for the answer to question number 1 presented in Figure 5.

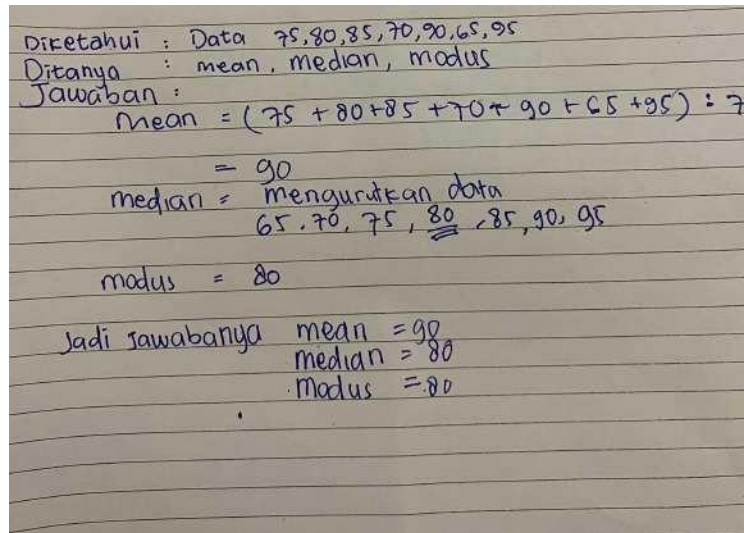


Figure 5. Answer Number 1 Subject PR7

Based on Figure 5, students (PR8) are able to understand the questions well even though the final answer obtained is not quite right on the mean and mode. According to the test result document of the answer sheet, it can be seen that PR8 has fulfilled indicators 1,3,4, and 5 but is not perfect on indicator 2. Strengthened by the results of the interview, the subject is able to explain the statement orally and in writing. The second indicator, the subject cannot use the right mathematical concept in the test questions on the mean and mode, so errors occur. The third indicator, the subject is able to compile evidence of the solution to the problem. The fourth indicator, the subject is able to explain the conclusion of the question asked orally and in writing. The fifth indicator, the subject has not been able to review the solution to the problem optimally.

The test results of female students with a low category, it appears that the subject is constrained when solving the problem given. The following are the results of subject PR4's answers to question number 1 presented in Figure 6.

Data = 75, 80, 85, 70, 90, 65, 95

* Mean = $\frac{75 + 80 + 85 + 70 + 90 + 65 + 95}{7} = 8$

* Median = 70

* Modus = -

Figure 6. Answer Number 1 Subject PR4

Based on Figure 3, it can be seen that students (PR4) have difficulty in completing the test questions. According to the test result document of the answer sheet, it can be seen that PR4 does not understand the concept of the problem and has difficulty in working on the questions presented. Strengthened by the results of in-depth interviews in the first Indicator, the subject can explain the statement in writing. The second indicator, they have not been able to use the right mathematical concept in solving the test questions. The third indicator, the subject has not been able to compile evidence of the right solution to the problem so that the subject cannot find the right final result. The fourth indicator, the subject has not been able to explain the conclusion of the question asked either verbally or in writing. The fifth indicator, the subject has not been able to review the problem solution optimally.

The results of this study support previous research by (Devi, 2019) which emphasized that women make fewer mistakes than men. In contrast, this study contradicts the results of previous studies by (Rosdiana et al., 2019) which showed that there were differences in male and female reasoning, at the stage of understanding problems, male reasoning abilities were better than females, this can be seen from the answers given by males in more detail than female answers. Overall, the results of this study complement the which discussed the differences in learning outcomes between male and female students at elementary school level. Overall, the results of this study support and strengthen the findings in previous studies. This study provides additional contributions in understanding students' mathematical reasoning in terms of gender in Elementary Schools.

Conclusion

Mathematical reasoning ability is categorized into 3 groups, namely high, medium, and low. The high category of male students meets indicators 1, 2, and 3 because they are less than perfect in indicators 4 and 5. The medium category of male students meets indicators 1, and 3 because they are less than perfect in indicators 2, 4 and 5. The low category of male students only meets indicator 1 and has not been able to meet the other indicators. Meanwhile, the high category of female students is able to meet all five indicators perfectly. The medium category of female students is able to meet indicators 1, 3, 4, and 5 but because they are perfect in indicator 2. The low category of female students only meets indicator 1 and has not been able to meet the other indicators. Based on the results of direct observation, in-depth interviews, and mathematical reasoning tests, it is concluded that female students at Muhammadiyah Elementary School Surakarta are superior in mathematical reasoning compared to male students.

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