Are Students' Critical Thinking Skills in Problem Solving Influenced by Gender?

Teguh Saryanto[1,*] Ikrar Pramudya[2] Sri Subanti[3]

[1] *Postgraduate of Mathematics Education, Faculty of Teacher Training and Education, Universitas Sebelas Maret Surakarta, Indonesia*
[2,3] *Faculty of Teacher Training and Education, Universitas Sebelas Maret Surakarta, Indonesia*
[*]*Corresponding author. Email:* teguhsaryanto@student.uns.ac.id

ABSTRACT

The Partnership for 21st Century Skills defines that critical thinking skills are one of the skills needed to prepare students in education and occupation. Students with a good level of critical thinking skills will solve problems with critical thinking steps, even though they are not perfect yet. This study aims to describe the eighth-grade student's mathematical critical thinking skills based on gender. This research was qualitative descriptive. The subject was 8th-grade junior high school students in Surakarta. However, this article presents the data merely from two male subjects and two female subjects as gender representatives. The instrument was validated by three experts. The instrument was researcher, critical thinking skills tests, interview guides. The data were validated through a triangulation method by comparing the data of test results and interviews. Data were analyzed through data reduction, data presentation, and concluding. As the conclusion of this study, male students master critical thinking indicators, i.e., in the determination of actions due to their accurate thinking. On the other hand, female students are mature in critical thinking indicators, i.e., in making conclusions due to their decent thinking process of seeing reality.

Keywords: *Critical thinking, Gender, Mathematics, Problem-solving.*

1. INTRODUCTION

Critical thinking is reasoning and reflective thinking by emphasizing decision making of what to believe or to do [1]. Essentially, critical thinking is an active process, where a person thinks deeply, asks questions, finds relevant information rather than passively waits for information [2]. Critical thinking is an ability that will influence a person as someone with the ability to think critically will have correct thinking in problem-solving [3]. Partnership for 21st Century Skills defines that critical thinking skills are one of the skills needed to prepare students for education and in the world of work [4]. Students with a good level of critical thinking will solve problems with critical thinking steps, especially on indicators of evaluation and conclusions with supporting evidence, even though the steps are not perfect [5].

Psychologically, men and women are different in which women are more interested in real-life problems, while men are more interested in abstract things [6]. In learning mathematics, the difference between men and women is that men are superior in reasoning, while women are superior in accuracy, precision, caution and attention [7]. In research on gender differences in mathematics education, most studies used standardized tests to compare the performance of male and female students. In America, the National Assessment of Educational Progress has been applied to compare the math abilities of male and female students [8].

The results of the literature review showed that in decision-making, students tend not to involve logical reasoning, hence they tend to produce wrong conclusions [9]. There is no interaction between learning factors and previous mathematical knowledge with an increase in critical thinking skills [10]. However, the student's curiosity factor has a significant effect on students' mathematical critical thinking skills. The performance of male students is better than female students in solving non-routine problems [11]. Junior high school students' mathematical critical thinking skills are low so that teachers need to facilitate them in learning to develop critical thinking skills [12].

Table 1. Activities and Indicators of Critical Thinking Skills

No	Activities	Indicators
1	Providing a simple explanation (practical)	Focusing the questions
		Analyzing questions
		Asking and responding to questions that require explanation
2	Building basic skills	Considering whether the source is trustworthy or not
		Observing and considering the result of observation
3	Concluding	Educating and considering the result of deduction
		Induction and considering the result of induction to come to the conclusion
		Creating and deciding the result of consideration
4	Beliefs	Defining terms and considering a definition and dimension
		Identifying assumptions
5	Action	Deciding an action
		Integrating with others

Critical thinking has 12 indicators which are grouped into five main activities [13] (Table 1).

This research only involved the aspects of concluding and action because they are more needed in contextual problem solving [14].

The results of the literature review showed that there is a research gap in expressing the critical thinking of male and female students in solving mathematical problems. This research is important to provide a theoretical contribution, especially in the aspect of decision-making.

2. METHODS

2.1. Design

This qualitative study used naturalistic and interpretive approaches related to the exploration of phenomena from within [15]. Qualitative study presents data without any manipulation [16]. The commonly used methods covered observation, interviews, and documentation [17]. This qualitative study aims to describe students' mathematical critical thinking skills based on gender.

2.2. Subjects

This research was conducted at SMP N 15 Surakarta, with a total of 64 students consisting of 36 male students is and 28 female students. The sampling employed is purposive method. Subjects are students who can implement critical thinking skills in problem-solving. In this paper, data was presented on two male subjects and two female subjects because their data represent the entire data.

2.3. Instrument

This study used a critical thinking test of flat-sided shapes materials. The instrument was validated by 3 expert lecturers from Mathematics Education with a doctoral education background. The expert suggested revising the redaction of the questions and correcting the answer keys and editing the images on the questions. The initial critical thinking skill test is presented in Figure 1.

Critical Thinking Skill Test

Information:

AB = BC = CD = DE

Question:

A cube is divided into 8 small cubes with the same volume. Identify the length of the small cube side of AB, AC, AD and BC?

Figure 1 Mathematical problems

2.4. Data Collection

Data were collected from tests, observation sheets, and in-depth interviews. The instrument was distributed to students via Google form. Then, the students did it on paper. After the test time was over, students were asked to take a picture of their work then send it via WhatsApp messenger. In-depth interviews were conducted through WhatsApp messenger. The data were validated through a triangulation method by comparing the data of test results and interviews.

2.5. Data Analysis

Data analysis was carried out in 3 stages, namely 1) data reduction, 2) data presentation, 3) concluding. Data reduction was to find important data needed in research. The presentation of data in qualitative research was in the form of a narrative text [18]. While the data deduction was done by taking the essence of the organized data presented in the form of short sentences but containing broad meaning.

3. RESULTS

The data observed in this study were in the results of the test and interviews. S-1 and S-2 were female subjects, while S-3 and S-4 are male subjects.

3.1. Subject S-1

S-1 is a female student. Figure 2 is S1's answer sheet. S1 rewrote the provided information in the question. S-1 answered question 1 by deducing information that the original cube can be divided into 8 small cubes by making a geometric picture as shown in the picture. S-1 viewed the large cube divided into 8 with 4 small cubes on the front side and 4 small cubes on the backside. Then, she concluded that length of the small cube side can be seen on the front side of the cube which is divided into four, in which AC is one side of the small cube.
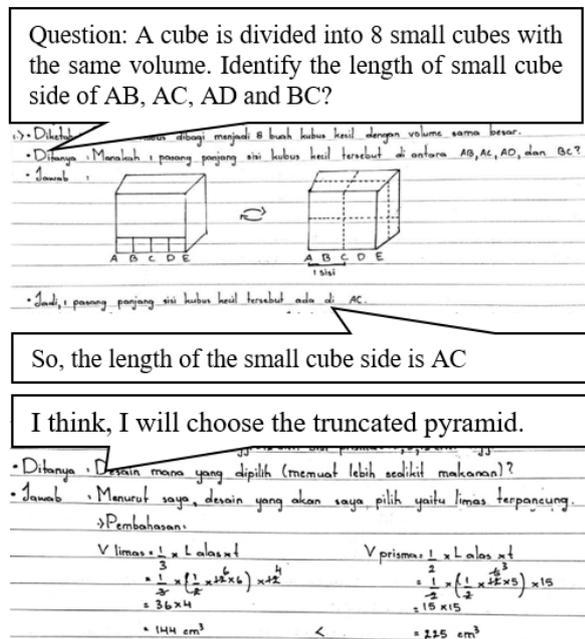
Figure 2 Answer sheet of subject S-1

Figure 2 is the answer sheet of S-1 subject for question 2 on the indicator of taking action. Subject S-1 rewrote the information provided in the questions. The action of the S-1 subject was to choose a pack of truncated pyramids (pack A) because the volume is smaller than the triangular prism (pack B). The packaging selection is in accordance with the expected goal, namely a smaller volume, but due to the wrong volume calculation, the packaging selection is incorrect. S-1 subject was good enough at memorizing the formulas for the volume of the pyramid and the volume of the prism, but she incorrectly chose the formula to determine the area of the pyramid base. The base of a rectangular pyramid should use the formula of $Area = s^2$, but the S-1 subject uses the formula for the $Are\ of\ triangle = \frac{1}{2}\ base\ x\ height$. She was still confused to determine the area of the pyramid base. Here is the author's interview with S-1;

> P : Why is the base area using that formula? What shaped base?
> S-1: Sorry sir, I didn't pay attention to the shape of the base.
> P : Because the base is square, how is the base area? why answered 12×6
> S-1: I forgot that the square side was the same, still confused.

3.2. Subjects S-2

S-2 subject is a female student. The S-2 subject rewrote what was understood from the question, and wrote what was asked briefly (Figure 3). The author asks S-2 why the answer to question no. 2 is AB and BC. Subject 2 answers: *"The cube is divided into 8 small cubes with equal volumes, then the cube must be cut into 4 pieces, and then each piece is cut into 2 pieces. Each of the 4-side length is equal to AB, BC, CD and DE. So, the 4 parts of the cube are divided into 2 parts and one pair of side lengths of the small cube is AB + BC = AC".*

The author asks subject 2, why the answer to the question no Can we understand that S-2 gives a reason, that to be 8 parts, the side of the front cube is cut into 4 equal parts (4 boxes), from 4 pieces of the box, divided into 2 parts by cutting the middle of the box, then the box is divided into two equally large cubes, so that it will form 8 pieces of the same large small cube. Then S-2 concluded that the small cube side obtained is a combination of AB and BC, then the side of the small cube is AB + BC = AC.

The S-2 subject tries to answer question number 2 by making calculations to find the volume of the two packages first. Her answer is correct in finding the volume of the pyramid before it was cut off, but she incorrectly found the volume of the package because she did not reduce the volume of the original pyramid with the volume of the lost pyramid. This subject did not precisely calculate the volume of the second package. In finding the area of the prism base, she incorrectly chose the length side of the triangle by placing the base and height of the triangle of 15 and 12, but the correct ones

were 5 and 12. The error in calculations caused her to incorrectly choose the action for question number 2.

So, design A is better because the volume is small and it can load less food.
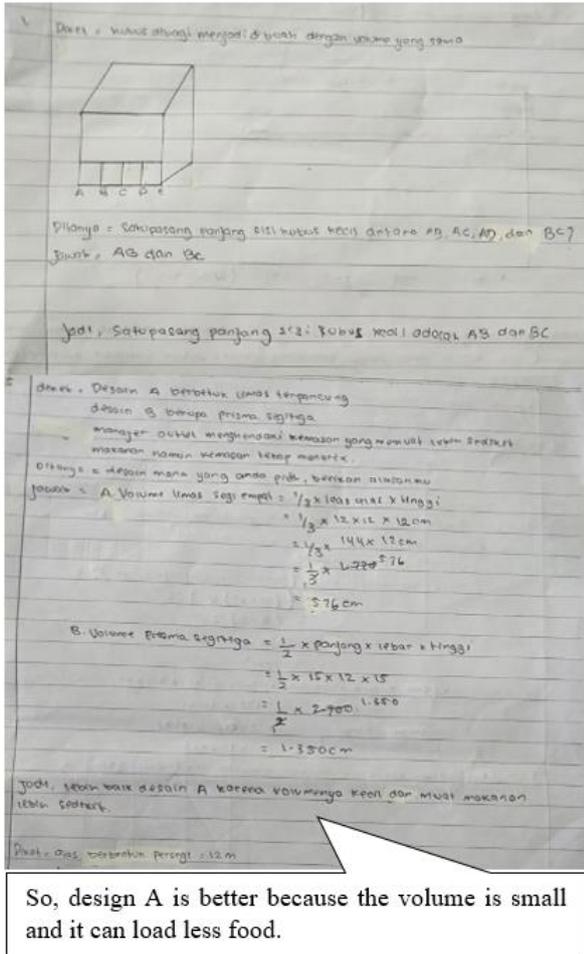
Figure 3 Answer sheet of subject S-2

3.3. Subject S-3

Subject S-3 is a male student. Based on Figure 4, he tries to answer question no.1 by redrawing the cube and dividing the front side of the cube by 4, and the right side of the cube by 4. The author asks why the answer to question no. 1 is AC. Subject 3 answers: *"Because if the cube above we make a sketch, it will look like the following (figure 3), so we can get the side of the small cube is AC"*.

He sees that the front side of the cube is the small cube of I, II, V, VI and the right-side cube is the small cube of III, IV, VII, VIII. Then he concludes that the side of the small cube is the same as AC. Even though his answer is correct, the picture as the basis for making the conclusion is incorrect. Based on the figure he made, cube II and cube III are the same cube, as well as cube VI and cube VII.

The S-3 subject is quite good at answering question number 2. He is careful enough to find the volume of a truncated pyramid, where he can find the volume of the package by finding the volume of a large pyramid (before

being cut off) minus the volume of the lost pyramid. He knew that $V_1 = \frac{1}{3} \times L \, a \times t = \frac{1}{3} \times 12 \times 12 \times 12 = 576$. and $V_2 = \frac{1}{3} \times L \, a \times t = \frac{1}{3} \times 6 \times 6 \times 6 = 72$. Thus, $V \, Truncated \, pyramid = 576 - 72 = 504$. He is also correct in doing mathematical calculations.

So, the outlet manager wants food design B which is like triangle prism because it loads less food than design A which is like an angular pyramid cut off.
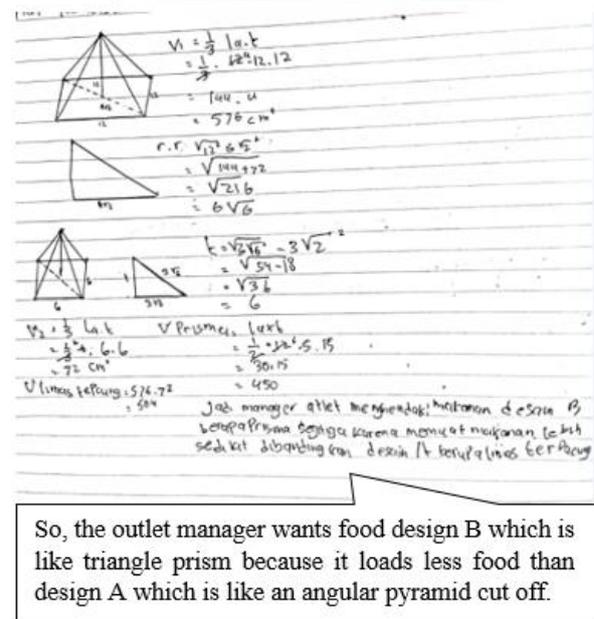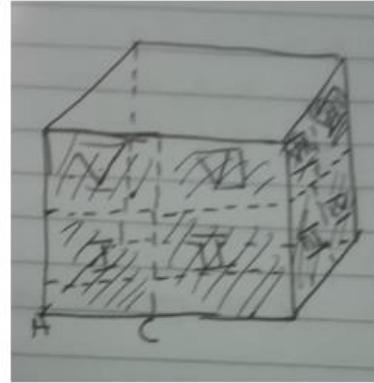
Figure 4 Answer sheet of subject S-3

3.4. Subject S-4

S-4 subject is a male student. Figure 5 is the answer sheet of Subject S-4. He did not rewrite the information provided in the questions but he used mathematical calculations by deducing information that the volume of the cube exemplified by $x^2=8$, so that the side of the cube is 2. The author asks S-4 about the correct answer $x^2=8$ or $x^3=8$. S-4 answers: *"$x^2=8$ sir"*. In this case, he understood the volume of the cube incorrectly where the volume of the cube should be exemplified by x^3, so that side of the cube is the root of 8, which is 2. He tried to conclude that the side of the small cube is AC obtained from the side of the original cube divided by two.

S-4 subject is quite good at answering question number 2. He is careful enough to find the volume of a truncated pyramid in which he considers the volume of a

large pyramid (before being cut off) with V_1 and the volume of the lost pyramid with V_2. He knew that $V_1 = \frac{1}{3} \times L\,a \times t = \frac{1}{3} \times 12 \times 12 \times 12 = 576$. And $V_2 = \frac{1}{3} \times L\,a \times t = \frac{1}{3} \times 6 \times 6 \times 6 = 72$ Thus, $V\ Truncated\ pyramid = 576 - 72 = 504$. He is also correct in performing the mathematical calculations.

Figure 5 Answer sheet of subject S-4

4. DISCUSSION

Subject S-1 tends to understand mathematical problems by seeing the concrete (reality) [19], where she answers question number 1 by seeing the cube as a real object, and does not make mathematical calculations to find the side length of the small cube. S-1 can answer questions well by relying on the precision and prudence that female students generally have[7]. She incorrectly identifies the volume of the prism in question 2. She also determines the formula incorrectly, which caused a miscalculation. She takes the wrong action for question 2 because she forgot the formula for finding the area of the base. In this case, S-3 have weaknesses in the accuracy of viewing mathematical problem [20].

The subject of S-2 is already good at answering question number 1 for acceptable reasons. Female students are often better at their thinking process of seeing reality than male students [21]. Subject S-2 is quite good at memorizing the formula in finding the volume of the pyramid and the volume of the prism, but she is not careful in applying logic to find the volume of a truncated pyramid. Her weakness is not careful in looking at mathematical problems causing unable to provide the expected answer [20].

S-3 is that the male student is less careful in looking at the problem of geometry building space, he is not precise in sketching cubes, where S-3 does not understand the relationship between one side and the other side in the same cube. This is a misconception in studying geometry, namely recognizing shapes [22]. Subject S-3 is quite good at analyzing a mathematical problem [23], in finding the volume of a flat-sided shape. He is also correct in understanding mathematical problems, and can take appropriate and thorough steps. Therefore, he chooses the correct action for question number 2.

The male student's S-4 subjects tried to answer geometric problems using mathematical reasoning, but he was not precise in providing formulas to determine the sides asked. He has weaknesses in the analysis of problems related to geometry. S-4 is good at analyzing questions related to determining action. He uses creative workmanship measures, as male students are more flexible in trying different strategies to those in class [24]. Male students' performance was better in solving non-routine problems compared with the performance of female students [11].

Based on the results of critical thinking tests for indicators of drawing conclusions, both male and female subjects can identify the elements needed to draw conclusions. Male and female subjects can solve problems on indicators of drawing conclusions in different ways. Female subjects prefer to draw sketches to help drawing conclusions on geometric problems [25], while male subjects choose to use mathematical calculations in drawing conclusions. Male and female students use different strategies in mathematical problem solving, which are influenced by cognitive abilities, psychological character mediated by experience and education [26]. Male students tend to use abstract strategies in solving math problems, whereas female students prefer to adopt concrete methods [24].

Based on the results of critical thinking tests for indicators of taking action, both male and female subjects can identify the reasons needed to take action, but they are different in terms of accuracy in answering problems. Female subjects tend not to be careful in solving problems in decision making, while male subjects show accurate and precise answers [20].

5. CONCLUSION

The research be concluded that there are differences in the critical thinking between male and female students at SMPN 15 Surakarta in solving mathematical problems of geometric content. Male student tends to master critical thinking skills especially in the aspect of determining action because male students show accurate

and precise answers, while female students tend to have good critical thinking skills in the aspect of drawing a conclusion because female students tends to understand mathematical problems by seeing the concrete (reality). Future studies can focus on the aspect of building basic skills and beliefs based on gender.

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