Conceptual Thinking Profile of Mathematics Education Department Female Student in Solving Problems

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Abstract. This research described the conceptual thinking of female student in solving math problems. The research subject was a female student of Mathematics Education who had the upper middle category of mathematics ability. This research was an exploratory research with a qualitative descriptive approach. The data were collected through problem solving tasks and in-depth task-based interviews. The validity of the data was done through continuous observation, time triangulation, and member check. Data analysis was carried out through several stages, namely data categorization, data reduction, data presentation, data interpretation, and conclusions. The results showed that in understanding the problem, the female student made symbolic and pictorial representations separately. She mentioned the concept while drawing. In making plans, the female student’s strategies were based on certain concepts and were related to problem questions, so that the plan of solving steps was not yet complete. In implementing the plan, the female student determined the initial steps for solving certain concepts that can be resolved and linked them to the problem questions. She did the problem solving partially based on the relationship between concepts, so that the problem solving steps were less systematic.

Keywords: conceptual thinking, female, problem solving

1. Introduction

The human ability to use their minds to understand the environment is a basic potential that makes humans think. Through thinking, humans have the ability to change themselves, and in fact most of human changes are the result of thinking activities. Suharnan [1] stated that some experts believe that thinking is an activity, like a circulation of blood. Therefore, thinking is considered as a neurological activity of the brain, not necessarily related to a problem. Some other experts believe that thinking is directly related to the problem being solved. Meanwhile, according to Solso [2], thinking is a process of forming new mental representations through information transformation and complex interaction of mental attributes.

There are two types of thinking that are commonly used in solving mathematical problems, namely conceptual thinking and procedural thinking. However, conceptual thinking has tremendous power when compared to procedural thinking. This is because mathematical problems are terms with concepts, so that with conceptual thinking, the problem can be easier to solve.

Conceptual thinking is very important for humans in an effort to solve various problems that are being faced. As mentioned by Skemp [3], the importance of conceptual thinking is because it can
provide the ability to adapt to the environment and make the environment according to their needs. The higher concept represented by a symbol, the more experiences it contains. Furthermore Libby [4] stated that since the time of Plato and Socrates, conceptual thinking is a very important aspect. Aristotle, a famous scientist, studied conceptual thinking at Plato’s school for 20 years. This is in line with Pushkin [5] who stated that conceptual learners have structured and networked knowledge so that they are able to evaluate, compare, and have attribution skills.

Several researchers stated their findings related to the importance of conceptual thinking. Arslan [6] stated that conceptual learning supports and evokes procedural learning but procedural learning does not support conceptual learning [6]. Meanwhile, Engelbrecht [7] stated that understanding the concept first can lead to understanding the acquisition of procedural knowledge, but procedural knowledge does not necessarily provide an understanding of the concept. Furthermore, Voutsina [8] stated two points. The first, conceptual knowledge can support appropriate procedural choices in solving problems. The second, conceptual knowledge can show that the procedures that have been developed can be applied to new problems.

Although conceptual thinking has the power to solve mathematical problems, most mathematics education students still think procedurally, there are still a small number of students who think conceptually. Thus, new problems or slightly complex problems, which require the use of concepts, will be difficult for them to solve. This is supported by the findings of Arslan [6] that the analysis of test results showed that 85% of students gave correct responses to procedural questions, but only 30% of them gave correct responses to conceptual questions. This is in line with Alimuddin [9] finding that out of 42 students who were given questions, all of them used trial and error. They were more likely to do a problem solving method in a procedural way and based on routine ways. Hejni [10] also explained the fact that solving problems using procedural thinking is still very dominant. They don’t think of a concept to solve a mathematical problem.

Students’ conceptual thinking is still low and they are accustomed to solving mathematical problems in a procedural way resulting in low learning outcomes. This is in line with the findings of Engelbrecht [7] that concept-based students scored significantly higher than procedure-based students. This result is an evidence that students who apply concept-based learning can effectively encourage the development of understanding without neglecting proficiency in procedural skills.

The studies that have been conducted by Kasemi [11], Engelbrecht [7], and Hejny [10] on conceptual thinking in solving mathematical problems focus on the implementation of learning conducted by teachers in the classroom. Those previous studies had not seen how conceptual thinking Mathematics Education students are expected to form conceptual thinking for students when they become teachers later. In addition, those studies only looked at the abilities and confidence of students in terms of mathematical problems in procedural and conceptual forms, not paying attention to gender factors, especially the female students. Whereas in terms of thinking, the female students are expansive, that is, they begin by trying to explore various aspects that are related to the object and then linking these parts. This way of thinking will have an effect when connecting between concepts when using conceptual thinking in solving problems. This is in line with Chung [12] who stated that female students were more thorough in processing information and Meyer-Levy [13] found that female students were more detailed in processing information and female students tended to use algorithmic strategies.

The research results that we describe in this article, focus on the female student Mathematics Education in solving problems. This student is a prospective teacher who later will become the forefront to form students’ conceptual thinking. How is it possible for a teacher who does not have the ability to think conceptually to convey learning that emphasizes conceptual thinking to students. Thus, it is very important to explore the conceptual thinking profile of female students.

Student conceptual thinking was obtained by using conceptual thinking work indicators based on Polya's stages. The work indicators are as follows.
2. Methods
The research subject was selected from female mathematics education students who has a tendency to be feminine. Determination of feminine traits was obtained through a test adopted from the Bem Sex Role Inventory Test (BSRI-Test) developed by Monto [14]. The subject was categorized as feminine women if the mean feminine score ≥ median feminine score and the mean masculine score<median masculine score. In addition, the subject was selected from the medium category of student math ability but at the top position. Medium math ability category if 80 > math test score ≥ 60.

The data were obtained through problem solving tasks one (TPM-1) and semi-structured interviews. TPM-1 was given to the subject and carried out in 4 stages according to Polya's stage. At the first stage, the subject read the problem then be followed by an interview to explore the subject's understanding of the problem. At the second stage, the subject made a problem-solving plan then be followed by an interview to explore what and how the subject's solving strategy would be. At the third stage, the subject solved the problems then be continued with interviews to explore what and how the subject did the problem solving. At the fourth stage, the subject checked the results of solving then be
followed by an interview to explore what and how the subject checks the results of the problem solving he had done.

Nine days later, the subject was again given two problem-solving tasks (TPM-2) followed by in-depth interviews to explore problem understanding, problem-solving plans, doing the problem solving, and checking the results of problem solving by the subject. The stages of implementing TPM-2 were the same as the stages of the implementing TPM-1.

The validity of the data was obtained through time triangulation, namely by giving TPM-1 and TPM-2 at different times. The data obtained through the giving of TPM-1 and TPM-2 were compared to the results to see data consistency. If consistent, the data was credible and the TPM-1 data would be analyzed. In addition, the validity of the data was also obtained through member check, which was by asking the subject to read and correct the suitability of what the researcher presented with what the subject meant. The validity was also carried out by continuously observing and scrutinizing the data.

The data analysis was carried out through the stages of categorizing data, reducing data, presenting data, interpreting data, and concluding. The results of this conclusion indicated the profile of conceptual thinking of mathematics education female student in solving problems.

3. Results

At the understanding mathematical problems stage, the female student make a separate pictorial representation with symbolic representation, as in the following figure.

![Figure 2. Students’ Drawing](image)

![Figure 3. Conceptual Thinking Scheme of Female Student at The Stage of Understanding The Problem](image)
Annotation:

- : Activity directions
- : ActivityIdentifying
- : RelationCircle

When defining a concept, the female student expressed verbally while drawing. She can identify the concepts that were in the problem. It can be seen in the following schematic completely.

Conceptual thinking scheme of female student at the stage of understanding the problem
At the stage of planning mathematical problem solving, the conceptual thoughts of the female student can be described as follows.

a. The female student formed the concept groups based on the relationship between the concepts. She classified into distance, time, and speed; right triangle; and circles.

b. The female student had not related the overall. She then related the parts that were deemed to be resolved and then related the parts that were asked in the problems.

c. The female student determined the solution plan based on the parts that were considered to be completed. In this case, she initiated a solution plan using $Tg 45^0$.

The female student conceptual thinking schemes at the planning solution stage

![Diagram](image)

**Figure 4.** The Female Student Conceptual Thinking Schemes at The Planning Solution Stage

Annotation:

- : Activity directions
- : Activity
- : Relation
- - - - : Loaded

At the stage of implementing mathematical problem solving plan, the conceptual thoughts of the female student can be described as follows.

a. In implementing problem solving plans, the female student made connections between concepts.

b. The female student used mathematical models, for example using $Tg 45^0 = \frac{6}{x}$. 
c. The female student understood the concept of the operation performed and can determine the meaning of the results of the operation.

d. The female student did the solutions based on parts that were deemed workable then related them to others, so that the direction of the computation sometimes changes, thus it was less systematic.

![Conceptual Thinking Scheme of The Female Student at The Stage of Implementing The Solution Plan](image)

**Figure 5.** Conceptual Thinking Scheme of The Female Student at The Stage of Implementing The Solution Plan

Annotation:

- : Activity directions
- : Stopped
- : Activity
- : Related
- : Back

At the stage of checking the results of the solution, the female student checked the results of the solutions, she checked the formula used. It can be seen in the following schematic completely.
4. Discussion

In understanding math problems, the female student made several verbal representations of the sentences contained in the problem. Making verbal representations correctly is one indication of understanding the problem. Making representations is very important as stated by Kaput (1989) that representation and symbol systems are fundamental in mathematics as a science because mathematics is "a representation that is inseparable from its goals and methods". By making representations, it means that female students have recognized the concepts in the problem, as suggested by Vergnaud (1997) that representation can be seen as an attribute of mathematical concepts.

Apart from verbal representations, the female student also made pictorial representations. This showed that she understood the concepts that existed in the problem as stated in NCTM [15] that understanding of mathematical concepts can be seen from the ability to present concepts in visual form. Verbal representations and pictorial representations made by both of them and show that she had understood this problem. As stated by Hiebert (1992) that characterizing actual understanding can be done through external representations of concepts, such as spoken language (verbal), images of objects, symbols, and physical objects.

The female student read sentence by sentence in the problem while identifying what concepts were known in the problem. What she did is relevant to what was stated by Polya [16] that in order to understand the problem, it is necessary to check what is known and what is asked in the problem.

The female student can define concepts even though they were not formal. This means that it includes understanding the concept, as expressed in NCTM [15] that understanding mathematical concepts can be seen, among others, by defining mathematical concepts both in writing and orally. She defined the concepts while drawing so intend to show how they were formed. According to Soedjadi [17], the definition which states the process of formation is called a genetic definition.
The female student started the initial steps of solving based on the part considered to be completed and related to what was asked. So that there were several concepts that had not been linked. She did not build an integrated conceptual structure so that the problem solving steps she took were less systematic.

Using concepts and linking concepts in solving problems that had been done by the female student had shown that she belonged to the category of conceptual thinking in solving problems. As expressed by Hiebert (Zubaadah) [18] that conceptual thinking is a process of thinking using concepts that are interrelated with one another. Likewise expressed by Marpaung (Zubaidah) [18] that conceptual thinking is a process of thinking using existing concepts in solving problems.

5. Conclusion
The female student made pictorial representations and symbolic representations when understanding the problems. She separated the two representations. She mentioned the concepts while drawing. At this stage, she showed an understanding of the problem. However, when making a problem-solving plan, she focused on a certain part (certain material) and then linked it to the part in question. As a result, only part of the concepts was related. So that the problem solving that she did was less focused and not systematic.

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