Mathematics Pre-Service Teachers' Reasoning Profiles Based on Self-Efficacy

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When solving problems, reasoning is needed to see the problem and sufficient information to make the right decisions. The reasoning profiles carried out are thought to be inseparable from its self-efficacy. This study aims to obtain an overview of the reasoning profiles of prospective mathematics pre-service teachers based on self-efficacy. This type of research uses descriptive qualitative methods. Data were obtained using questionnaires, tests, and interviews. The self-efficacy questionnaire was categorized into high, moderate, and low categories. One informant was taken from each category to study the reasoning profiles of prospective mathematics pre-service teachers more deeply. The data analysis technique in this study uses the stages of data reduction, data presentation, data interpretation, and conclusion. The results showed that participants in the high self-efficacy category had no difficulty interpreting information, modeling, completing, and drawing conclusions. Participants in the moderate category can interpret information and model but tend not to be thorough in solving problems. Meanwhile, participants in the low self-efficacy category tend to be less likely to interpret information.

Keywords: analogy, self-efficacy, reasoning process, review

INTRODUCTION

Solving daily life problems requires reasoning skills about data in a certain context (Lloyd & Frith, 2013). Through the reasoning possessed, one can see the problem and the sufficiency of information to draw conclusions (Saleh et al., 2018). Reasoning skills need to be developed to be able to make the right decisions in life (Bunge & Leib, 2020; Mehraj A. Bhat, 2016). Reasoning plays an important role in mathematics (Indrawatiningsih et al., 2020; Morsanyi et al., 2018), especially at the time of decision-making (Beatty & Thompson, 2012), comparing similarities, and explaining mathematical structures logically (Tak et al., 2021).

Mathematical reasoning is necessary for understanding mathematical materials, and through learning mathematics, one is trained in mathematical reasoning (Hasanah et al., 2019; Kartono & Shora, 2020). Reasoning is defined as using reason to reach conclusions (Fyfe & Brown, 2017; Jäder et al., 2016) and drawing conclusions based on facts (Nurjanah et al., 2020).

But in reality, the mathematical reasoning of new students is close to the specified average score (Mumcu & Aktürk, 2017). Students have difficulty generalizing and connecting mathematical patterns (Razi et al., 2019) and have low reasoning ability (Zulkipli et al., 2020). This certainly needs to be a concern to find the root cause of why mathematical reasoning is still low and solutions are needed to improve it.

It is said that a person has begun reasoning if they are conducting thought processes actively and evaluatively (Schwarz & Asterhan, 2008). The process of mathematical reasoning relates to processes related to the search for equations and differences and processes related to the validation (Jeannotte & Kieran, 2017). The process of finding equations and differences can be generalizing, guessing, identifying patterns, comparing, and classifying. At the same time, the validation process is a process of validating, justifying, and proving. This is in line with the reasoning process, according to (Bronkhorst et al., 2020), where the reasoning process includes selecting and interpreting information, connections, verification, and concluding. While according to (Rodrigues et al., 2021), the process of reasoning includes generalizing, justifying, exemplifying, comparing, and classifying.

Failure to implement reasoning schemes related to everyday problems sometimes weakens their confidence in solving problems or vice versa, encouraging improvements in the guesswork (Datsogianni et al., 2020). A person with high mathematical reasoning will use their ability selectively to process information (Persson et al., 2021).

Mathematical reasoning is suspected to be related to aspects of self-efficacy. This is reinforced by the results of previous studies where self-efficacy is a significant predictor of reasoning performance (Kingston & Lyddy, 2013). Mathematical self-efficacy, self-efficacy of tasks, and well-designed learning have a shared and significant influence on the reasoning (Mukuka et al., 2021).

Self-efficacy becomes an important part owned of every prospective student or mathematics teacher. With self-efficacy, one will devote all the necessary energy to solving every problem faced (OECD, 2013). In addition, a person who has self-efficacy will view new problems as challenges to overcome, not as threats, and try to develop more complex strategies to those solve problems (Li et al., 2020), understand the actions taken, interpret the results obtained, and focus more on solving problems (Hammad et al., 2020).

Self-efficacy is a person’s belief in understanding and solving problems based on their potential, leading to successful outcomes (Said et al., 2018; Tezer et al., 2019; Unrau et al., 2018). Another definition related to self-efficacy, namely, is the belief of a person using their ability to solve problems using certain means (Šorgo et al., 2017). A person with good self-efficacy tends to be future-oriented and considers any activities to be done (Kirbulut & Uzuntiryaki-Kondakci, 2019). Thus, self-efficacy is a person’s belief in planning, persistently facing problems, and solving various types and levels of problems, following their goals and potential.

These problems indicate that reasoning needs to be a concern for prospective mathematics teachers, students, and the relationship between self-efficacy and the reasoning process. For this reason, it is necessary to study how the mathematics pre-service teacher’s reasoning processes are based on self-efficacy more deeply.

RESEARCH METHOD

Self-efficacy data collection uses a questionnaire consisting of 24 questions with a choice of answers from scores 1 to 10. A score of 1 states “Not sure you can do,” and a score of 10 states “Very confident you can do.” Questioner self-efficacy is based on three dimensions: level, generality, and strength (Bandura, 1997), which are modified according to needs. The questionnaire results are used to categorize self-efficacy, i.e., high, moderate, and low categories. The questionnaire was filled out by 24 students in the third semester of the Mathematics Education Study Program of Muhammadiyah Purwokerto University. Based on the results of the self-efficacy questionnaire, one subject (participant) was taken from each category of self-efficacy.

To obtain the data on the reasoning process used, tests and interviews were conducted. The interviews, tests, and guidelines are developed based on reasoning indicators (Bronkhorst et al., 2020; Jeannotte & Kieran, 2017) that are modified according to needs. Participants were given a question consisting of 2 questions by taking algebraic materials.

Data analysis is carried out in-depth with the following stages: data reduction, data presentation, interpretation of results, and conclusion drawing (Sukestiyarno, 2020). The data reduction stage was carried out by selecting three of the 24 participants who took the test. The three participants selected based on consideration fall into each category of self-efficacy. The simplification of the data obtained is presented and studied in depth to get conclusions. The interpretation of the results is based on test results and interviews. Triangulation test techniques are used to test the credibility of data, namely comparing test results and interviews to get complete data related to the reasoning process of prospective mathematics teachers based on self-efficacy.

RESULT AND DISCUSSION

The results of the self-efficacy questionnaire that the 24 participants had filled obtained four participants in the high category, 15 participants in moderate category, and five participants in the low category. Three participants were taken: R1 for the high category, R2 for the moderate category, and R3 for the low category. Here are descriptions of test results and interviews for each category of self-efficacy:

High Category Self-Efficacy

Participants in the high self-efficacy (R1) category were able to correctly solve problems related to the set. R1 writes down all the information on the question and determines the problem (the number of students who take all three elective courses) with x. The information on the problem is then modeled and described using a Venn diagram, as in Figure 1.

FIGURE 1
R1 ANSWER TO THE SET QUESTION

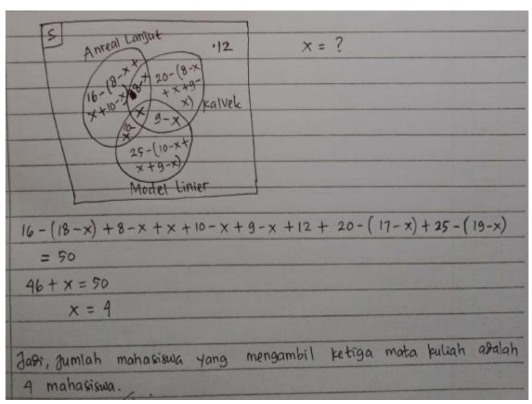
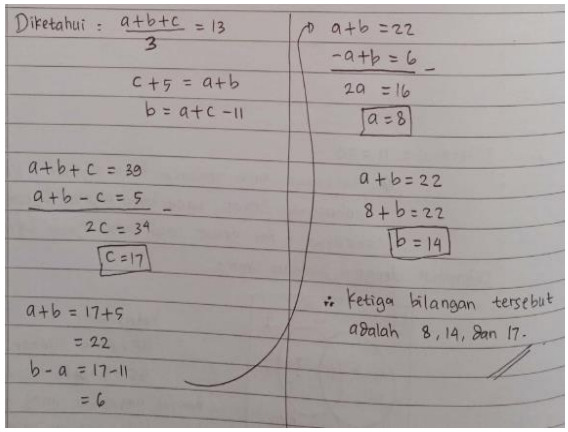


Figure 1 shows that R1 appears to have no difficulty modeling and depicting it in Venn diagrams. Venn diagrams make it easier for R1 to solve problems and draw conclusions based on the context of the problem. Likewise, in problem number two, related to linear equation systems, R1 does not seem to have significant difficulties in solving problems, as in Figure 2.

FIGURE 2
R1 ANSWER TO THE PROBLEM OF THE LINEAR EQUATION SYSTEM



R1 begins by meaning the first number with a, the second number with b, and the third number with c. Furthermore, based on information about R1 modeled into three mathematical equations, R1 selects the mixed method (illumination and substitute) to solve the given problem. The illumination method is used to obtain the value c, while the substitute method is used to simplify the second and third equations after the value of c is known. This step makes the two equations (two and three) simpler. R1 then laminates b so that it is obtained a = 8. Using the selected illumination and substitute method, R1 is efficient enough to make it easier to get the three numbers. This result was reinforced by the results of an interview with R1. Here's an interview with R1.

P : Are you having trouble solving problems?

R1 : Have no difficulty.

P : What causes you no trouble?

R1 : Remember and use the concept of operations involving two sets to complete the concept of operations involving three sets.

P : How is the strategy to solve this problem?

R1 : Read, write down information, model, and represent to facilitate problem-solving.

P : How do you be sure that the answer is correct?

R1 : Review the answers that have been given.

Moderate Category Self-Efficacy

The problem-solving process carried out by R2 is almost similar to that of R1. R2 can interpret all the information on the question and model it. The step taken by R2 is to determine the number of students who take A, K, or M courses only. The simplification result is then inserted into the Venn diagram. R2 uses the formed Venn diagram to make it easier to determine the number of students who take all three courses. R2 made a mistake in its calculations. R2 writes 50 = 2x + 38, which should be 50 = x + 46, as in Figure 3. This error is thought to have originated from inaccuracy in writing the equations formed. R2 writes x – x, which should be (8 – x).

FIGURE 3
R2 ANSWER TO THE SET QUESTION

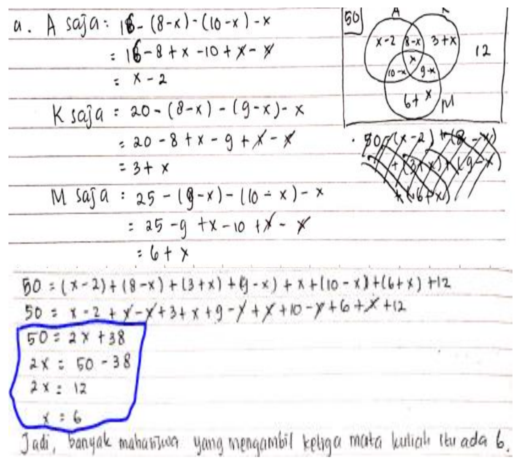
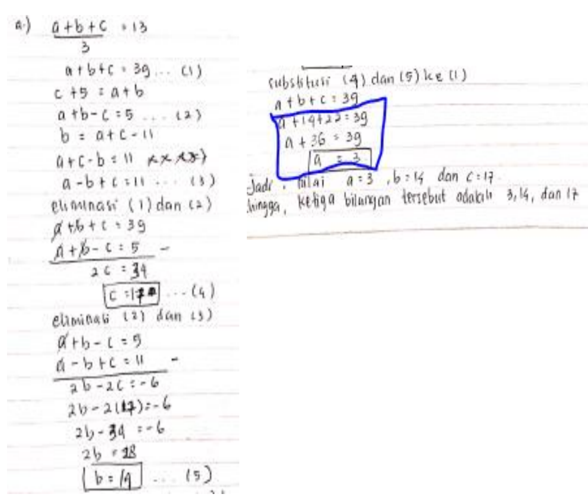


Figure 3 shows that the inaccuracy performed by R2 at the time of calculation makes the problem-solving process wrong. Errors in the problem of set material are repeated when solving linear equation system problems, as in Figure 4.

FIGURE 4
R2 ANSWER TO THE PROBLEM OF LINEAR EQUATION SYSTEMS



In the linear equation system, R2 represents all three numbers in a row with a, b, and c, as in Figure 4. R2 converts the information in the problem into three equations. To get all three, R2 numbers using the substitute elimination method. The illumination is performed using equations (1) and (2), as well as equations (2) and (3). When substituting the variable c, R2 makes the mistake of entering the number 22, which should be 17. This error is suspected to be due to the inaccuracy of R2. The error in replacing the value at the substitute's time makes the next process wrong. The results were reinforced by the results of an interview with R2. Here's an interview with R2.

P : How is the strategy to solve this problem?

R2 : Read, write down information, write down problem-solving flows, and remember the concepts used.

P : How do you be sure that the answer is correct?

R2 : When the settlement process is nothing strange and easy to complete.

P : Do you review the answers given?

R2 : The review is carried out if there are doubts in the settlement process.

Low Category Self-Efficacy

Participants in the low self-efficacy (R3) category began the settlement by interpreting the information on the question and continued by representing the information in a Venn diagram, as in Figure 5. R3 made an error in representing it in the Venn diagram. This error is suspected to be caused by R3 misinterpreting the information in the question. R3 interprets the numbers of students taking A, B, and C courses only, respectively, as 16, 20, and 25. Conceptual errors made by R3 result in the subsequent settlement process.

FIGURE 5
R3 ANSWER TO THE SET QUESTION

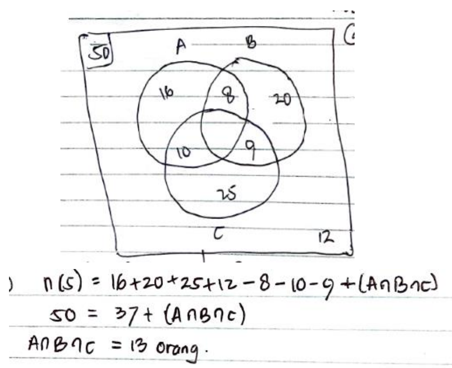


Figure 5 shows that, in addition to making conceptual errors, R3 also made procedural errors. R3 is inconsistent in performing calculation operations. At the time of slices, two sets use subtraction operations while three sets use addition operations at the time of slices. Errors at the time of representation and calculation procedures make the completion process and conclusions wrong. The results of the interviews with R3 reinforce these results. Here's an interview with R3.

P : Are you having trouble solving the problem?

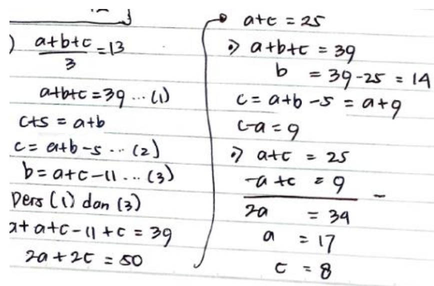
R3 : Yes, it is a bit hesitant in solving the problem about the set.

P : In which part do you feel hesitant?

R3 : Represents information into a Venn diagram.

Unlike the set problem, in the linear equation system problem, as in Figure 6, R3 can understand information precisely. The information is, then, converted into three equations. R3 prefers to use the substitute method first rather than the illumination method. The substitute process begins by substituting equation (3) into equation (1). The substitution process carried out is correct. It's just that the lack of information on the answer makes the answer less systematic. R3 only writes equations (1) and (3) when what is meant is to substitute equation (3) into equation (1).

FIGURE 6
R3 ANSWER TO THE PROBLEM OF THE LINEAR EQUATION SYSTEM



The next process also shows a lack of information related to the settlement process. In addition to the lack of information in the settlement process, R3 tends to be less precise in writing the settlement procedure. For example, R3 writes c = a + b – 5 = a + 9, which should be written as c = a + b – 5. The next step should be c = a + 14 – 5. R3 is suspected of deliberately shortening the completion step until the equation c = a + 9 is obtained. Nevertheless, the settlement process carried out by R3 gets the correct results.

The description of test results and interviews shows that the higher the category of self-efficacy, the better the reasoning process. The results are thought to be influenced by the participant's ability to understand the problems that exist within the problem. The process of understanding the problem is inseparable from the initial knowledge and prerequisites possessed. The reasoning produced based on the knowledge that is already owned allows a person to predict circumstances that have never been experienced before and solve the problems they experience (Bibel & Kreitz, 2015).

When participants can use prerequisite materials, it will facilitate the process of modeling into the appropriate form. R1 and R2 use the understanding of two-set slices to solve the problem of three-set slices. An understanding of simple concepts is used to solve more complete problems with similar structures. These results are in line with previous research where the process of retrieving material that has been studied facilitates the process of solving subsequent problems (Peterson & Wissman, 2018), and previous memories can affect reasoning and problem-solving (Simms et al., 2018). The use of known schemes makes it easy to resolve problems and the process of concluding(Richland & Begolli, 2016; Simms et al., 2018). In addition, the structural similarity is key to solving problems (Chuderska & Chuderski, 2014; Kao, 2020).

When the problem-solving process is related to a simpler concept, it needs to be supported by the ability to use and manipulate concepts according to the context of the problem faced (Barr et al., 2014). Using simple concepts to solve more complex problems is often called an analogy. An analogy is used when the problem-solving process is related to a simpler concept (Macagno et al., 2016; Vogelaar & Resing, 2018). Conceptualization that has relationships makes it easier in the problem-solving process [48]. The initial knowledge is used to solve problems that are poorly understood so as to get a reasonable conclusion (Macagno et al., 2016).

The process of interpreting information will affect the next step, which is the process of modeling into the form of appropriate representations. The selection of forms of representation is influenced by the understanding of the information (Napitupulu et al., 2016). The ability to recognize, interpret, and analyze is important in the reasoning process (Siemon et al., 2018). Modeling problems are experienced by R3 when described in Venn diagrams. R3 misrepresents the information in a Venn diagram. This error certainly results in an error in the next process, namely, solving the problem.

The reasoning process of mathematics pre-service teachers is allegedly also influenced by reviewing the problem-solving that has been done. Mistakes made by participants in the self-efficacy category are being suspected not because of their inability to solve, but because they do not review (recheck) the problem-solving. The process of systematically rechecking gives strength to the completion process (Capraro et al., 2012).

This research is limited to the reasoning process of mathematics pre-service teachers based on self-efficacy. There may be other factors that also influence the reasoning process of mathematics pre-service teachers. In addition, further research is possible to explore the process of mathematical reasoning seen from its structure.

CONCLUSION

Every individual must have self-efficacy, especially when solving mathematical problems that require quick decision-making and conclusions. The better the self-efficacy you have, the better the reasoning process. Optimizing analogies using similar knowledge that has been possessed helps the process model in the form of appropriate representations. In addition, it is necessary to do a review process (recheck) on the resolution of problems carried out to reduce the occurrence of errors. The practical implication of this research is to provide knowledge for mathematics pre-service teachers to always maintain and optimize their self-efficacy in supporting the mathematical reasoning process. It is necessary to optimize the initial abilities possessed and review them to improve mathematical reasoning.

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