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Reflective Thinking Ability in terms of Mathematical Resilience of Mathematics Student Teachers

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Abstract: This study aims to describe and analyze mathematical reflective thinking ability in terms of mathematical resilience in mathematics student teachers. Three participants of this qualitative descriptive study were 4th-semester student teachers at one of the universities in Jakarta, selected using the purposive sampling technique. The research instruments used were a mathematical reflective thinking ability test, a mathematical resilience questionnaire, and an interview guideline. Data was validated using time triangulation and analyzed using the constant comparative method, with the following steps: (1) data reduction and categorization; (2) data presentation; and (3) concluding. The results showed that the student teachers with high mathematical resilience had good mathematical reflective thinking skills because they could fulfill all mathematical reflective thinking ability indicators and have high self-confidence and assurance. Meanwhile, student teachers with moderate resilience lacked mathematical reflective thinking ability because they could not meet all indicators, were less thorough, and lacked details even though they had good enthusiasm and self-confidence. Meanwhile, students with low resilience had poor mathematical reflective thinking ability, were careless and not detailed, and tended to quit when encountering difficult problems.
Keywords:reflective thinking ability, pre-service mathematics teacher, mathematical resilience

1. Introduction

The COVID-19 pandemic has influenced all sectors globally, including the education sector, to utilize digital technology in their daily lives. The optimal use of digital technology is one of the characteristics of the 4.0 Industrial Revolution [1], [2]. Dealing with the 4.0 Industrial Revolution requires high adaptation and consistency so that careful preparation is a must [3], [4]. One of the important elements to consider is preparing and improving the competence of graduates who have 21st-century skills (Learning and Innovations Skills).

The 21st-century skills have five main domains; one of them is the thinking skill. In addition, the thinking skill is also an aspect of life skills that need to be developed through the educational process [5]–[7]. Through thinking skills, a person can observe and solve all life problems, including mathematics. When a person does mathematics, whether it is only to understand mathematical concepts, use them in solving mathematical problems, or use mathematics in everyday life, of course, must be accompanied by thinking skills. Therefore, thinking skill is essential that for every student at every level of education.

One of the thinking skills included in the Higher Order Thinking Skill (HOTS) is the ability to think reflectively [8]. The reflective thinking ability is called "the capacity of human minds and brains in understanding and creating knowledge" [9]. In comparison, [10] defined the reflective thinking skill as a process of interpreting one experience to the next one by making a deeper understanding of the relationship and connecting other experiences or ideas. Furthermore, it is stated that reflective thinking ability will certainly be critical in solving mathematical problems, called mathematics reflective thinking ability [11].

In addition to the ability of reflective thinking mathematically, a positive adaptive attitude is also needed [12] in solving mathematical problems, a quality attitude [13] reflected in a diligent and persistent attitude despite facing problems in learning mathematics. The attitude is mathematical resilience, one of the attitudes of internal factors affecting a person's success in learning mathematics [14], [15]. This is evidenced by [16] research that students with high mathematical resilience could solve mathematical problems well, while students with low resilience have more weaknesses in solving mathematical problems.

Therefore, both mathematical reflective thinking skills and mathematical resilience are interesting and important to study. Several previous studies have been carried out, for example examining the mathematical reflective thinking ability with certain learning models or strategies, such as problem-based learning, metacognitive and Argument-Driven learning, scaffolding strategies, and knowledge sharing learning strategies [17]–[20]. Also, the study of mathematical reflective thinking ability was associated with other mathematical abilities, learning styles, and even students' initial abilities, including reflective thinking and problem-solving abilities [21], [22], reflective thinking ability and prior knowledge [23] & [24], reflective thinking ability and learning styles, interest in learning and even self-confidence [25]–[27].

On the other hand, research related to mathematical resilience is also diverse. Many are also related to other mathematical abilities, for example, mathematical communication skills based on mathematical resilience [16], [28] and problem-solving and mathematical literacy in terms of resilience [29] & [30]. Creative thinking and critical thinking abilities are developed from students' mathematical resilience [31]–[33] and reflective thinking skills in terms of students' mathematical resilience [34].

Previous studies mentioned above were conducted mostly on high school students. Only one study was related to mathematical reflective thinking ability in terms of mathematical resilience, conducted in Semarang with vocational students as the research subject. Thus, it is necessary to study mathematical reflective thinking ability in terms of the mathematical resilience of mathematics student teachers as the related study is limited. This study aims to describe and examine in-depth the mathematical reflective thinking ability in terms of the mathematical resilience of mathematics student teachers at a university in Jakarta.

2. METHODS

This research is a qualitative descriptive study. It was conducted at one of the universities in Jakarta, and the research participants were mathematics student teachers in the fourth semester. The instruments used were a mathematical resilience questionnaire, a mathematical reflective thinking ability test, and an interview guideline.

The mathematical resilience questionnaire consisted of 32 items, with positive and negative statements. It had been tested for validity and reliability so that it can be used to measure the mathematical resilience of mathematics student teachers. The indicators of the mathematical resilience used in this study are: (1) Having the belief that mathematics is valuable and worthy to be practiced and studied; (2) Having the will and persistence in learning mathematics, despite the difficulties, obstacles, and challenges; (3) Having the self-confidence to learn and master mathematics, based on an understanding of mathematics, the ability to create strategies, the assistance of tools and other people, and experience; (4) Have a defensive nature, never quitting and always give a positive response.

The mathematical reflective thinking ability test comprised five problems that satisfied the reliability and validity test and thus can be used to measure the reflective thinking ability of mathematics student teachers. The indicators of mathematical reflective thinking ability used in this study are: (1) Analyzing the truth of the problem/solution/analogy or generalization of mathematics; (2) Identifying mathematical concepts or formulas used in non-simple math problems; (3) Discovering various strategies in solving mathematical problems.

This study used a semi-structured interview because it is more flexible and can dig answers from the participants more sharply. Interviews were conducted with the participants selected based on their level of mathematical resilience. The questions asked were related to the mathematical reflective thinking ability test completed previously.

The researchers employed a triangulation method: the test, documentation,, and interview to examine the data validity. The data analysis of this research used the constant comparative method. Data analysis is done by the constant comparative method, comparing one datum to another, then constantly comparing categories with other categories [35]. The steps in data analysis include: (1) reduction of data and categories by selecting data according to what is being studied and removing the unnecessary data from the data analysis process; (2) data presentation, where the reduced data is presented based on the needs in analyzing mathematical reflective thinking ability in terms of the mathematical resilience of mathematics student teachers; and (3) concluding and verification, where the data presented is compared and analyzed based on indicators of the mathematical reflective thinking ability test and adjusted to the level of mathematical resilience of research participants.

3. RESULTS AND DISCUSSION

3.1. Result

Twenty-eight mathematics student teachers were selected as the participants in this research, and a mathematical resilience questionnaire was administered to determine the category of their mathematical resilience level. The level of resilience was determined by adopting Srifuddin in [16], as presented in Table 1. Students are in the high resilience category when their score is greater than or equal to 2.7, the moderate category if it is between 1.2 and 2.7, and the low resilience category when the score is less than 1.2.

Table 1. The Classification of Mathematical Resilience Level

Criteria	**Score**	**Category**
$X \geq (M+1SD)$	$X \geq 2.7$	High resilience
$(M-1SD) \leq X < (M+1SD)$	$1.2 \leq X < 2.7$	Moderate resilience
$X < (M-1SD)$	$X < 1.2$	Low resilience

The score of the mathematical resilience was not an interval scale. Thus, the Rasch model approach, with Winstep 4.3.3 software, was employed to modify the scores into interval data to operate. Figure 1 presents the output of the winstep program.

Person STATISTICS: MEASURE ORDER

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMEASUR-AL CORR.	PTMEASUR-AL EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	Person
99	112	32	3.67	.39	2.49	4.50	2.03	2.82	.78	.77	71.9	72.5	144PB
94	109	32	3.25	.36	1.28	1.31	1.13	.60	.90	.77	71.9	67.2	094PB
95	108	32	3.11	.36	1.40	1.81	1.23	1.05	.89	.77	68.8	65.5	104PB
108	108	32	3.11	.36	1.09	.50	1.01	.12	.88	.77	59.4	65.5	284PA
116	106	32	2.86	.35	1.49	2.22	1.32	1.49	.90	.77	53.1	62.3	274LA
84	105	32	2.74	.35	.95	-.20	.89	-.48	.85	.77	62.5	61.6	044PC
91	104	32	2.62	.35	.97	-.11	1.07	.41	.81	.77	59.4	61.0	064PB
102	104	32	2.62	.35	1.07	.41	1.04	.29	.90	.77	53.1	61.0	174PB
110	104	32	2.62	.35	1.01	.12	1.01	.11	.86	.77	53.1	61.0	214PB
54	103	32	2.50	.34	.93	-.32	.91	-.38	.76	.77	71.9	60.7	024PB
115	103	32	2.50	.34	1.01	.12	.97	-.06	.84	.77	53.1	60.7	264PA
93	102	32	2.38	.34	1.32	1.53	1.28	1.35	.84	.77	50.0	61.8	084PA
98	101	32	2.27	.34	.71	-1.50	.71	-1.49	.86	.77	71.9	62.5	134PA
111	100	32	2.15	.34	.75	-1.21	.74	-1.30	.86	.77	75.0	63.0	224PA
101	99	32	2.03	.34	.76	-1.17	.78	-1.06	.82	.77	68.8	63.7	164LB
28	96	32	1.68	.34	1.17	.76	1.15	.68	.58	.78	68.8	66.0	014PB
96	96	32	1.68	.34	.76	-1.04	.76	-1.02	.83	.78	81.3	66.0	114PB
100	96	32	1.68	.34	.90	-.38	.90	-.34	.76	.78	75.0	66.0	154PA
107	96	32	1.68	.34	1.07	.36	1.08	.41	.77	.78	62.5	66.0	194PA
109	95	32	1.56	.35	.60	-1.87	.63	-1.67	.80	.78	78.1	66.8	204PC
85	94	32	1.44	.35	.71	-1.20	.66	-1.42	.81	.78	84.4	67.9	054PB
92	94	32	1.44	.35	1.71	2.43	1.71	2.38	.50	.78	62.5	67.9	074LA
113	92	32	1.20	.35	.78	-.81	.76	-.86	.75	.78	78.1	69.3	244LA
55	91	32	1.08	.35	.57	-1.82	.66	-1.32	.80	.78	84.4	69.9	034LD
112	91	32	1.08	.35	.39	-2.89	.48	-2.25	.93	.78	90.6	69.9	234PB
97	90	32	.96	.35	.80	-.67	.90	-.27	.70	.78	81.3	70.6	124PA
114	88	32	.71	.35	1.50	1.63	1.48	1.54	.71	.78	59.4	71.7	254PA
103	82	32	-.03	.35	1.64	2.02	2.21	3.02	.49	.76	56.3	70.1	184PA
MEAN	98.2	32.0	1.95	.35	1.01	.0	1.00	-.1			68.7	66.0	
P.SD	6.2	.1	.75	.01	.41	1.6	.40	1.5			10.6	3.4	

Figure 1. The Output Measure Order Using Winstep 4.4.3

The mathematical resilience level of student teachers can be summarized in Table 2. Most mathematics student teachers have moderate resilience (17), seven people with high resilience and five people with low resilience.

Table 2. Resilience Level Categorization Results

Resilience Level	Frequency
High	6
Moderate	17
Low	5

Next, one research subject from each category of mathematical resilience was chosen, RF (coded S1) for the high category, SN (coded S2) for the medium category, and LG (coded S3) for the low category. The three subjects were chosen by purposive sampling in order to achieve the objectives of this study. The data analysis results of each subject and the triangulation of the method carried out will be discussed in the following section.

3.2. Discussion

The discussion of the three research subjects is presented one by one, starting from the research subject with high, followed by medium and low resilience levels.

3.2.1. S1 with High Resilience

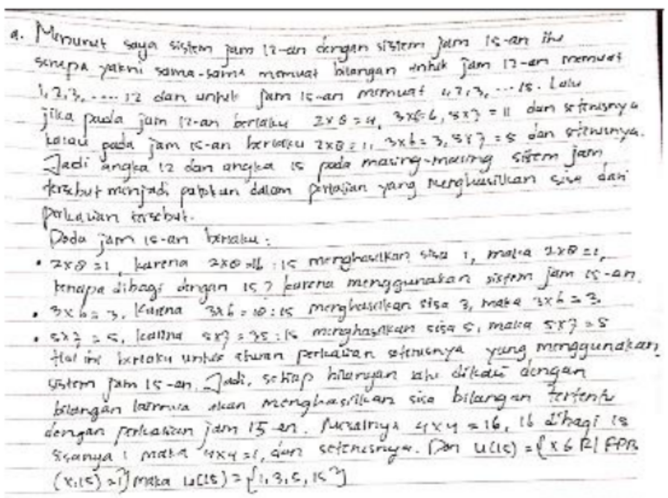
Problem 1: Let there is a 12-hour clock. It contains the numbers 1,2,3…,12, assumed to be S and 2x8 = 4, 3x6 = 6, 5x7 = 11 and so on applies. In addition, we can also construct a system named U (12), consisting of {[1], [5], [7], [11]}, which is a group.

Note that:

a. Similar to the 12-hour clock, we can also construct another clock system.
   Suppose R = {1,2,3,…,15} is the set containing all numbers in the 15-hour clock and U(15) = {x∈RI GCF (x,15)=1}.

Question: Clarify the similarity mentioned in point a and explain the principles, rules, or concepts related to the similarity!

The indicator of Problem 1 is able to analyze the truth of the question/solution/analogy or generalization of mathematics. The research subject is asked to clarify or analyze the truth of the analogy or similarity of the case in the problem. Figure 2 shows S1's answer for Problem 1, and Table presents the result of the S1 interview related to Problem 1.


a. Menurut saya sistem jam 12-an dengan sistem jam 15-an itu serupa yakni sama-sama memuat bilangan untuk jam 12-an memuat 1,2,3,....12 dan untuk jam 15-an memuat 1,2,3,...15. Lalu jika pada jam 12-an berlaku 2x8=4, 3x6=6, 5x7=11 dan seterusnya kalau pada jam 15-an berlaku 2x8=1, 3x6=3, 5x7=5 dan seterusnya. Jadi angka 12 dan angka 15 pada masing-masing sistem jam tersebut menjadi patokan dalam perkalian yang menghasilkan sisa dari perkalian tersebut.

Pada jam 15-an berlaku:

- 2x8=1, karena 2x8=16:15 menghasilkan sisa 1, maka 2x8=1, kenapa dibagi dengan 15? karena menggunakan sistem jam 15-an.
- 3x6=3, karena 3x6=18:15 menghasilkan sisa 3, maka 3x6=3.
- 5x7=5, karena 5x7=35:15 menghasilkan sisa 5, maka 5x7=5

Hal ini berlaku untuk aturan perkalian seterusnya yang menggunakan sistem jam 15-an. Jadi, setiap bilangan jika dikali dengan bilangan lainnya akan menghasilkan sisa bilangan tertentu dengan perkalian jam 15-an. Misalnya 4x4=16, 16 dibagi 15 sisanya 1 maka 4x4=1, dan seterusnya. Dan U(15) = {x∈R| FPB (x,15)=1} maka U(15) = {1,3,5,15}

Figure 2. S1 answers for Problem 1

Table 3. S1 Interview Results for Problem 1

Researcher (R)	Subject 1 (S1)
Do you understand the problem?	Alhamdulillah, I can understand it clearly.
Please, Explain.	So Problem 1 asks us to find and explain the similarities in this problem.
How many similarities have you found?	There are several similarities. For example, the 12-hour clock is similar to the 15-hour clock system, S12, and R15. Then, the operations that apply to S12 are also similar to the operations apply to R15. If S12 applies modulo 12, if R15 applies modulo 15. Also, U12 and U1 have the same members of the set, and both are the GCF of 12 or 15, that is 1.

Did you just read and answer when you did this problem, or did you need time to understand the problem?	I didn't understand it right away, but it can be understood if you read it slowly, think about it carefully, understand what the question wants, look at what is known in this problem one by one.
After solving problem 1, did you re-check the solution?	I re-checked it. I'm worried that I missed some information, so I have to re-check it before continuing to Problem 2
Jadi kamu yakin ni ya sama jawaban kamu? Are you sure with your answer?	God's willing. Hopefully, it is perfect.
Can you re-check the last sentence?	Oh yes, something is incorrect; I was not careful in calculating the GCF x with 15.

Figure 2 and Table 3 reveal that S1 cannot directly answer Problem 1. However, S1 was confident that s/he could answer this question even though it takes time to understand the problem. The answers show that S1 could answer this question well. S1 could translate all the information in the problem and clarify all similarities in the problem. S/he also reflected at the end of the stages before moving on to other problems. There was an error at the end of the solution due to not being careful, and s/he could realize the mistakes if given another chance.

Furthermore, we analyze S1's answer for question Problem 2, as follows
Problem 2: Let (Z6,+) is a group. From the following five subsets of Z6: A. {0}; B. {0,1}; C. {0,3}; D. {0,2,4}; E. {0,1,2,3,4,5}.

Question :

a. Identify all the concepts, rules, properties, or formulas used to make the five subsets above into a subgroup (Z6,+).
b. If any, choose a subset that is not a subgroup of (Z6+), and explain!

This indicator of this problem is able to identify mathematical concepts or formulas used in non-simple math problems. S1's answer and interview results are presented in Figure 3 and Table 4.

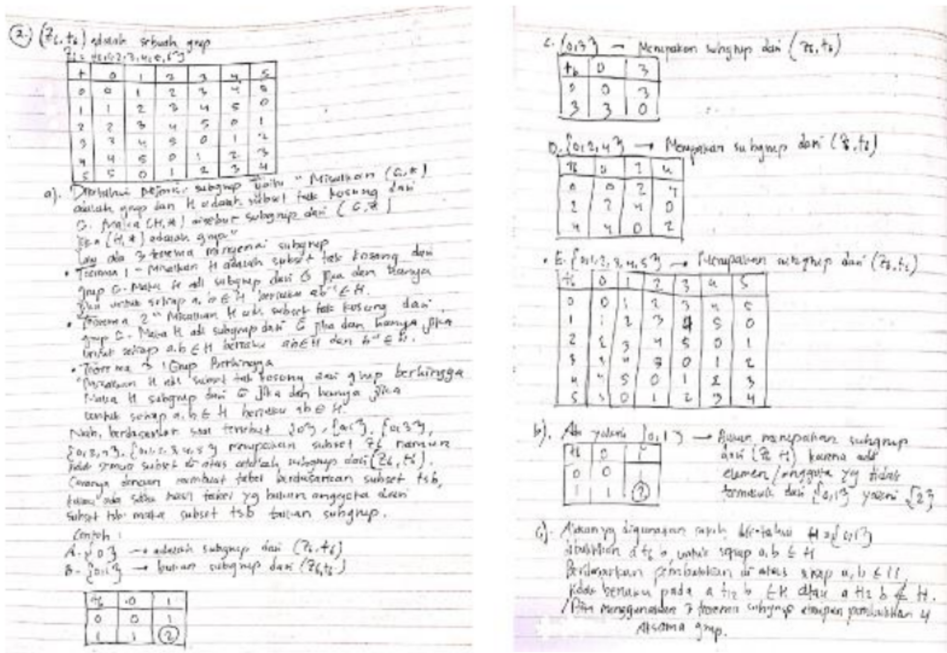


Figure 3. S1's answers for Problem 2

Table 4. S1's Interview Results for Problem 2

Researcher (R)	Subject 1 (S1)
Problem 2 is easy, isn't it?	Not really. Many steps must be taken. If you are not careful, you can make mistakes when choosing a non-subgroup.
What should be done to solve Problem 2?	First, I summarized the concepts for the subgroup. The next step was to choose one of the subgroup concepts that I could use for the five subset options in the problem. Then, I checked options A to E to determine which ones are not the subgroup of (Z6,+).
After concluding which option is not a subgroup of Z6, did you re-check your long answer?	Yes, I re-checked to ensure there were no forgotten concepts and typos.
So, are you sure about your answer?	God's willing Yes, I am sure.

Figure 3 and Table 4 indicate that S1 could identify the concepts asked by the problem, solve mathematical problems given calmly and not in a hurry, was confident and sure that s/he could solve this problem even though the stages were not simple. S1 was also able to carry out the reflection stage at the end before moving on to the next problem. Figure 3 and Table 4 also inform that S1 could find various strategies for solving mathematical problems, connect old experience with new knowledge in solving math problems, carefully think when solving the problem step by step, and not forget to re-check the solution before moving on to another problem.

3.2.2. Subject 2 (S2) with Medium Resilience

S2's answers can be seen in Figure 4 and Figure 5, and the interview results are shown in Table 5.

Figure 4. S2's answers for Problem 1

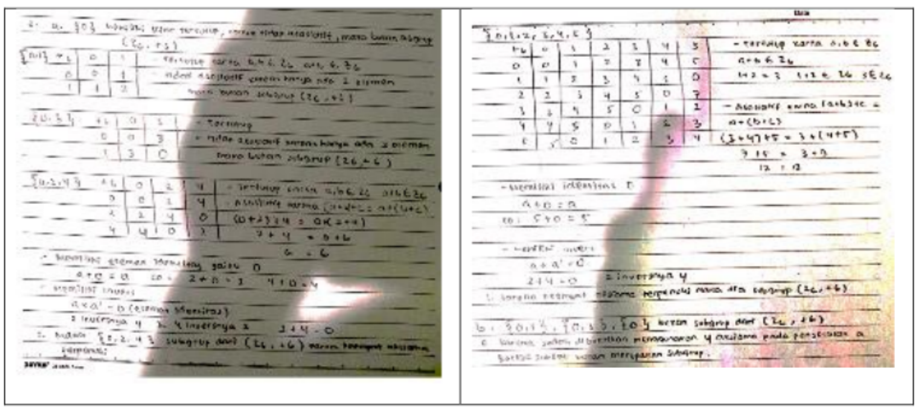


Figure 5. S2's answers for Problem 2

Table 5. The Interview results of S2

Researcher (R)	Subject 2 (S2)
We will discuss Problem 1	Ok
Do you understand the problem?	Yes, the similarity analysis of the data in Problem 1.
Explain!	So, in this question, there are several same analogies. Now, we are asked to analyze whether the analogies in this problem are the same.
So, how many of the same analogies did you manage to analyze?	First, the concepts of the 12-hour or S clock system are the same as the 15-hour or R clock. The S members are 1 to 12, while R members are 1 to 15 Then, U12 and U15 have similarities because both members have GCF = 1, with 12 for U12 and with 15 for U15.
Are there any other analogies that have not been analyzed?	I think that's all
Are you sure this is the correct answer?	Yes, I am sure. Hopefully, it is correct.
This problem is easy, isn't it?	Not really. I had to re-read many times to understand what the problem wanted. This question is a bit different from the usual questions.

After you did this problem, did you re-check your answers?	Yes, I did. To ensure whether there is anything wrong in the calculation or writing of the symbol.
Problem 2 is not difficult, is it?	It is the same as Problem 1. It needed concentration, and it was not enough to just read it once. I needed to re-read so that I didn't make a wrong step.
What are the steps to solve it?	I understand the data given in the problem. I looked for what was asked in the problem, then explained the concept of a subgroup using four group axioms. Next, I tried out the concept of the five known subsets in the problem and concluded which subset is not a group.
After concluding which option is not a subgroup of Z6, did you re-check your answer?	Yes. I re-check, but I am a little doubtful. There are so many that are not subgroups.

Figure 4, Tables 4 and 5 show that S2 cannot immediately solve Problem 1. However, S2 tried to re-read the problem so that s/he could understand and re-try to solve Problem 1. Although s/he was not completely sure of the answer, S2 kept trying, as evidenced by some concepts that had not yet been clarified and S2's explanation not as detailed as S1. This indicates that S2 had not been able to translate all the information. However, S2 reflected at the end of the stage before moving on to another problem.

Furthermore, for Problem 2, S2 could not identify all the concepts requested by the problem, find various strategies for solving mathematical problems, not connect old experience with new knowledge well in solving math problems.

3.2.3. Subject 3 (S3) with Low Mathematical Resilience

S3's answers can be seen in Figure 6, and the interview results are shown in Table 6.

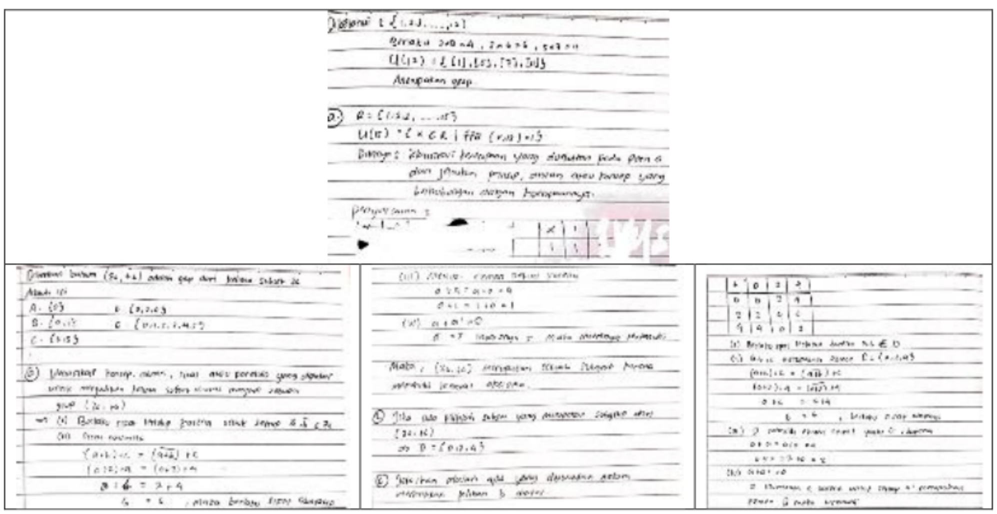


Figure 6. S3's Answers

Table 6. The Interview Results of S3

Researcher (R)	Subject 2 (S2)
The answer to Problem 1 is interesting. Please, explain it to me.	Yes, I had read it many times but still didn't understand. I tried to write something, but I was not confident. I finally gave up and moved on to another problem because I was worried that I would run out of time.

What about Problem 2? Is it also hard?	It was easier to understand than the previous problem, but I still had doubts. There are many things to identify. There are subsets, subgroups, and not to mention groups.
After doing the problem, did you re-check your answer?	No, I surrendered. I had a headache.

Figure 6 and Table 6 reveal that S3 could not solve Problem 1. She felt the problem was difficult and did not understand what was being asked in the problem. S3 felt hopeless and was unsure that s/he could solve the problem, so s/he quitted trying and failed. However, S3 managed to identify the known data in the problem. S3 also made an error in presenting the mathematical concept requested by Problem 2, did not match the concept to all the data given in the problem, and did not reflect before moving on to another problem. S3 could not discover various strategies for solving math problems nor connect previous experiences with new knowledge in solving math problems.

4. Conclusion

Based on the results and discussion in this study, the following are the conclusion of this study.

a. Mathematics student teacher with a high level of mathematical resilience could meet all indicators of mathematical reflective thinking ability, explain the identification of known facts and data, identify the problem and explain strategies to conduct, link experience with new knowledge, think with full consideration, confidence and certainty when working problem-solving step by step. The student also did not forget to re-check the answer before moving on to other problems.
b. The student with moderate mathematical resilience did not fulfill all indicators of mathematical reflective thinking ability. However, they could explain the identification of known facts or data, explain the identification of the problem. S/he could not translate all the available information but could explain the strategies conducted despite not being detailed. S/he continued to try to solve the problem and did not give up. S/he also reflected at the end of the stages before moving on to other problems.
c. The student with low mathematical resilience could only fulfill some indicators of mathematical reflective thinking ability. S/he could explain the identification of facts despite incomplete. On the other hand, s/he could not explain the problem and the strategies used. S/he was careless in solving the problem, could not explain the conclusions correctly, and quitted when experiencing problems in solving problems.

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