Problem solving and cognitive style: An error analysis

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Abstract. Problem-solving and cognitive style are two things that are important to note, but the reality is rarely considered especially cognitive style. Student cognitive style can influence problem-solving abilities. This study aims to investigate student errors based on Newman in problem solving, in terms of independent and dependent field cognitive style. The study was conducted on junior high school students in Indonesia, the method used is exploratory involving 2 Subject. Subjects are taken from independent and dependent field style cognitive groups. Stages of problem-solving according to Polya’s includes: understanding the problem, devising a plan, carrying out the plan, and look back. Errors according to Newman include errors in reading, comprehension, transformation, process skills and encoding. Data were collected using the Group Embedded Figure Test (GEFT) and problem-solving test. The conclusion shows that subject with field dependent cognitive style with the initials SFD tend to make errors at the transformation stage in making models, process skills in manipulating algebra and calculation processes, and conclusions for making errors in the previous stage. Whereas subject with independent field cognitive style with the initials SFI tend to make errors at the process skill stage in manipulating algebra and calculation processes.

1. Introduction
Problem-solving ability in the 2013 curriculum in Indonesia is one of the Higher Other Thinking Skills (HOTS) in mathematics that is important to be trained on students. In line with [1] suggested that problem-solving is one of the mathematical abilities that must be mastered by students. This is because problem-solving can train patterns of thinking that can be applied in solving problems of daily life. As [2] suggested that problem-solving is as an effort to find a way out of goals that are not easy to achieve. Problem-solving is the thought process of a person in determining what must be done when he does not know what to do. Also, problem-solving is something that will determine the success of increasing the ability to think at a higher level. Based on this opinion, it illustrates that the importance of problem-solving is taught to students. There are two problem-solving roles, namely as a learning approach and ability.

Problem-solving skills are very important given to students, as [3] suggested that problem-solving tasks important are trained on students. Besides, according to [4] problem-solving in mathematics can train students to find concepts, principles, process information in solving diverse problems, see the relationship between causes and make conclusions. Another opinion [5] that problem solving needs to be improved by using various methods and analyzed for errors. Problem solving is an essential ability that must be possessed by middle school students [6]. Students' abilities in problem solving need to be analyzed to see their success [7]. Analyzing step-by-step answers of students in problem solving is important, because it can have an impact on student success in subsequent problem solving [8]. Likewise in Brunei, problem solving is a very important framework in the school curriculum [9]. Solve the
problem not just achieving the learning objectives, but also the process of solving problems is important [10]. Taking into account various opinions, it can be concluded that the process of the students’ stages in problem-solving needs to be analyzed in terms of concepts, formulas, and procedures. This has not been examined. Various factors can affect problem-solving abilities, including learning styles and cognitive styles. Studies conducted by [11] concluded that problem-solving is influenced by Kolb's learning style. The study [12] found student learning more concerned with the results of the process.

Problem-solving is also influenced by language literacy and mathematical competence [13, 14]. The study of problem-solving in PISA conducted by [15] found that students were low in-process and low in problem-solving skills. In some case, problem-solving experiences obstacles, therefore we need to analyze the shortcomings [16] and according to [17] need explore mental structure and mechanism in problem solving. Problem-solving can be influenced by learning motivation and mathematical disposition [18] and [19] state that problem-solving can be influenced by student experience and behaviour, other than that [20] argue that students in solving problems involve a variety of cognitive skills so that they have difficulty in solving mathematical problems. The exposure gives an illustration that research on problem solving has been done a lot. His research was conducted on students, teachers and pre-service teachers. Problem solving as a heuristic strategy, ability, and approach or learning.

For further improvement, it is important to analyze students’ error on solving problems. Research has been done by [21] about students’ error in the ability to represent, but the research does not analyze errors according to Newman’s. Besides, various factors that can affect students’ problem-solving abilities, one of them is cognitive style. Research on cognitive style has been carried out by [22] on students’ cognitive processes in solving-problems in the Area Conservation concept. Also, [23] examines cognitive style implications in the assessment of creativity. Research on problem solving with cognitive style has been done by [24] but not independent and dependent field cognitive style.

Noting the description of previous research that has been done relating to problem solving and cognitive style, not many people have researched about the analysis of problem solving errors in terms of cognitive style. The problem solving studied is according to [2] and [25] including understanding the problem, devising a plan, carrying out the plan, and looking back. Error according to Newman consists of reading, comprehension, transformation, process skills, and encoding. Cognitive style consists of independent and dependent fields. This research is on the subject matter of two-variable linear equations, with the aim of investigating of the students’ error in problem solving based on of cognitive style.

2. Method
This research uses exploratory method with think aloud technique, involving two variables namely problem solving and cognitive style. This research is a qualitative study conducted in grade 8 one of the junior high schools in the City of Tasikmalaya Indonesia. The stages of the research include: giving a Group Embedded Figure Test (GEFT) to one class of respondents to obtain cognitive style data, then grouping them namely Field Dependent (FD) and Field Independent (FI). The GEFT instrument consists of 29 questions. Furthermore, the FD and FI groups performed problem solving tests according to Polya's heuristic using think aloud techniques. Respondents take turns given tests to measure the ability of problem solving according to Polya’s heuristic, namely understand the problem, devise a plan, carry out the plan, and look back. Problem solving answers are analyzed to obtain student error data based on Newman, namely errors in reading, comprehension, transformation, process skills and encoding. The steps of taking research subjects are: given the GEFT questionnaire, grouped FD and FI. Then a problem solving test is given to each group, and the answers are analyzed. Then the interview was conducted based on the answers to problem solving, to explore the respondent’s error. Finally, two subjects were taken from the FD group with the SFD symbol, and from the FI group with the SFI symbol. Two subjects were selected who experienced the most errors. Data analysis techniques include three stages, namely data reduction, data presentation, and conclusions. At the reduction stage cognitive grouping is performed, namely students who get a score of ≥12 namely independent field and students with a score of ≤11 namely field dependent. Furthermore, analyzing the problem solving errors in the two-variable linear equation material. At the stage of presenting data, a mapping of errors was carried out by subject in the dependent and independent field cognitive style. The last stage of the conclusion is to describe the errors of each cognitive style namely SFD and SFI.
3. Result and Discussion
This research is about errors according to Newman on the problem-solving material linear equations of two variables in terms of independent and dependent field cognitive style. The suitability of problem solving with Newman errors can be seen in Table 1.

| Problem Solving          | Newman Errors                                                                 |
|--------------------------|-------------------------------------------------------------------------------|
| Understand the problem   | Reading in recognizing symbols, terms or words contained in the problem. Comprehension is writing down what is known and asked in the problem. |
| Devise a plan            | Transformation is writing down plans, completion strategies, formulas, and mathematical modeling. |
| Carry out the plan       | Process skill is carrying out steps or procedures for solving problems and performing calculation operations. Encoding is appropriate in writing answers and conclusions. |
| Look back                | Transformation, process skill, and encoding.                                 |

Table 1 gives an illustration that the left column is Polya’s problem solving step, and the right column is the error analyzed at each stage.

Respondents consisted of two respondents who had independent cognitive style fields namely SFI and had dependent cognitive style namely SFD. SFI respondents at the stage of understand the problem write what is known and asked and write with the appropriate symbols. Thus, SFI does not make errors in reading and comprehensions. In the devise a plan stage, SFI can turn problems into mathematical forms by writing plans, completion strategies, formulas, and mathematical modeling so that making errors on transformations does not happen. At the carry out the plan stage, carry out the plan or do the calculation process, but it is wrong to answer the age of Ica $y = -4$, which should be $y = 6$. This is because when the process of eliminating equation 1 with equation 2 is wrong in its operation. Then there are stages that are not done, namely about the age of Agus and the age of Ica in 2025, so that SFI cannot carry out workmanship procedures in a direction and do not get the right answer. SFI looks confused when doing the calculation process and make some errors. Figure 1 is the answer of SFI.

Figure 1 shows that SFI is wrong in making the calculation process so that it results in wrong in encoding or making conclusions. SFI respondents did not answer the look back stage. The look back stage is the students have to solve the problem in another way but the answer is the same as the carry out the plan.
stage. Through think aloud, it was revealed that in daily learning students were never given a problem by working on a minimum of two ways or various ways in accordance with [2].

SFD respondent in the understand the problem stage write what is known and asked of the problem completely and clearly, and change the problem into mathematical symbols. Means SFD does not make errors in reading and comprehension. At the carry out the plan stage, make mathematical models of linear equations correctly, write the variables correctly. SFD made an error in the process skill, that is, in the calculation process, making a 2y elimination error on the right side should be -2y but answering + 2y. This results in an error in the next stage which is encoding, and does not answer the look back. SFD errors in problem solving are in process skills and encoding and do not answer the look back stage as shown in Figure 2.

![Figure 2. SFI Error in Process Skill and Encoding](image)

Figure 2 shows that SFD has an error in the process skill and also has an error in the encoding, but at the stage of understanding the problem and devising a plan, there is no error. SFD respondents like SFI did not answer the look back stage, with the reason that they did not understand the purpose of the problem, because they never knew the questions answered in two different ways. Through think aloud, SFD is able to answer using other methods with the same results as at the carry out the plan stage.

SFI respondents with independent cognitive style fields and SFD with dependent cognitive style both have Newman errors on relatively similar problem solving. Figure 3 illustrates the stages of Polya’s problem solving and Newman errors from SFI and SFD.

![Figure 3. Stages of Problem Solving and Error of Newman SFI and SFD](image)

| Colour      | Remark     |
|-------------|------------|
| Error       | Error      |
| Error due to before | Missed stage |
| No Error    | No Error   |
Table 2 is the explanation of the code from Figure 3.

| Code | Remark | Code | Remark |
|------|--------|------|--------|
| R    | Problem Solving questions | T1   | x – 4y = – 9 |
| T    | Variable Thinking | T2   | x – 2y = 3 |
| DIK  | Known | P1   | Age of Agus |
| DIT  | Asked | P2   | Age of Ica |
| C1   | Three years ago, Agus was four times the age of Ica | Q1   | Age of Agus in 2025 |
| C2   | The next three years Agus is twice the age of Ica | Q2   | Age of Ica in 2025 |
| C3   | What is their age ratio in 2025? | E    | Age ratio of Agus and Ica in 2025 |

4. Conclusion

Based on the results and discussion, the conclusions of this study are SFI and SFD respondents in problem-solving according to Polya's stages on the two-variable linear equation material, which has relative abilities and errors according to Newman. Both can answer correctly at the stage of understanding the problem and devise a plan. Thus in these two stages do not make error according to Newman on reading, comprehension, and transformation. In the carry out the plan stage, SFI and SFD make relatively similar error, namely in the wrong process skills and encoding. At the look back stage, SFI does not answer while SFD answers but is wrong.

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6. References

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