Epistemic cognition of student in solving mathematical problem

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Abstract. Assessment of the 2013 curriculum, aspects of knowledge became one of the important aspects. Epistemic cognition is one of the research studies on this knowledge. Epistemic cognition influence how individuals understand the nature of problems and decide what kinds of strategies are appropriate for solving them. In the context of mathematics, epistemic cognition can help the students to solve mathematical problem correctly. The aim of this research was to describe epistemic cognition of student in solving mathematical problem. This research was a qualitative research with case study method. The instrument of this study is the researcher themselves that assisted by problem solving test on the learning topic of systems of linear equation. The interview method was used to collected data in this research. Based on the result of the research, students carry out metacognition strategies at the stages of exploring, planning and implementing, students use a rational problem solving approach because students use formulas that they already know as approaches in determining the components of the problem, and students carry out justification at the stages of problem solving done rationally.

1. Introduction
According to recent developments in teacher learning theory, mathematics content and pedagogical content knowledge play a greater role in professional development [7]. But, the mathematics skill of student in Indonesia at poor condition. This can be seen from the results of the 2011 Trends in the International Mathematics and Science Study (TIMSS) revealed that Indonesia was ranked 38th out of 42 countries in the field of mathematics [12]. Based on the TIMSS data above, it shows that mathematics education in Indonesia still needs to be improved and developed to be better. Many factors influence the development of mathematics education, one of which is the competence possessed by the instructor and the competence of students in receiving knowledge. Performance Based Teacher Education suggests that teachers need to have content knowledge, behavior skills, and human relations skills competencies [4]. Knowledge becomes something that must be owned by a teacher, considering that one of the teaching roles is to transfer knowledge to students. However, over decades of research, many advances have been made in understanding how learners think and in developing approaches for teaching and assessing skillful thinking [6, 10, 11].

Assessment of the 2013 curriculum, aspects of knowledge became one of the important aspects, so that in-depth studies were needed on knowledge. Greene used the epistemic cognition term to describe research studies on this knowledge [4]. Chinn et. al defined epistemic cognition as a complex of cognitions that are related to the achievement of epistemic ends such
as true beliefs, justified beliefs, understanding, and knowledge and its representations [3]. Epistemic assumptions influence how individuals understand the nature of problems and decide what kinds of strategies are appropriate for solving them. One of the primary concerns of epistemic thinking research is understanding how people think about matters such as knowledge, truth, and justification [1]. Understanding how people think about epistemic matters is highly important in current knowledge societies in which information has become more abundant and accessible, yet also increasingly diverse [1].

In Mathematics, epistemic cognition can be seen when students solve mathematical problems. Schoenfeld states that when individuals solve mathematical problems influenced by several strategies in metacognition [9]. Therefore, the strategy of metacognition is one of the factors that influence the epistemic cognition of students in solving mathematical problems. Epistemic cognition research of students in solving mathematical problems besides being influenced by metacognition strategies is also influenced by the approach used and how to justify the resolution of these problems [8].

One of the mathematical material that is difficult for students to understand is a two-variable system of linear equations. This can be seen from the National Examination Results data for the 2016-2017 academic year of Vocational High School shows that the absorption capacity of the material for two-variable linear equations is only 52.27 [2]. This is still a low absorption so it needs to be repaired. Therefore, in this study the researcher will describe the epistemic cognition of students in solving mathematical problems a two-variable system of linear equations.

2. Research Methods
This research used the qualitative method with descriptive research type. The strategy used is case study strategy. The subject of the study was one student from a 10th grade at Bendo Vocational High School. The data from this study comes from the results of related tests of mathematical solving problem and the results of in-depth interviews. Data collection techniques in this study by providing written tests of mathematical solving problems on the subject of research. Furthermore, an in-depth interview was conducted with the research subject. The results of written test and interview transcripts were analyzed, then described the problem solving based on the Schoenfeld phase relating to epistemic cognition.

3. Result and Discussion
The data collection was conducted by giving a the test works on two-variable linear equation system problems and interviews were processes of the research subject solved the problem (Problem) Lisa and Muri work at a bag factory. Lisa can complete 3 bags every hour and Muri can finish 4 bags every hour. Lisa and Muri's working hours are 16 hours a day with 55 bags of bags made both. If the working hours are different, determine their working hours and explain the steps in the process.

3.1. Metacognition Strategy
The research subject carries out a metacognition strategy in solving problems which is first seen in the stages of exploring, planning and applying. The following are the results of the written test and subject interview related to the metacognition strategy at the exploratory stage.
RE1 Ok. From that information, what formula or principle can be used?
RS1 From the number of bags made in each hour and the number of working hours of the two workers, we can create a two-variable linear equation system.
RE2 So that information can be used?
RS2 Yes, it will be used later.

Based on interview data and written tests in Figure 3.1, The research subjects obtained new information that from the number of bags that can be made per hour and the number of working hours of the two workers can be changed to a two-variable linear equation system. New information obtained by the research subject is still in the context of the problem and is used at the analysis stage. This indicates that the research subject is monitoring, then controls by continuing to the planning stage. Overall, the research subject can do the exploring stage in solving problems.

At the planning stage, the research subjects carry out planning metacognition strategies. The following data on the results of written tests and interview the research subjects related to metacognition strategies at the planning stage.
RE3 We will discuss what steps you will use to solve the problem. What is your first step?
RS3 First, we make a mathematical model of the problem above. The mathematical model that can be made is two systems of two-variable linear equations
RE4 After that?
RS4 We must look for variables x and y using the elimination and substitution formulas (combined)
RE5 What is the next step?
RS5 After finding the x and y values, we can find the number of working hours of each worker.
RE6 In your opinion, is there another way to find these x and y variables?
RS6 There is. Because in solving the system of two linear equations there are 4 ways, namely: the graph method, elimination, substitution and combination (elimination and substitution). The other way, I forget ...

![Figure 3.1](image1)

![Figure 3.2](image2)
Based on interview data and written tests in Figure 3.2, the research subject explained the steps to be taken in solving the problem. The steps are to make a mathematical model of the problem into a two-variable linear equation system, look for the value of x using the elimination method, find the y value using the substitution method, then use the x and y values to find the working hours of each worker. The research subject also explained that there were more than one way to solve the problem, but the research subjects could only use that method to solve the problem.

At the stage of applying, the research subjects carried out monitoring and control metacognition strategies. The following are the results of the written test and interview of the research subject regarding the metacognition strategy at the stage of applying.

![Figure 3.3.](image)

- **RE7** Okay. We start from the first step first.
  - What was the first step?
  - RS7 Make a mathematical model of the problem.
  - RE8 How do you make the mathematical model?
  - RS8 We suppose Lisa's working hours with x and Muri's working hours with y. Every hour Lisa made 3 bags and Muri made 4 bags, in one day they made 55 bags, then $3x + 4y = 55$.
    - Then, the number of Lisa and Muri working hours is 16 hours, then $x + y = 16$. 
  - RE9 What is the second step?
  - RS9 We look for the value of the variable x using the elimination method.
  - RE10 And then?
  - RS10 After we find the value of the variable x, we enter it in one of the two-variable linear equation systems to find the y value (substitution method).
  - RE11 Is there any other way?
  - RS11 Actually there is, but this is the easiest method because after we find the x variable by means of elimination, then the y value we can find by substituting the x value
  - RE12 Okay. Which means you have tried another way?
  - RS12 Not yet. But I'm sure this is the easiest and shortest way
RE13 After finding the value of the variables x and y, what next step?
RS13 We can look for the number of hours Lisa and Muri work in a day using the values of the x and y variables.

Based on interview data and answer sheets such as Figure 3.3, the subjects of the research were the subjects who used the study subjects to find Lisa's working 9 hours and Muri 7 hours a day. This indicates that the steps used by the research subjects are appropriate for problem solving (monitoring). Seeing the steps used are appropriate, the research subjects did not make any changes in the steps used (controls).

3.2. Problem Solving Approach

The following data from the written test results related to the problem solving approach of the research subject at the stage of applying.

![Figure 3.4](image_url)

Based on interview data at the stage of applying and the answer sheet like Figure 3.4, the subject uses a rational problem solving approach. This can be seen in the use of the elimination method to find the x variable and substitution method to find the y value. The research subject uses formulas that he already knows as an approach in determining the components of the problem.

3.3. Justification

Based on interview data related to the first problem, the subject of the study carried out justification at the stages of problem solving. At the reading stage, the subject of the study carries out justification for the problem of the question revealed by the subject. The problems expressed by the research subjects were Lisa and Muri's working hours in a day. The research subjects carry out justification at the reading stage seen in conversation RE1-RS1. At the stage of analyzing, the subject of research carries out justification for information obtained from questions and formulas or principles derived from that information. The information obtained by the research subject is two systems of two-variable linear equations that must be sought for the values of the variables x and y. Based on this information, the research subjects looked for x and y values. The research subjects carried out justification at the analysis stage seen in conversation RE2-RS2.

At the planning stage, the subject of the study carries out justification for the strategies or steps that the subject will use to solve the problem. The research subjects carried out the justification seen in the conversation RE3-RS6. At the stage of applying the subject of research carry out justification for the implementation of steps at the planning stage. The research subjects carry out justification at the stage of implementation seen in conversations RE7-RS12.
At the verification stage, the research subject carries out justification for the solution to the problem. The research subject carried out justification at the verification stage seen in conversation RE13-RS13.

The justification carried out by research subjects in solving problems is done rationally. Suppose the justification of the research subject to one of the application of the steps used in solving the problem as follows.

**RE11** Is there any other way?

**RS11** Actually there is, but this is the easiest method because after we find the $x$ variable by means of elimination, then the $y$ value we can find by substituting the $x$ value

**RE12** Okay. Which means you have tried another way?

**RS12** Not yet. But I'm sure this is the easiest and shortest way

Based on the conversation, the subject of the research subject provided rational justification because it used logic rather than trial and error or information in the form of mere perceptions.

4. **Conclusion**

This study concludes that Epistemic Cognition of students at in solving system problems in two-variable linear equations divided into three parts. First, metacognition strategies (planning, monitoring and control): students carry out metacognition strategies at the stages of exploring, planning and implementing. At the stage of exploring, students carry out monitoring and control of new information and formulas derived from that information. At the stage of planning, students carry out planning, namely determining the steps or strategies that will be used to solve the problem. At the stage of implementing, students carry out monitoring and control on the implementation of the steps. Second, problem solving approach: students use a rational problem solving approach because students use formulas that they already know as approaches in determining the components of the problem. And the last, justification: students carry out justification at the stages of problem solving. At the reading stage, students carry out the justification of the problem from the problem. At the analysis stage, students carry out justifications for information obtained from questions and formulas or principles derived from that information. At the exploration phase, students carry out justifications for new information obtained by the subject. At the planning stage, students carry out justifications for strategies or steps that students will use to solve problems. In the verification phase, students carry out justification for the solution to the problem. The justification carried out by students in solving problems is done rationally.

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