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Students' Reflective Thinking Profiles in Problem-Solving Based on Mathematical Resilience

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Abstrak

Penelitian ini berkontribusi pada penelitian yang terus berkembang yang menyoroti kemampuan berpikir reflektif siswa jika ditinjau dari resiliensinya dalam menyelesaikan permasalahan matematis. Kami mengeksplorasi resiliensi matematis dari 36 siswa yang diklasifikasi menjadi tiga kelompok tingkatan, yaitu rendahm sedang dan tinggi. Selanjutnya, masing-masing kelompok dipilih 2 siswa yang diteliti untuk mengetahui profil berpikir reflektifnya dalam memecahkan masalah matematis. Penelitian kami melihat tiga indikator berpikir reflektif, yaitu: elaborating/comparing dan contemplanting. Kami menggunakan soal pemecahan masalah dan pedoman wawancara yang telah tervalidasi oleh ahli dari kalangan pendidik dan praktisi. Sedangkan triangulasi data yang digunakan adalah metode. Penelitian ini mengidentifikasi secara empiris tiga "profil" yang berbeda dalam hal berpikir reflektif matematis. Profil-profil tersebut adalah: Siswa yang memiliki resiliensi matematis tinggi mampu memenuhi 3 fase berpikir reflektif yaitu fase reacting, comparing dan contemplatin, Siswa yang memiliki resiliensi matematis sedang hanya mampu memenuhi 2 fase berpikir reflektif yaitu fase reacting dan fase comparing, Siswa yang memiliki resiliensi matematis rendah hanya mampu memenuhi 1 fase berpikir reflektif yaitu fase reacting.
Kata Kunci: Berpikir Reflektif; Pemecahan Masalah; Resiliensi Matematis.

Abstract

This study contributes to the growing body of research that highlights students' reflective thinking abilities in relation to their resilience in solving mathematical problems. We explored the mathematical resilience of 36 students, classified into three level groups: low, medium and high. Furthermore, we selected two students from each group to investigate their reflective thinking profiles in solving mathematical problems. Our research examined three indicators of reflective thinking: elaborating/comparing and contemplating. We employed problem-solving questions and interview guidelines that have been validated by experts, including educators and practitioners. Meanwhile, Triangulation of data was used as the research method. This study empirically identified three distinct "profiles" of mathematical reflective thinking. These profiles are: Students with high mathematical resilience can fulfil all three phases of reflective thinking: reacting, comparing, and contemplating; Students with moderate mathematical resilience can only fulfil two phases of reflective thinking: reacting and comparing; Students with low mathematical resilience can only fulfil one phase of reflective thinking: reacting.
Keywords: Reflecting Thinking; Problem-Solving; Mathematical Resilience.

I. INTRODUCTION

Reflective thinking is an essential cognitive ability that empowers individuals to comprehend, critique, assess, seek information, and evaluate the problems they encounter (Erdoğan, 2020; Yaacob et al., 2020;). It plays a pivotal role in fostering thought processes during problem-solving situations by providing opportunities to utilize knowledge and experiences relevant to the problem at hand and devise the most effective strategies to achieve the desired outcome (Özçakir Sümen, 2023). Despite its significance, reflective thinking skills are often overlooked or inadequately developed in traditional classroom settings. To gauge a student's reflective thinking abilities, it is crucial to engage them in activities that elicit their level of reflective engagement. One such activity is mathematical problem-solving (Kholid et al., 2020; Musodiqoh & Jaelani, 2024). Aligned with this notion (Nobutoshi, 2023) emphasize that reflective thinking skills emerge and flourish when students actively engage in the problem-solving process. Therefore, the importance of reflective thinking in mathematics education, particularly in the context of solving and tackling mathematical problems, cannot be overstated. By cultivating reflective thinking abilities, students can effectively navigate the complexities of mathematical problems, develop deeper conceptual understanding, and enhance their overall problem-solving prowess.

Problem-solving is an essential aspect of mathematics learning. It serves as a central focus in mathematics education due to its significance in developing students' mathematical abilities and forming the core of the mathematics curriculum (Faulkner et al., 2023; Lisnani & Inharjanto, 2023). Problem-solving itself entails the process undertaken by students to find solutions or overcome obstacles they encounter. Rott et al. (2021) outlines four strategies for problem-solving: understanding the problem, devising a plan, executing the plan, and evaluating the obtained solution. Problem-solving demands creative and critical thinking skills; therefore, students must be equipped with these abilities to effectively tackle mathematical problems.

Students exhibit varying characteristics when faced with problems. Mathematical learning presents a range of challenges for students. A significant issue is the differing perceptions among individuals regarding the difficulty of mathematics (Wiguna, Candiasa, & Arnyana, 2024). Some students can solve problems quickly, while others take longer to reach a solution. Additionally, a student's perseverance and tenacity in the face of challenges significantly impact their performance, highlighting the importance of resilience (Weißenfels et al., 2023). Resilience is the characteristic of perseverance, determination, and self-belief that students possess to overcome anxiety (Widhi et al., 2023). Resilience can be interpreted as the ability to cope and adapt when faced with challenging events or problems in life (Vinogradov et al., 2023). Adolescents or students in secondary education are chosen as research subjects because adolescence is a transitional period where individuals experience significant changes in their lives.

One aspect that can build resilience in high school students is for adolescents or

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students to have clear goals in their lives, so that it is easy to rise from setbacks (Kuperminc et al., 2020). In addition, to form resilience, the interaction between internal factors, a supportive family, social conditions, environment, and education functions independently (García-Crespo et al., 2021). Therefore, the resilience that students have is influenced by various factors, one of which is the level of education.

Solving math problems requires a diligent and persistent attitude, so that mathematical resilience is needed (Suri & Herman, 2020). Students' mathematical resilience to overcome obstacles in learning mathematics (Ariyanto et al., 2018; Iswanto & Faradillah, 2023). Mathematical resilience has several indicators, (Ariyanto et al., 2019) the indicators of mathematical resilience are as follows: 1) Show a diligent attitude, work hard, believe in yourself, and don't give up easily in the face of problems, failures, and uncertainties. 2) Be easy to help, show a desire to socialize, discuss with peers, and adapt to the environment. 3) Bring up new ways/ideas and find creative solutions to challenges. 4) Use failure experiences to build self-motivation. 5) Have a curiosity, reflect, research, and utilize various resources. 6) Have the ability to control oneself and be aware of one's feelings.

Based on research Kuncoro and Juandi (2023) one way to increase mathematical resilience is by using problem-based learning, which pays special attention to supporting improvement. The differences or characteristics of students in solving problems are different.

Students' ability to engage in reflective thinking plays a crucial role in fostering their resilience when encountering challenges in mathematics (Hammad et al., 2024). By encouraging students to critically analyze their problem-solving processes, identify their strengths and weaknesses, and evaluate the effectiveness of their strategies, reflective thinking equips them with the tools to persevere through difficulties. This introspective process helps students develop a deeper understanding of their own learning styles, allowing them to adapt their approaches and develop more effective problem-solving strategies. Ultimately, this enhanced resilience empowers students to navigate complex mathematical concepts with confidence and achieve greater success in their mathematical endeavors.

Based on the above description and considering the importance of reflective thinking skills and resilience in students' mathematical problem-solving, the researcher feels the need to understand the profile of students' reflective thinking skills in solving mathematical problems, when viewed from their resilience. The aim is to estimate the maximum extent of students' reflective mathematical thinking skills in solving mathematical problems. This can then be used as evaluation material for teachers to improve teaching methods and strategies by considering their students' resilience. Ultimately, this research discusses the students' reflective thinking profiles in problem-solving based on mathematical resilience.

II. METHOD

This research employs a qualitative descriptive approach, gathering information from factual circumstance. The researcher served as the primary instrument, with a test question sheet as the supporting instrument. Data collection techniques included tests, interviews, and documentation.

The research commenced with the selection of subjects based on their mathematical resilience. The Mathematical Resilience Scale used in this study was adapted from an instrument developed by Kooken et al. (2024). The scale consists of 68 items divided into three factors: value, struggle, and growth. Grouping was determined by low, medium and high. Six students were selected as research subjects: two with low resilience, two with medium resilience and two with high resilience.

Participants undertook a mathematical problem-solving test on systems of two linear equations. The test items had been validated by three experts (a mathematician, a mathematics education specialist from a higher education institution, and a practicing mathematics teacher). Subsequent to completing the test, their responses were analysed based on indicators of reflective thinking, specifically reacting, comparing, and contemplating. Following the test, students participated in semi-structured interviews using a validated interview guide developed by educational experts and practitioners.

III. RESULT AND DISCUSSION

Based on the test results for the six subjects, the scores were obtained as shown in Table 1 below.

Table 1.
Test Scores of Subjects Based on Mathematical Resilince

Subject	Math resilience
S21	High
S25	High
S10	Medium
S31	Medium
S20	Low
S15	Low

Data obtained from written tests and interviews with six designated research subjects are presented based on the components of reflective thinking: reacting, comparing, and contemplating. These components are aligned with the indicators of students' reflective thinking abilities, which include: Interpreting a case based on the mathematical concepts involved, Identifying the mathematical formulas and concepts involved in non-routine mathematical problems, Evaluating and checking the validity of an argument based on the concepts and properties used, Drawing analogies between two similar cases, Analyzing and clarifying questions and answers, Generalizing and analyzing generalizations, Distinguishing between relevant and irrelevant data, Solving mathematical problems.

Therefore, this stage will reveal the achievement of the reflective thinking indicators for each subject. The analysis of data from written tests and interviews of the six subjects is as below.

Both students with high mathematical resilience fulfilled all indicators of the 3 phases of reflective thinking, namely the reacting, comparing, and contemplating

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phases. One description of reflective thinking in problem solving on subject S21 is described as follows:

A. Reacting fase

1) Fact identification

Subject S21 was able to read carefully the questions given and in part a) for question number 1 Sasa bought 3 packs of stick noodles and 2 mineral water for Rp 12,500.00. Kurnia bought 4 packs of stick noodles and 1 bottle of mineral water for Rp 13,000.00 and Dewi bought 4 stick noodles and 3 mineral water and paid with Rp 50,000. Problem number 2 test scores of Suzan, Toni, Amar and Tiara = 82, 80, 78 and 90 The average test score becomes 83 after including the test scores of Caca and Roni, the difference between Caca and Roni scores = 8, with Caca's score greater than Roni's score. Then for question number 3 qbal with 2 Alkaline batteries and 3 Eveready batteries for Rp 27,000.00. Risky with 3 Alkaline batteries and 3 Eveready batteries for Rp 33,000.00. Thus, the subject can explain completely what is known in the problem, thus fulfilling that the subject is able to explain about the identification of facts that have been done in the stage of understanding the problem in the reacting phase that has been done in the stage of understanding the problem in the reacting phase (Figure 1).

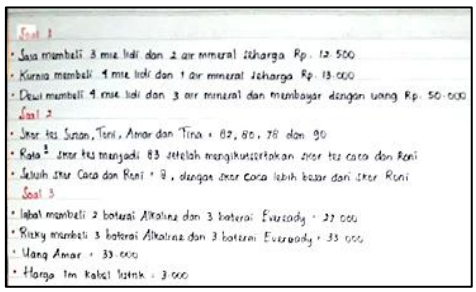

Figure 1. Fact Identification

2) Linking fact identification, question identification and data sufficiency with information

The subject can explain the mathematical model, in question number 1 it is assumed that x is a stick noodle and y is mineral water and the equation becomes

3x + 2y = 12,500

4x + y = 13,000

and for problem number 2, suppose x is Caca and y is Roni and the problem becomes

x = (average x number of students) - (number of known scores)

As for problem number 3, suppose x is Alkaline battery and y is Eveready battery with equation

2x + 3y = 27,000

3x + 3y = 33,00

this means that the subject can explain completely what is asked, so that it fulfils a in the stage of understanding the problem in the reactin phase (Figure 2).

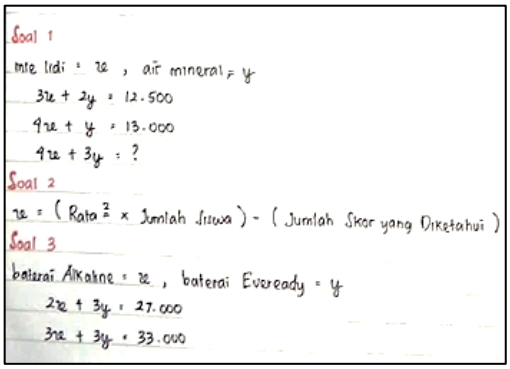

Figure 2. Connecting

Based on the interview of subject S2102, the subject has read completely and subject S2105 is able to mention what is known in problem number 1, problem number 2 and problem number 3. Subject S2106 is also able to mention what is asked in the three questions. In question S2107

the subject felt sufficient about the information known in the problem. Here's a snippet of the interview.

P2503 : What do you think about the questions I gave you? Was it difficult or easy?

S2103 : From the questions that you gave me, I think the questions were not bad.

P2505 : Then, the questions I gave you, what do you know from the three questions starting from number 1 to number 3?

S2105 : What is known for question number 1 is that Sasa bought 3 packs of stick noodles and 2 mineral waters for Rp 12,500. Etc. Risky with 3 Alkaline batteries and 3 eveready batteries for Rp 33,000.

P2506 : Then can you mention what is asked of the three questions?

S2106 : The question is about the change received by Dewi. And for question number 2 what is asked is the score obtained by Caca and Roni. The question for question number 3 is how many batteries can Amar buy with Rp 33,000 minus the price of the electric cable of Rp 3,000.

P2507 : Okay, then from the three questions do you think the information given is enough to answer what is asked in the question?

S2107 : It's enough.

B. Comparing fase

1) Problem-solving strategies

S21 explained the method used in solving the problem that had been faced, namely by using the mixed method (Figure 3).

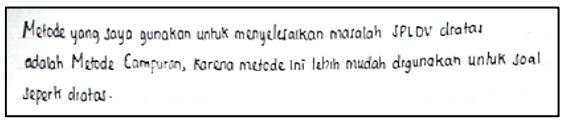

Figure 3. Problem-Solving Strategies

2) Linkages between problems

The subject can explain the relationship or link between problems that have been faced before and problems given by researchers, namely both looking for the price or value of an item and using methods in System of Linear Equations in Two Variables (SLETV) (Figure 4).

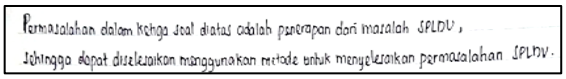

Figure 4. Linkages between Problems

Based on interview S2108 the subject explained the most effective method used, namely using the method of elimination and substitution. in question S2109 the subject used the method of elimination and substitution in working on the problem given. and in statement S2111 the subject was able to explain the relationship with the problem that had been done before. Here's a snippet of the interview.

P2508 : To solve the SLETV problem, what method do you think is the most effective?

S2108 : Using the mixed method of elimination and substitution because this method is easier to use for problems like the one above.

P2509 : Then in working on the given problem, what method did you use?

S2109 : The method I used to solve the SLETV problem above is the mixed method, because this method is easier to use for problems like the one above.

P2510 : Can you mention other two-variable linear equation system problems that you have faced?

S2110 : The SLETV problems that I have encountered I have experienced in my daily life.

P2511 : Then how does that problem relate to the problem in the question

S2111 : Problems like the three problems above are applications of SLETV problems, so they can be solved using the method to solve SLETV problems.

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C. Contemplating fase

1) Explaining problem-solving

In problem number 1 the subject makes a mathematical model then eliminates the equation so as to obtain the value x = 2,700 after that substitute the value x = 2,700 into the equation 3x + 2y = 12,500 and obtain the value y = 2. 200 and for problem number 2 the subject made a mathematical model obtained an equation then from the equation was eliminated so that Caca's score was 88 and Roni's score was 80, and for problem number 3 the subject first made a mathematical model then eliminated the equation using the elimination method so that the value x = 6,000 was obtained and then used the substitution method by substituting it into the equation 2x +3y = 27,000 to produce a value y = 5,000 (Figure 5).

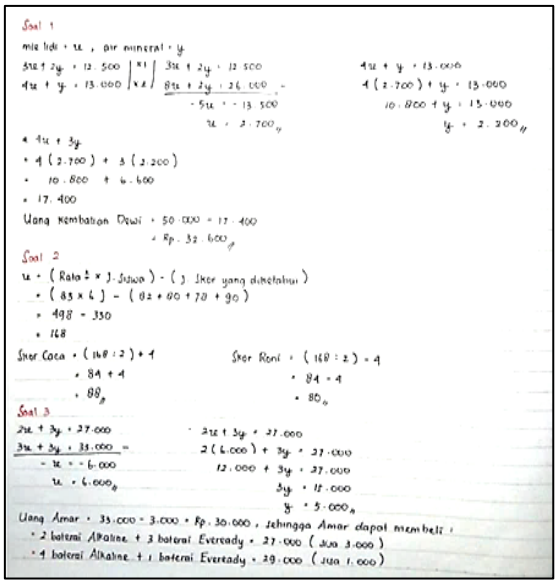

Figure 5. Problem-Solving

2) Checking

At the review stage for the Contemplating phase can be described as follows. The subject explained that the answers obtained had answered the questions from the problem with the results, namely for question number 1 the money received by Dewi was RP 32,600, for question number 2 the scores received by Caca and Roni were 80 and 88 respectively, and for question number 3 Amar could buy 2 Alkaline batteries and 3 Eveready batteries or Amar could buy 4 Alkaline batteries and 1 Eveready battery.

3) Conclusion

The subject can explain that the conclusion obtained is correct, namely for question number 1 Dewi gets change of Rp 32,600, for question number 2 the score received by Caca is 80 and the score received by Roni is 88. Then question number 3 Amar can buy 2 alkaline batteries and 3 eveready batteries or Amar can buy 4 Alkaline batteries and 1 Eveready battery and the conclusion is SLETV is a system of several linear equations of 2 similar variables (Figure 6).

Figure 6. Conclusion of Answer

Based on the results of the interview S2114 the subject can solve the problems of the three problems. statement S2115 the subject can detect no errors. in statement S2116 the subject can conclude the answer correctly. Here's a snippet of the interview.

P2512 : Does the mathematical model that you have made reflect the problem?

S2112: Yes

P2514 : Then can you mention the answers you got from the three problems you have done?

S2114 : The answer to question number 1 obtained the x value is 2,700 and the y value = 2,200, Dewi bought 4 stick noodles and 3 bottles of mineral water and entered the x and y values 4 times 2,700 plus 3 times 2,200 and the result is 17,400 then 50,000-17,400 = 32,600. for question number 2 using the average obtained x value = 168, then obtained Caca's score = 88 and Roni's score 80.

P2515 : From the answer you did. Are you sure about that answer?

S2115: Yes, sure

P2516 : Then what is the conclusion that you get in the problem?

S2116 : The conclusion obtained is so in number 1 Dewi gets change of Rp 32,600, for question number 2 the score received by Caca is 80 and the score received by Roni is 88 and number 3 Amar can buy 2 Alkaline batteries and 3 Eveready batteries or Amar can buy 4 Alkaline batteries and 1 Eveready battery so the conclusion is SLETV is a system of several linear equations of two variables.

Based on the explanation above, it can be concluded that the subject in the high category with the initials S21 is reflective because the subject fulfils the 3 phases of reflective thinking, namely the reacting phase, the comparing phase and the contemplating phase.

Using the same profile analysis method as subject S21. The other five subjects analysed their problem-solving results based on reflective thinking skills and conducted interviews. The following is a resume of the six profiles of the six research subjects.

At the stage of understanding the problem in the Reacting phase, based on the analysis of the 6 main subjects in the study, all subjects can make conclusions based on understanding what is known correctly, can write down what is asked, and can also create and define mathematical symbols or models correctly, and explain the relationship between the two.

The stage of planning a problem solving plan in the Comparing phase, students' answers in this phase affect their understanding of the material. Where in understanding the material that students have is included in reflective thinking ability, because it is expected that students can compare reactions with other experiences, such as referring to a general principle, or problems that have been done before. So that students can make a plan for solving the problem. In this study, there were 4 subjects who were able to go through the Comparing phase, namely 2 subjects from the high resilience category, subject S21 and subject S25 and from the medium resilience category, subject S10 and subject S31. Subjects in the low resilience category, namely subject S20 and subject S15, did not go through this phase because they did not understand the material and problems given so they could not develop their problem solving.

The stage of carrying out problem solving in the Contemplating phase, researchers know that only subjects with high resilience categories, namely subject S21 and subject S25. Subjects with medium category subject S10 are still confused about substituting and the subject's arithmetic skills are also lacking as well as the medium category subject S31 whose arithmetic skills are lacking so that students are less thorough in problem solving and

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for subjects with low resilience category subjects S20 and S15 do not really know the method to be used and lack arithmetic skills so they cannot solve the problems given. Student skills should be very influential in problem solving. The review stage in this phase, only subjects with high mathematical resilience category went through this stage. Subjects with moderate mathematical resilience and low mathematical resilience categories could not solve the problem which resulted in no conclusion. In addition, these four subjects could not identify whether there were any mistakes when working on the problems given.

IV. CONCLUSION

Based on the results and discussion, students who have high mathematical resilience are able to fulfil the 3 phases of reflective thinking, namely the reacting, comparing and contemplating phases and fulfil all indicators of reflective thinking, students with high mathematical resilience are able to explain the identification of facts or what is known, explain the identification of questions and can connect fact identification, identification of questions and data sufficiency, can explain the strategies that have been done in solving SLETV material problems, can explain the strategies that will be done, can relate between problems, can solve SLETV problems, students can also explain the results obtained and whether there are errors and students can explain the conclusions that have been obtained with the right process.

Students who have moderate mathematical resilience are only able to fulfil 2 phases of reflective thinking, namely the reacting phase and the comparing phase and indicators that meet students with moderate mathematical resilience students are able to explain the identification of facts or what is known, explain the identification of questions and can connect the identification of facts, identification of questions and data sufficiency, can explain the strategies that have been done in solving SLETV material problems, can explain the strategies that will be done, can relate between problems. However, students are less careful in calculating and explaining the SLETV problem solving given. Students also cannot explain the results obtained and do not know the location of the error so they cannot correct it, so students cannot explain the conclusions obtained correctly.

Students who have low mathematical resilience are only able to fulfil 1 phase of reflective thinking, namely the reacting phase and indicators that fulfil students with moderate mathematical resilience students are able to explain the identification of facts or what is known, explain the identification of questions and can connect the identification of facts, identification of questions and data sufficiency, but in the comparing phase and contemplating phase students cannot explain the strategies that have been done in solving SLETV material problems, cannot explain the strategies that will be done, cannot relate between problems. However, students are less careful in calculating and explaining the SLETV problem solving given.

Students also cannot explain the results obtained and do not know the location of the error so they cannot correct it, so students cannot explain the conclusions obtained correctly.

It is expected that further research will be conducted to delve deeper into the learning of students with lower resilience. The objective is to equip them with reflective thinking skills comparable to students with moderate resilience. This will enable them to effectively navigate the 'comparing' and 'contemplating' phases, allowing them to articulate strategies previously used in solving Simultaneous Linear Equations problems, outline future approaches, connect different problems, and identify errors for improvement. In this context, resilience needs to be cultivated in students to empower them to overcome mathematical challenges and enhance their reflective thinking abilities.

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