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Student's Anomaly Reasoning in Solving Number Pattern in terms of Gender

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Abstract. *Relational reasoning plays an important role in helping students to understand mathematical concepts. The student's ability to distinguish patterns or objects is one of the understandings of mathematical concept indicators. The anomaly dimension is part of the relational reasoning that students need to be able to determine a pattern or object in mathematics. This study aims to reveal the student's relational reasoning ability of anomaly dimension in solving number pattern problems in terms of gender differences. The subjects of this study are 52 grade-8 students in one of Muhammadiyah Junior High Schools in Kartasura. We used two similar problems on number patterns to disclose the student's ability to identify the pattern deviation in solving problems. The two selected students had relatively similar in their mathematical abilities. The finding showed that female subject met the three anomaly dimension indicators: identification, interpretation, and adaptation. Conversely, male student cannot fulfill the anomaly indicators. He cannot recognize pattern deviation in the formed mathematical model. He also failed to identify a pattern different from the two problems. Although the subjects interviewed were limited, the finding provided the insightful into the differences in anomaly reasoning abilities in male and female students.*

Keywords*: relational reasoning, anomaly reasoning, gender, number pattern*

Introduction

Understanding the concept of a pattern is necessary for students to master the material and solve problems, especially in determining a number pattern (Apiati, Heryani, & Muslim, 2019). However, most students still have difficulty solving pattern regularity problems. This is because students cannot identify or generalize a pattern (Indha, Sari, Hidayanto, & Malang, 2018). Students need help when determining patterns and only focus on specific formulas so that students cannot solve the problem correctly (Ariyanti & Setiawan, 2019). Octriana, Ilma, and Putri (2019) revealed that when students do the number pattern problem, they first submit a conjecture to find the formed pattern. However, when drawing conclusions, the student cannot explain because he made a mistake in operating the numbers.

The reasoning is one of the mathematical skills that must be developed in mathematics learning, besides other abilities such as problem solving, communication, connection, and representation (National Council of Teachers of Mathematics, 2000). In addition, NCTM (2000) also states that reasoning abilities can help students recognize patterns, structures, or regularities that appear in symbolic objects or the real world. Relational reasoning is one of the important dimensions of reason for students to understand mathematical concepts (Miller & Bunge, 2014) and help students solve mathematical problems in new situations (Bernard, 1987). Dumas, Alexander, Baker, Jablansky, and Dunbar (2014) explain that solving number patterns is also related to students' relational reasoning abilities.

Relational reasoning is a fundamental cognitive process involved in the conceptual formation and includes the ability to detect similarities and differences between objects, concepts, and situations (Alexander, Zhao, & Sun, 2020; Dumas & Alexander, 2018; Jablansky, Alexander, Dumas, & Compton, 2020). In education, relations play a role in helping individuals integrate various information in a coherent mental representation (Dumas, Alexander, & Grossnickle, 2013). In addition, relational reasoning is a relevant high-level skill in reading and understanding learning (Alexander, Jablansky, Singer, & Dumas, 2016; Goldman & Pellegrino, 2015).

There are four measurements of relational reasoning: analogy, anomaly, antinomy, and antithesis. The first dimension is analogy, the process of finding the equation of a pattern or object. The second is anomaly, the process of finding deviations or differences in a pattern or object. At that point, the third is antinomy, the process of finding a extraordinary or special relationship of a pattern or object. The final dimenson is antihesis, the process of finding opposite relationships in a pattern or object (Alexander et al., 2020; Dumas & Alexander, 2018). The four dimensions of relational reasoning are interrelated in finding a pattern or object. Relational reasoning has important educational implications in learning, especially in connecting various information from different sources. Anomaly is one of the dimensions of relational reasoning that are very important to recognize or identify deviations or differences in patterns in an object (Alexander et al., 2020; Dumas & Alexander, 2018).

Anomaly reasoning ability is indispensable for students to deal with current and future uncertain situations. The ability to make the right decisions must be supported by recognizing patterns and pattern deviations in the phenomena that occur. The ability to identify an anomaly involves the ability to identify an idea, concept, or unforeseen event (Kendeou, Butterfuss, Van Boekel, & O'Brien, 2017). It does not only involve differentiating patterns between a set of objects, ideas, or situations, but anomaly reasoning also requires the detection of pauses from existing patterns (Alexander et al., 2016). Therefore, students who master the ability of anomaly reasoning can more easily identify deviations from an expected idea, concept, or pattern. The indicators used in anomaly reasoning according to Winder, (2016), are anomaly identification, ability to identify the deviation of objects and pattern formed; anomaly interpretation, ability to estimate the patterns of deviations identified in mathematical models; and anomaly adaptation, ability to adjustment of the deviation pattern to the steps of its solution.

Besides reasoning ability, gender differences also affect students' problem solving ability (Davita & Pujiastuti, 2020), the way of obtaining mathematical knowledge and the thinking process (Imamuddin & Isnaniah, 2018), and influence the high or low reasoning ability of students in solving mathematical problems (Siswanti & Khabibah, 2016). In mathematics learning, male students and female students differ in solving a problem (Supriyanto, Mardiyana, & Subanti, 2014). Gender factors in learning are caused by biological differences between male students and female students' brains. Male students are generally superior in mathematics because of their better spatial abilities, while female students are superior in language and writing (Afandi, 2016; Dilla, Hidayat, & Rohaeti, 2018). Furthermore, when male and female students are given problem-solving-based questions, both of them tend to have different problem solving strategies (Nur & Palobo, 2018).

Several researhers have conducted research related to relational reasoning and gender differences. Mackintosh and Bennett (2005) concluded that the relational reasoning of male students outperformed female students in solving visuospatial problems. The same result was also put forward by Grossnickle, Dumas, Alexander, and Baggetta (2016) where male students are superior to female in solving visuospatial problems. On the dimension of the analogy, which is one of the components of relational reasoning, Hill, Foster, Elliott, Shelton, McCain, and Gouvier (2013) also revealed that male students are superior in solving visuospatial problems compared to female students.

Dumas et al. (2013) in a literature study related to relational reasoning in education revealed that most studies focus more on the analogy dimension which is to determine the similarity of patterns of an object. Meanwhile, research on other dimensions of relational reasoning: anomaly, antimony, and antithesis, is still limited. Based on this, the study of different dimensions of relational reasoning is important to reveal the pattern of relational reasoning as a whole. In this study, we only focused on studies related to student anomaly reasoning in solving number pattern problems in terms of gender. This research is significat to help educators identify students' individual differences in aspects of reasoning. Understanding of students' differences can help educators formulate appropriate learning strategies to assist students better understand mathematical concepts and solve math problems correctly.

Method

This research uses a qualitative approach with a case study design. This study aimed to describe the student's ability of relational reasoning on anomaly dimensions in terms of gender differences. The subjects of this study were 52 students of grade VIII consisting of two classes at one of the Muhammadiyah schools in Kartasura. Furthermore, all subjects were given two problems related to anomalous reasoning ability. We adapted the relational reasoning test compiled by Anggraini, Mubarokah, and Widadah (2020) and have been declared valid. Both questions were chosen because they have the similar context, which is to determine the number of movements of a dancer or circus performer at a performance. But in both questions have different concepts of settlement. Using these two questions is likely to explore students' ability to identify anomalies or deviations in solving the problem. Two anomalous reasoning ability test problems are presented in Table 1.

Table 1. Anomaly reasoning ability test questions

Number	Question
1	In a cultural event in the city of Jogja held in the south square, various art performances were performed to enliven the event. One of them is the dance performance performed by the Ramayana dance studio. In the first 5 minutes, the dance group performed two types of movements. After that, the dance group breaks down into two groups with different dance moves in each group. If every 5 minutes the group breaks down into two groups and each group have two different movements, then how many moves are formed if the dance is performed during the $\frac{1}{2}$ hour?
2	The circus team from Solo performed attractions in celebration of the anniversary of the Solo city. At the celebration, the circus team made five kinds of movement changes in the first 5 minutes. Then the circus team does five more movement changes every 5 minutes. So how many moves are made if the circus team performs attractions during the $\frac{1}{3}$ hour?

Furthermore, each student's test results are analyzed using the assessment rubric according to the anomaly reasoning indicators as presented in Table 2.

Table 2. Anomaly reasoning indicators assessment rubric

Number	Indicator	Score	Note
1	Anomaly Identification	0	Students are unable to identify the deviation of objects or pattern
		1	Students are able to to identify the deviation of objects or pattern but incorrect
		2	Students are able to identify the deviation of objects or pattern correctly
2	Anomaly Interpretation	0	Students are unable to estimate the patterns of deviations identified in mathematical models,
		1	Students are able to estimate the patterns of deviations identified in mathematical models, but incorrect
		2	Students are able to to estimate the patterns of deviations identified in mathematical models correctly
3	Anomaly Adaptation	0	Students are unable to adjustment of the deviation pattern to the steps of its solution.
		1	Students are able to adjustment of the deviation pattern to the steps of its solution but incorrect
		2	Students are able to adjustment of the deviation pattern to the steps of its solution correctly

Based on the test results, the summary of student scores was presented in Table 3. Furthermore, we selected two students purposively with different gender criteria and had above-average scores as subject. Male student is coded by S1, and female by S2. Then, both subjects are interviewed to confirm the students' answers in the answer sheet and explore the student's reasoning process when solving the questions.

Table 3. Summary of student test score

Categorize	Score	Male (N=26)	Female (N=26)
Low	0 – 2	8	3
Moderate	3 – 4	8	10
High	5 – 6	10	13
Average		3.5	4.2
Min		0	1
Max		6	6

In this study, there are three steps of data analysis techniques used: data reduction, data presentation, and conclusion drawing (Miles & Huberman, 2020). The data reduction process was obtained from the selection of the students' answer sheet and interview transcript of the selected subject. In presenting the data, we display the descriptions and pictures of student work as well as excerpts of interview results. At the last stage of data analysis, conclusions are drawn from the data that have been presented.

Results and Discussion

This section presents data analysis of students' answers in solving two anomaly reasoning test questions and interviews on male and female subjects. We use anomaly reasoning indicators from Winder (2016) as a framework for analyzing the data obtained. In the anomaly identification indicators, we analyzed students' ability to identify patterns formed from given problems. On the interpretation of anomaly, we analyzed students' ability to predict pattern deviations from mathematical models. Then on the adaptation of the anomaly, we analyzed the ability of students to adjust the deviation of patterns to the steps of solution.

Table 3 shows that female students outperform male students in solving problems related to anomaly reasoning. More female students got high and moderate scores than males, with 23 compared to 18. On the other hand, female students with low scores are fewer than males, three compared to 8. When viewed from the average, female students had an average score higher than males, 4.2 versus 3.5. Based on the answer sheet analysis, most male students have yet to be able to correctly identify deviations in the solution pattern in two similar problems. They use the same pattern to solve the problem. The differences in the solution patterns of male and female students are discussed as follows.

Male Subject

Figure 1 and 2 present the male subject's solution (S1) to questions number 1 and number 2. Figure 1 shows that S1 solves question number 1 by first converting the time used to perform dance movements, namely $\frac{1}{2}$ hours into 30 minutes. Then, the subject determined the number of periods each group of dancers which broke into two groups for 30 minutes by dividing the time to perform dance moves by the time which each group broke into two groups. In Figure 1, S1 can determine the number of periods each group which breaks down into two, namely 6 times. Furthermore, S1 determines the number of dance movements of each period using a multiplication pattern. S1 begins by determining, which is $U_1 = 44$ different dance moves that the dancers perform during the first period which is 5 minutes. Furthermore, S1 determines the number of dance movements in the second period by multiplying the movements in the first period by 2 so that it is obtained $U_2 = 4 \times 2 = 8$. In the same way, S1 multiplies the number of moves in the previous period by 2 to get the number of moves in the sought-after period. In the 6th period, S1 determined the movements formed by the dancers, namely dance movements $U_6 = 64 \times 2 = 128$. It appears that S1 uses multiplication patterns to solve problems related to dance moves performed for 30 minutes. This shows that S1 is able to identify patterns from mathematical models formed from problem number 1.

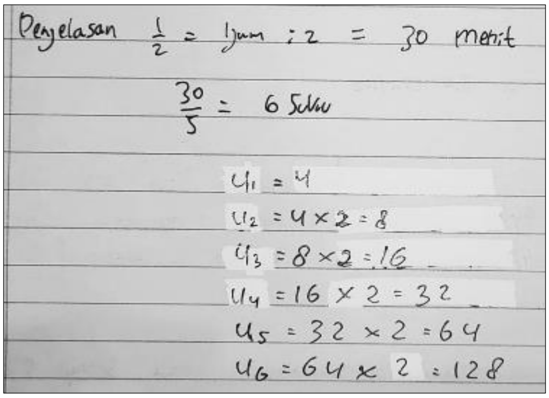

Figure 1. Male student's answer of task 1

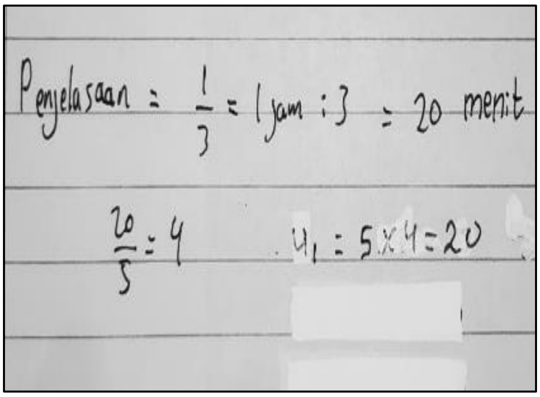

Figure 2. Male student's answer of task 2

Furthermore, we conducted an interview with S1 regarding the steps for solving question number 1 as presented as follows.

P	:	*Please explain your understand about question number 1!*
S1	:	*In question number 1, it is known that in the first minute each group performs 2 types of movements, after 5 minutes they split into two groups. Asked how many movements are done for* $\frac{1}{2}$ *hour?*
P	:	*How do you know the pattern in solving the problem number 1?*
S1	:	*I first look for many movements that will be done by dividing the time, which is 30 minutes divided by 5 minutes and we get 6 terms.*
P	:	*Why do you use multiplication method to solve the problem?*
S1	:	*Because each group splits into 2, it can be solved by the multiplication process.*

The interview results show that S1 can identify the appropriate pattern to solve problem number 1, namely by multiplication. S1 explains that the multiplication pattern is used because every 5 minutes the group breaks down into 2. Thus, the movements constitute twice from the previous. Based on S1's answers and interview results, it can be concluded that S1 can correctly identify the pattern of solving question number 1.

In Figure 2, it appears that S1 also uses the same pattern to solve problem number 2. S1 first converts the time used to perform the entire movement in the circus attraction, which is $\frac{1}{3}$ hours to 20 minutes. Then S1 divides the time to make a movement change by the time it takes to perform 5 different movements so that 4 periods of movement change are obtained. The next step, S1 uses the multiplication pattern to solve problem number 2, namely by directly multiplying the number of movement changes in 5 minutes by the number of movement change periods, namely 4 so that 20 movements are obtained. Although the answer given by S1 is correct, that is, there are 20 movements for 20 minutes, S1 does not present the solution pattern of each period of movement change in the answer sheet.

Furthermore, we conducted an interview with S1 regarding the answer to question number 2 as presented as follows.

P	:	*Please explain your understand about question number 2!*
S1	:	*In question number 2, it is known that there are 5 kinds of movement changes for 5 minutes. Then asked a lot of movement for 20 minutes.*
P	:	*How do you know the pattern in solving the problem?*
S1	:	*To find out the pattern of the solution, in question number 2, I first look for many movements by dividing the time, which is 20 minutes divided by 5 minutes and get 4 terms*
P	:	*Why do you use multiplication method to solve problem number 2?*
S1	:	*After getting a lot of change moves, it can be multiplied by the number of known moves.*
P	:	*How is the multiplication process?*
S1	:	*5 x 4 = 20*
P	:	*If it is multiplied by 4 terms, then what about the multiplication process in each term?*
S1	:	*I don't understand, sir*
P	:	*You mentioned that you are multiplying by 4 terms, it means that there should be 4 steps or 4 terms*
S1	:	*Maybe*
P	:	*What is the process to obtain the first, second and third terms?*
S1	:	*I don't know, sir*

The interview results show that S1 can understand the solution of question number 2. However, S1 was unable to identify the problem-solving pattern appropriately. S1 uses the direct multiplication method to calculate the number of movements for 20 minutes. S1 multiplies the number of movements in 5 minutes by the number of periods of movement change which is 4 so that 20 movements are obtained. However, S1 cannot present how many movements in the first, second, and third periods. S1 does not understand how to compile the pattern of solving problem number 2. This shows that S1 cannot recognize the patterns formed from mathematical models in problems. In other words, S1 has not met the anomaly identification indicators.

The inability of S1 to recognize patterns implis in being unable to meet the indicators of anomalous interpretation and adaptation at once. In anomalous interpretation indicators, S1 is unable to predict any deviation of patterns from the formed mathematical model. Whereas in anomalous adaptation, S1 is unable to solve according to the pattern of deviations that appear unfulfilled. Thus, it can be concluded that male students do not yet have the relational reasoning ability of anomalous dimensions indicated by the inability to identify pattern deviations, estimate the appearance of deviations, and adjust the settlement according to the patterns of deviations that appear in questions number 1 and 2.

Female Subject

Figure 3 and 4 present the solution of the female subject (S2) to questions number 1 and number 2.

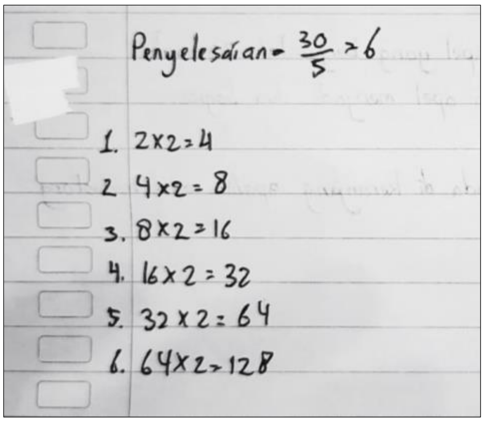

Figure 3. Female student’s answer of task 1

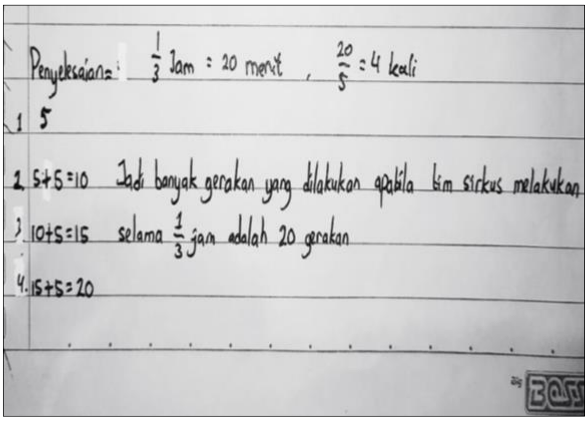

Figure 4. Female student’s answer of task 2

Figure 3 shows that S2 begins the problem solving by converting the time used to perform dance movements, which is 30 minutes. Then S2 determines the periods each group of dancers turns into two groups for 30 minutes by dividing the time it takes to perform dance moves with the time each group turns into two groups. In Figure 3, S2 shows the number of periods each group changes to two groups i.e. 6 periods. Furthermore, the subject uses the number of periods as a term that must be determined to solve problem number 1. Figure 3 shows that S2 uses the multiplication form to solve the problem. At first there were 2 groups with each performing 2 different movements. S2 determines many movements in the first period by $U_1 = 2 \times 2 = 4$ movement. Next, S2 determines, $U_2 = 4 \times 2 = 8$ that is, the second period in which each group of dancers performs 2 different movements. Because in the second period there were 4 groups, overall 8 different movements were formed. In the same way, S2 multiplies the number of different movements in the previous period by 2 to obtain the number of moves in the sought-after period. In the sixth period S2 obtained many movements formed by the dancers, namely $U_6 = 64 \times 2 = 128$ different dance movements. It appears that S2 uses a multiplication operation to solve problem number 1. S2 is able to identify patterns formed from question number 1.

Furthermore, we conducted an interview with S2 regarding students' answers to problem number 1.

P	:	*Please explain your understand about question number 1!*
S2	:	*Question number 1, every 5 minutes the dance group is divided into 2 groups and each group performs 2 different movements. Then asked how many types of movement formed during $\frac{1}{2}$ hour.*
P	:	*How do you know the pattern in solving the problem?*
S2	:	*In question number 1, we look for many movements that will be done by dividing the time, which is 30 minutes divided by 5 minutes and we get 6 times. Then because each group splits into 2 groups and each has 2 different movements, 4 movements are obtained in 2 dance groups. Then the 2 dance groups split again into 2. So that it can be counted 4 movements multiplied by 2. Then in the next step also multiplied by 2 again until the 6th step..*
P	:	*Why do you use multiplication method to solve the problem?*
S2	:	*Because each group splits into 2, it is the same as multiplied by 2. So it can be solved by the multiplication process*

Based on the S2 answer's sheet and the interview's results on question number 2, S2 can identify the pattern of solving the question by multiplication. Thus, S2 already has the ability to reason anomalies in the anomaly identification indicator in problem number 1.

In Figure 4, S2 begins the solution of question number 2 by converting the time used to perform movements on circus attractions, namely $\frac{1}{3}$ hours to 20 minutes. Then S2 divides the entire time to perform the movement by the time it takes to perform 5 movement changes so that 4 periods of movement change are obtained. S2 uses the summation pattern to solve problem number 2. At first there were 5 movement changes that were made every 5 minutes. Then every next 5-minute the circus team made 5 more movement changes. S2 determines the movement changes in the first 5-minute period by writing $U_1 = 5$. Furthermore, S2 determines movement changes in the second 5-minute period i.e., $U_2 = 5 + 5 = 10$. This means that the circus does 10 movement changes in 10 minutes. In the same way, S2 sums up the number of movement changes in the previous period with 5 movement changes to get a lot of movement changes in the sought-after period. In the fourth period S2 obtained many changes in movements made by the circus team, namely movements $U_4 = 15 + 5 = 20$. It appears that S2 uses the summation pattern to solve problem number 2.

Furthermore, we conducted an interview with S2 regarding the steps for solving question number 2 as presented as follows.

P	:	*Please explain your understand about question number 2!*
S2	:	*In question number 2, it is known that the circus team made 5 kinds of movement changes for 5 minutes. Then asked a lot of movement for 20 minutes.*
P	:	*How do you know the pattern in solving the problem?*
S2	:	*To find out the pattern of the solution, in question number 2, I first look for many movements by dividing the time, which is 20 minutes divided by 5 minutes and get 4 terms.*

P : *Why do you use the summation method to solve problem number 2?*
S2 : *Because in question number 2, after getting the many steps of movement change, then each step can be added with many changes to the next movement up to the 4th step. So that in the last step 20 kinds of movement changes are obtained.*
P : *It means that the pattern used in solving the two questions is different?*
S2 : *Yes sir, the question number 1 uses a multiplication pattern and question number 2 uses a summation pattern.*

The interview results show that S2 understands how solving problem number 2 and can identify the correct pattern. S2 uses the appropriate steps to solve problem number 2, namely with a summation pattern. S2 is able to recognize the difference in the solution pattern in problem number 1 and 2. S2 uses the multiplication pattern to solve problem number 1 and the summation pattern to solve problem number 2. This shows that S2 has met the anomalous identification indicator, which is able to identify patterns deviations from the mathematical model formed.

Besides the ability to identify anomaly, S2 is also able to estimate deviations or differences in patterns from previous problems. Based on the interview results, S2 can find out the deviations or differences in the solution patterns used to solve the problem and then adjust the estimated pattern deviations with the appropriate solution steps. In other words, S2 can meet the indicators of anomalous interpretation and adaptation. Thus, it can be concluded that S2 already has anomalous reasoning ability shown by the accuracy of S2 in identifying pattern deviations, estimating the appearance of deviations, and adjusting the problem solving according to the pattern of deviations that arise in the problem.

The results of the data analysis showed that there were differences in male and female students in recognizing pattern deviations in solving problems related to number patterns. In problem number 1, both subjects were able to recognize the patterns formed in relation to the many movements the dancers performed over 30 minutes as multiplication patterns. In this case, both subjects calculated the number of movements in a given period with twice the number of movements in the previous period. Because in the first 5 minutes each group breaks down into two groups and each group performs 2 different dance moves, then in the first period there are 4 different dance movements. In the second period, both subjects determine dance movements as twice as many movements of the first period so that $4 \times 2 = 8$ dance movements are obtained. In the same way, both subjects were able to determine many movements during the 30 minutes or until the sixth period of 128 dance movements.

In problem number 2, male and female subjects used different methods to determine the number of different movements at the circus attraction for 20 minutes even though the results obtained were the same at 20 movements. The male subject performed a direct multiplication of the number of different movements for 5 minutes, that is, 5 movements, with the multiplicity of periods of movement change, that is, 4 periods. So that 20 changes of movement for 20 minutes were obtained. In this case, male subject cannot implement number pattern to solve the problem. This shows that male subject has unable to recognize the differences in problem solving patterns of questions number 1 and 2. In other words. In other words, the male subject has not been able to meet the indicators of anomalous identification. As a result, the subject is also unable to meet the indicators of interpretation and adaptation of anomaly.

In contrast, female subject used a summation pattern to determine the amount of movement in a 20-minute circus attraction. The subject understands that if in each period there are 5 different movements in the circus attraction then many movements in the next period are determined by augmenting the movements of the previous period by 5 movements. This shows that female subject is able to recognize different solution patterns from question number 1. Thus, it can be said that female subject is able to meet the indicators of anomalous identification. In addition, female subject was also able to predict patterns and solve problems using patterns that were different from previous patterns. In other words, female subject was able to meet the indicators of anomalous dimensions in relational reasoning.

The findings showed that there were differences in the solution patterns of male and female students in solving problems, especially seen from the anomalous dimensions that were the focus of this study. The male subject has not been able to recognize the deviations of the emerging solution patterns. Male subject tends to solve directly, although he does not understand the patterns formed. On the contrary, female student is able to recognize the deviation of patterns from the mathematical models formed so that the patterns of solving carried out are different from before. Differences in the reasoning abilities of male and female students were also found in the Demirtas (2011) which examined the ability of scientific reasoning in students based on gender. Demirtas (2011) showed that female students are outperform in correlational dimensional reasoning. However, in the dimension of combinatorial reasoning, male students are superior to female students. In another type of reasoning, Valanides (1997) concludes that male students are outperform in probabilistic reasoning. In contrast to the results of the study above, several studies have shown that there is no difference in reasoning ability based on gender (Aciömeroğlu & Aciömeroğlu, 2017; Bezci & Sungur, 2021; Ha, Sya'bandari, Rusmana, Aini, & Fadillah, 2021; Talib, Maimum, Malik, & Ali, 2018). Yusuf and Sukestiyarno (2022) in their research related to statistical reasoning skills also show that male and female students with a field independent learning style have relatively similar reasoning skills. However, the way of solving male and female students is different. Male students often do not associate the results of the solution with the initial problem. The results of the research above show that there is a variation of students' reasoning abilities when viewed from the aspect of gender differences. However, teachers need to consider individual differences such as gender to design appropriate learning strategies, for developing students' reasoning skills.

As stated by NCTM (2000), reasoning ability is one of the competencies that must be developed in mathematics learning. Reasoning ability is also one of the aspects that must be developed to improve critical and creative thinking skills as 21st century skills that students must have (Apriliana, Handayani, & Awalludin, 2019; Marzuki, Saiman, & Wahyudin, 2022). The ability to think critically and creatively is an important component to be able to develop or innovate in science and technology. One of the developments in reasoning skills can be done by selecting the appropriate learning strategies to develop students' reasoning abilities (Apriliana et al., 2019; Khotimah & Masduki, 2019; Khotimah, Masduki, & Sungkono, 2019)

Although the subjects used in this study were limited, this research provided important information regarding the relationship between gender differences and relational reasoning, especially the anomalous dimension in solving the number pattern problem. The differences in relational reasoning ability of anomalous dimensions based on gender found in this study can be considered by teachers to facilitate students with appropriate learning strategies according to students' individual differences. This is necessary for students to have the ability of anomalous reasoning to recognize deviations that occur in a model or object. This ability is notable for making decisions in uncertain situations in the present as well as in the future.

Conclusion

There are differences in relational reasoning ability in the anomalous dimension based on gender differences. Female student is able to recognize the existence of pattern deviations in mathematical models formed from two similar problems. Female student can identify pattern deviations, predict patterns formed, and can adjust the completion steps based on pattern deviations. Thus, female student met all three indicators of relational reasoning of anomalous dimensions. In contrast, male student cannot recognize any pattern deviations in the formed mathematical model. Male student failed to identify patterns that differed from previous problem-solving patterns. Thus, male student cannot meet all three indicators of anomalous dimensions.

Although the information obtained in this study provides significant information in the study of relational reasoning, one subject used in each gender is one of the limitations of this study. Broader subject engagement will be able to provide more comprehensive information on the relationship between relational reasoning and gender differences. In addition, the selection of material on number patterns to analyze the reasoning ability of anomalous dimensions is also one of the limitations of this study. The expansion of the material used to analyze students' anomalous reasoning ability will provide more comprehensive information regarding the reasoning ability of anomalous dimensions in mathematics.

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