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EXPLORING STUDENT ALGEBRAIC THINKING IN SOLVING MATH PROBLEMS IN TERMS OF KOLB'S LEARNING STYLE

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Abstract

Algebraic thinking plays an important role in solving problems, especially related to algebra. This study aims to explore the students' algebraic thinking profile in solving problems in terms of the stages of Kolb learning style. This type of research is qualitative with a case study approach. The subjects of the study were 54 students of grade VIII at one of the private secondary schools in Surakarta, Central Java. The research instruments used include algebraic thinking test questions, KLSI (*Kolb Learning Style Inventory*) questionnaires, and interview guidelines. The data was analyzed by reducing data, presenting data, and drawing conclusions. The finding showed that all subjects have met the algebraic thinking indicators on the generalization component. The subjects are able to recognize the pattern and use the discovered pattern to determine the next pattern. The subjects have also the ability to solve the problem using a simplification strategy. The finding also showed the CE stage learning style tends to use their experience about the prior knowledge had learned to solve the problem. Meanwhile, the AE, AC, and RO stage learning styles tend to use their logic by utilizing the information on the problem to solve the problem. Thus, it can be concluded that the different stage learning styles affect the different strategies in solving generalization problems.

Keywords: generalization, Kolb learning style, algebra thinking

1. Introduction

Algebraic thinking is a process that involves mentality, including the development of ideas about variables, generalization, and the creation of relationships between variables (Amerom, 2002). Kieran (2004) argues that algebraic reasoning can be seen as a situational quantitative method that emphasizes perspective and uses tools that are not necessarily symbols, but cognitive aids to develop and continue algebraic discussions in the classroom. Algebraic thinking is the process of reasoning about the description of a particular situation, using correct presentations, concrete models and symbols, to discover the unknown using a balanced strategy (Warren et al., 2009). Algebraic reasoning is a proper way to think about mathematical content (Alghtani & Abdulhamied, 2010). Ntsohi (2013) describes that algebraic thinking is the use of symbols and mathematical tools to describe various situations mathematically that represent information from graphs, tables, diagrams and equations as well as mathematical observations such as calculating unknown values, determining and proving relationships between roles used. Algebraic thinking is the activity of looking for patterns in mathematical problems that make connections between symbols and generalize them through the representation and manipulation of symbols (Andriani, 2015). Inganah (2016) showed that algebraic thinking is a method of symbol manipulation, while algebraic reasoning is a way of solving quantitative problems through analysis of symbol use.

Kieran (2004) explained that algebraic thinking skills involve three components of activities, namely generalization activities, transformation activities, and global meta-level activities. Generalization activities involve the formation of theorems and equations to algebraic objects. Transformation activities involve changing the form of sentences or equations to maintain alignment. While global meta-level activities are operations that use algebraic operations as tools, they are not actually algebraic phenomena. These three activities are independent components, not levels of algebraic thinking. In addition, Lew (2004) proposed six components of algebraic thinking including generalization, abstraction, analytical thinking, dynamic thinking, modeling, and organization. Generalization is the process of defining the general pattern of relationships between certain objects. Abstraction is the use of symbols related to the nature and concept of mathematics. Thinking analysis is the process of solving an equation using inverse operations. Dynamic thinking is solving a problem using a trial-and-error strategy. Modeling is creating stories and models that relate to expressions. The organization encounters all the independent variables that are important in its research activities. In this study, researchers adopted the components of algebraic thinking developed by Lew (2004), namely generalization, abstraction, analytical thinking, dynamic thinking, and modeling. We used Lew's algebraic thinking components because he present more detailed components that can help researchers to investigate the student's algebraic thinking.

Algebra plays an important role in solving problems in mathematics, science, business, economics, business, computer science and other everyday life (Booker, 2009). Usiskin (2020) showed that algebraic thinking is very important because algebraic thinking is basically a concept used to solve problems. Windsor (2010) explained that algebra is very important because it can add thought to solve a concrete problem using abstractions and operations in mathematical units in real and logical. In everyday life algebra is widely used, so thinking about algebra becomes important (Nurhayati et al., 2017). Algebraic thinking cannot be separated from students' problem-solving abilities. A mathematical problem can be defined as a word, story, or verbal problem (Phonapichat et al., 2014). Algebra problem solving is able to teach students to think creatively, critically, rationally, and abstractly. Therefore, students are able to solve problems using algebra. (Febriansyah, Yusmin, & Nursangaji, 2016). Mulyati (2016) suggests that problem solving is a skill that students must have after learning mathematics. Problem-solving skills are the ability to reason, understand problems, plan strategies, carry out procedures in solving problems, and draw conclusions (Martha, Maimunah, & Roza, 2022). The skills needed by students are needs that can solve problems in everyday life and can develop further. Through problem solving, students learn to apply math skills in new ways to develop a greater understanding of mathematical ideas and experiences (Badger et al., 2012).

Research on algebraic thinking in junior high school students has been conducted by several researchers (Wilujeng, 2017; Rosita, 2018; Aryani et al., 2018; Kusumaningsih et al., 2018; Harti & Agoestanto, 2019; Nurmawanti & Sulandra, 2020). The research by Wilujeng (2017) revealed the profile of students' algebraic thinking skills at a high level of mathematical ability to solve problems well, while low-level mathematical skills in understanding problems only read and did not have a solution plan. Furthermore, Rosita (2018) showed that FI subjects tend to have higher algebraic reasoning abilities than FD subjects. Research by Aryani et al., (2018) stated that the algebraic reasoning of junior high school students in solving mathematical problems in terms of adversity quotient can improve academic competence, and develop algebraic reasoning in problem solving. Kusumaningsih et al., (2018) revealed that the algebraic thinking ability of men and high group students met five categories of algebraic thinking indicators while the algebraic thinking ability of men and low group students met three categories of algebraic thinking indicators. Research by Harti and Agoestanto (2019) showed that the algebraic thinking ability of junior high school students in problem-based learning reaches the minimum completeness criteria. Subsequently, Nurmawanti and Sulandra (2020) showed that the average junior high school student will think algebraically by looking at images, making representations, finding functional relationships, making generalizations, and applying general formulas. Based on the results of these researchers, there are differences with this study, namely in the use of algebraic thinking components and cognitive style reviews in determining the algebraic thinking profile of junior high school students.

A study by Windsor (2010) discussed algebraic thinking where the construction and development of students' algebraic thinking can be carried out by solving problems. In addition to thinking and solving problems, students have different learning styles that affect students thinking processes. Tanta (2010) explained that learning styles can affect student learning outcomes. Rofiqoh and Rochmad (2016) stated that learning style is a crucial and important factor that affects how well students understand the lesson they are learning. Learning style is another important element in helping students become effective problem solvers. Kolb (1984) explained that learning style is an individual choice to combine experience and process change.

Based on the previous research, the studies that examined students' algebraic thinking skills associated with the Kolb's learning style are still limited. The Kolb's learning style is presented in four stages, namely active experimentation (AE), abstract conceptualization (AC), reflective observation (RO), and concrete experience (CE) (Manolis et al., 2013). This research focuses on revealing the students' algebraic thinking skills in terms of the Kolb learning style. The purpose of this study is to analyze and describe the profile of students' algebraic thinking in solving mathematical problems in terms of the Kolb learning style stages. This research is expected to be useful to find out how the profile of students' algebraic thinking and add insight related to students' algebraic thinking processes in terms of learning style stages. The result of this study is also significant for teachers to design the lesson that facilitates the students with the learning style diversity to develop the student's algebraic thinking.

2. Method

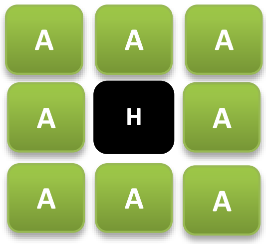
The type of research is qualitative with a case study approach. This research investigates the student's algebraic thinking individually with a specific characteristic, that is the students with different learning styles. Thus, the case study is the appropriate design for this study. The subjects of this study were 54 grade VIII students at one of the private secondary schools in Surakarta District, Central Java. Three instruments were used to collect the data, i.e. algebraic thinking test questions, KLSI (*Kolb's Learning Style Inventory*) questionnaires adapted from Kolb (1985), and the interview guidelines. Researchers compiled the algebraic thinking test question from the 2011 TIMSS questions for grade VIII (TIMSS, 2013).

This study adopted five algebraic thinking components proposed by Lew (2004) including generalization, abstraction, analytical thinking, dynamic thinking, and modeling. Then, researchers compiled ten questions where each algebraic thinking components contain two questions. Before use, the questions were validated by three experts in mathematics education. Based on the validation results, the researchers set eight questions by eliminating two problems on the components of analytical thinking. After that, researchers piloted the test instruments on 20 students which were not included as the research subjects. Based on the piloted, researchers made improvements to the questions for more understanding to the student. Subsequently, researchers used the KLSI questionnaires to classify the stages of student learning style. In addition, researchers used interview guidelines to reveal the students' algebraic thinking processes at each stage of Kolb's learning styles. Before use, interview guidelines are also validated by experts.

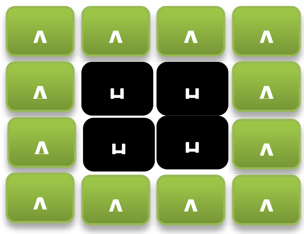
Based on the analysis of the algebraic thinking test results, the student's solution steps on the abstraction, dynamic thinking, and modeling problems were relatively similar and demonstrated the correct solution. Despite the students' solution on the generalization was also correct, however, the strategies used by subjects were varied. Therefore, this study focuses on investigating the student's thinking process in solving the generalization problems which contains two questions. The first problem aims to explore the students' ability to recognize picture patterns and determine the next pattern using the discovered patterns. The second problem aims to explore the students' ability to solve the problem using a simplification strategy. Both questions are presented in Table 1.

Table 1. Algebraic Thinking Test Questions

No	Question
1	The 3 x 3 square shape consists of 8 gray tiles and 1 black tile.



The 4 x 4 square shape consists of 12 gray tiles and 4 black tiles.



The table below shows the number of tiles arranged into square shapes of various sizes. Complete the table below to find out the number of tiles that arrange the square!

Shape	**The number of black tiles**	**The number of grey tiles**	**Total Tiles**
3 x 3	1	8	9
4 x 4	4	12	16
5 x 5	9	16	25
6 x 6	16		
7 x 7	25		

No	Question
2	If a + b = 25, determine the value of 2a + 2b + 4.

To analyze the students' answers of the algebraic thinking test, researchers use assessment rubrics as presented in Table 2.

Table 2. Assessment Rubric

Judging Criteria	**Score**
The solution steps and answer are correct	3
The solution steps are correct but the answer is incorrect	2
The partial solution steps are correct but the answer is incorrect	1
The solution steps and answers are incorrect	0

Subsequently, based on the KLSI questionnaires analysis, the students' stages of learning style of the 54 participants can be classified into CE, RO, AC, and AE as presented in Table 3. Table 3 shows that the students with RO stage learning style are the most dominant than other stages with 22 students. Meanwhile, the students with CE stage learning style are the least than other stages with 6 students. In this research, two students of each stage's learning style with high scores on algebraic thinking tests were selected to be interviewed regarding their thinking process in solving problems. To facilitate the analysis, the subjects are coded by CE1, CE2, RO1, RO2, AC1, AC2, AE1, and AE2.

Table 3. Summary of Students' Learning Styles

No	Learning Stages	Number of students
1.	Concrete Experience (CE)	6
2.	Reflective Observation (RO)	22
3.	Abstract Conceptualization (AC)	12
4.	Active Experimentation (AE)	14

Analyzing data is carried out by document analysis first, namely analyzing students' answers in solving algebraic thinking test questions. In addition, researchers conducted interviews to obtain more in-depth information about students' algebraic thinking in solving problems related to Kolb's level of learning style. In this study, the data analysis techniques involve the data reduction, data presentation, and drawing conclusions. The data reduction encompasses the activities to select and classify the important information obtained from KLSI questionnaires, students' answer tests, and interviews. The data presentation involves the activities to present the data narratively and supported by tables and figures. Finally, the drawing conclusions include the activities to make conclusions based on the results of data analysis.

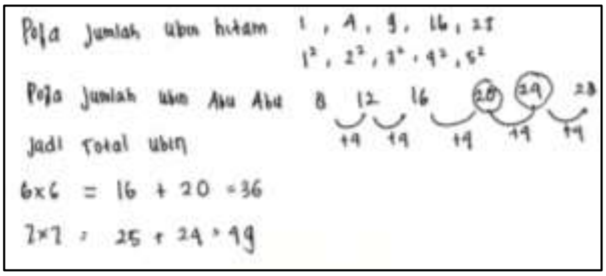
3. Results and Discussion

3.1 Results

This section discussed the analysis of the student's algebraic thinking in terms of the stages of learning styles by Kolb in solving two generalization problems.

Analysis of the first problem

The first problem aims to explore the student's ability to solve generalization problems in algebraic thinking. In this problem, students are required to recognize the picture patterns and determine the next pattern using the discovered patterns. Figure 1 shows the answer of CE1 in solving the first problem. A similar solution strategy was also carried out by AE1.


Pola Jumlah ubin hitam 1, 4, 9, 16, 25
$1^2, 2^2, 3^2, 4^2, 5^2$
Pola Jumlah ubin Abu Abu 8 12 16 20 24 28
+4 +4 +4 +4 +4
Jadi Total ubin
6x6 = 16 + 20 = 36
7x7 = 25 + 24 = 49

Translate:
Pattern number of black tiles 1,4,9,16,25
$1^2, 2^2, 3^2, 4^2, 5^2$
Pattern number of gray tiles 8, 12, 16, 20, 24, 28
So the number of tiles
6 x 6 = 16 + 20 = 36
7 x 7 = 25 + 24 = 49

Figure 1. CE1 answer to question number 1

Based on Figure 1, CE1 solves the problem by first determining the pattern of the number of black tiles which are 1, 4, 9, 16, and 25. Then, CE1 solves the problem with a pattern of the number of gray tiles, which is +4 obtained from the difference between a 3 x 3 square shape and a 4 x 4 square shape. After that, CE1 can determine the number of black tiles on a 6 x 6 square shape and a 7 x 7 square shape by adding each number of black tiles plus 4. Then, CE1 can solve the problem with the total tiles on each square shape, namely 6 x 6 and 7 x 7 square shapes. Based on Figure 1, it can be concluded that CE1 can understand the generalization of a given figure pattern $1^2 2^2 3^2 4^2 5^2$.

The researchers interviewed with CE1 regarding the answer to question number 1. Excerpts of the interview with CE1 are presented as follows (R: Researcher).

R : Explain what do you know about question number 1?

CE1: what is known is that there is a 3 x 3 square shaped tile consisting of 8 gray tiles and 1 black tile. Then there are 4 x 4 square shaped tiles consisting of 12 gray tiles and 4 black tiles.

R : Then, try to explain how to solve the problem?

CE1 : right, judging from the table right bu from the number of black tiles it forms a pattern from 1 to 4, 9 to 16 25 when squared to , , , and so on. Then for the number of gray tiles it can also form a pattern, continue to find the same number of tiles the total tiles continue to stay in total so 5 x 5 = 16 + 20, 20 it gets from the pattern gray tiles will be added 4 make if 16 plus 4 will result in 20 so the total will be 36. $1^2 2^2 3^2 4^2$

R : okay well, then how?

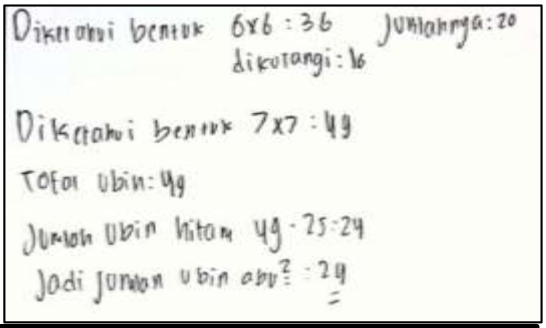
CE1 : for square tiles in the shape of 7 x 7 it is the similar the work becomes 25 plus from the pattern 20 plus 4 it becomes 24, then 25 plus 24 the result is 49 is the total sweet potato.

Q : Why do you use that method to solve it?

CE1 : because by finding the pattern first it is easier to solve it.

Based on the results of the interview, CE1 can explain how to determine the number of gray tiles obtained from the shape of the pattern. CE1 creates a pattern in advance for the number of black tiles by squaring and for the number of gray tiles a pattern of + 4 is obtained from the difference. Then, CE1 to obtain a total of 6 x 6 square tiles is by adding the number of black tiles with the number of gray tiles which is 20. CE1 obtains 20 by summing the number of gray tiles on a 5 x 5 square shape i.e. 16 plus a gray tile pattern which is +4. Then, CE1 can also explain how to determine the number of gray tiles in a 7 x 7 square shape and how to calculate the total tiles in the same way as in a 6 x 6 square shape. Based on the results of interviews and analysis of answers to question number 1, it can be concluded that CE1 is able to recognize the patterns and determine the next pattern using the discovered patterns. In other words, CE1 has the ability in solving generalization problem. The similar ability was demonstrated by AE1.

Furthermore, the solution steps of AC1 in solving problem number 1 is presented in figure 2. The similar solution strategy is also carried out by CE2, AC2, AE2, RO1 and RO2.


Diketahui bentuk 6x6 : 36 Jumlahnya : 20
dikurangi : 16
Diketahui bentuk 7x7 : 49
Total ubin : 49
Jumlah ubin hitam 49 - 25 : 24
Jadi jumlah ubin abu² : 24

Translate:
Known form 6 x 6 = 36, the amount = 20
Reduced = 16
Known form 7 x 7 = 49
Number of tiles = 49
Number of black tiles 49 – 25 = 24
So, number of gray tiles = 24

Figure 2. AC1 answer to question number 1

Based on Figure 2, AC1 solves the problem with a known tile shape, which is 6 x 6 = 36. Then, to find the number of gray tiles, AC1 multiplies the shape of the tile, then subtracts the multiplication result by the number of black tiles, which is 16, so AC1 gets the answer 20. After that, AC1 solves the problem with a known 7 x 7 square shape by multiplying it so that the total tiles are obtained. AC1 can solve the problem with the number of gray tiles by subtracting the total tiles from the number of black tiles on a 7 x 7 square shape. Based on Figure 3, it can be concluded that AC1 can solve the problem of algebraic thinking correctly and AC1 can understand the generalization of a table figure pattern that has been given, but AC1's answer is almost similar to CE2's answer. AC1's understanding of generalization is supported by the results of the researchers' interviews with AC1.

R : Try to explain what you know from question number 1?

AC1: What I know from the problem is how to determine the number of pieces that make up the pieces in the picture that is already in question and the data in the table.

R : Try to explain how you determine or solve the problem?

AC1: the way to determine from the question is known 6 times 6 equals 36, 36 is the total tile. Then 36 minus 16 makes the result 20, so the number of gray tiles is 20. Keep that square tile in the form of 7 x 7 i.e. 7 multiplied by 7 in total 49. Continue to look for the number of gray tiles is 49 minus 25 so that the result is 24.

R : Why do you use that method to solve it?

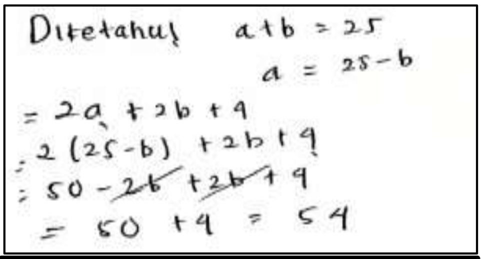
AC1: The reason I use this method is because it is easy to understand.

Based on the results of the interview, AC1 can explain how to determine the number of gray tiles by multiplying the shape of the square and then reducing it by the number of black tiles. Based on the results of interviews and analysis of answers to question number 1, it can be concluded that AC1 is able to recognize the patterns and determine the next pattern using the discovered patterns. In other words, AC1 has the ability in solving generalization problems. A similar ability was demonstrated by CE2, AC2, AE2, RO1 and RO2.

The results of the data analysis showed that all subjects have the ability to solve the generalization problem. Subjects are able to recognize the pattern and use the discovered pattern to determine the next pattern. However, there are differences in their strategy for solving generalization problems. In the first strategy by CE1 and AE1, the subjects identify the total tiles that make up the square as the summation between the number of black and grey tiles. Then, the subjects identify the pattern of the number of black tiles as the arithmetic sequence with the common difference is 4. So, the next pattern is obtained by adding the previous pattern and 4. As a result, the subjects able to determine the total tiles that make up the square on the next patterns. The second strategy used by CE2, AC1, AC2, AE2, RO1 and RO2 to determine the unknown grey tiles and total titles. In the second strategy, subjects first determine the total number of tiles by multiplying the square pattern. Then, the subjects identify the number of grey tiles by subtracting the total number of tiles and black tiles.

Analysis of the second problem

The second problem aims to explore the students' ability to solve generalization problems. In this problem, students are required to solve problems using a simplification strategy. Figure 3 presented the answer of the CE1 in solving the second problem. A similar solution strategy is also carried out by CE2 and RO2.



Translate:
Known a + b = 25
a = 25 – b
= 2a + 2b + 4
=2 (25-b) + 2b + 4
=50 – 2b + 2b + 4
= 50 + 4 = 54

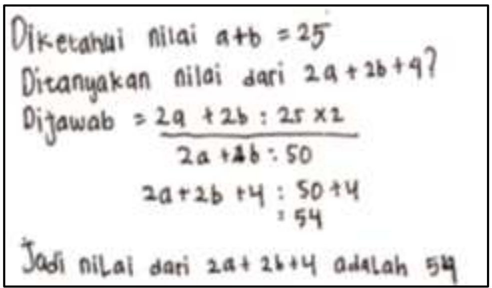
Figure 3. CE1 answer to question number 2

Based on Figure 3, CE1 solves the problem by writing down first what is known which is a + b = 25. Then CE1 moves b to the right side so that a = 25 - b is obtained. After that, CE1 solves the problem by substituting the value of a = 25 -b into the form of a question 2a + 2b + 4. Thus, CE1 can solve the problem by obtaining the result of 54. Based on the student's answer, CE1 used the substitution strategy to determine the unknown variable in the second problem. The subject first simplified the a + b = 25 to a = 25 – b and then substituted a into 2a + 2b + 4 to obtain 54. The excerpt from the interview with CE1 supported the analysis result.

R : Explain what do you know about question number 2?
CE1 : *a* + b = 25
R : Then how do you solve it?
CE1 : It was to find the value of 2*a* + 2b + 4 where *a* + b = 25. To make it easy, *a* + b = 25 could be arranged to *a* = 25 – b by move b to the right segment. So, we can substitute *a* to determine the value of 2*a* + 2b + 4.
R : Why do you use that method in solving the problem?
CE1 : yes because from my experience if there is such a problem, we can moving one of the variable to other segments. In my opinion, it is the fastest and easiest way.

Based on the interview results, CE1 can explain the strategy to determine the value of 2a + 2b + 4 by looking at what is known in the problem, namely a + b = 25. Then, CE1 moves *b* to the right segment. CE1 explains that the value of 2*a* is obtained by replacing the coefficient *a* with *a* = 25 – b. Based on the results of the interview and the results of the analysis of the answer to question number 2, it can be concluded that CE1 is able to solve problem related to generalization by simplifying the equation. To solve the second problem, CE1 used the substitution strategy by manipulating one equation so that can be substituted to other equation.

Furthermore, Figure 4 showed the solution steps of AC1 in solving problem number 2. A similar solution strategy was also demonstrated by AC2, AE1, and AE2.



Translate:
Known value a + b = 25
Asked the value of 2a + 2b + 4 ?
Answered = 2a + 2b = 25 x 2
2a + b = 50
2a + 2b + 4 = 50 + 4 = 54
So the value of 2a + 2b + 4 is 54

Figure 4. AC1 answer to question number 2

Based on Figure 6, AC1 solves the problem with 2a + 2b equals 25 times 2 then 2a + 2b equals 50. After that, AC1 solves the problem with 2a + 2b + 4 with the equation 2a + 2b replaced by 50 and added by 4 to obtain 54. Based on Figure 6, it can be concluded that CE1 is able to solve the problem by simplifying the equation, that is 2a + 2b to 2(a + b) so that the calculation becomes easier. AC1's understanding of the solution steps is supported by the excerpts of the interview.

R : Try to explain what do you know about question number 2?
AC1: a + b is equal to 25, then we asked to determine the value of 2a + 2b + 4
R : How do you solve the problem?
AC1: 2a + 2b equals to 25 times 2 obtained 50.
R : Why are *a* and *b* should be multiplied by 2?

AC1 : because the problem is 2a + 2b, so 2a + 2b equal to a+b times two. Keep 2a + 2b equal to 50. Then 2a + 2b + 4 is 50 plus 4 the result is 54.

R : Why do you use that method in solving the problem?

AC1 : It was easy to understand and apply.

Based on the results of the interview, AC1 can explain what is known in the problem. Then AC1 explains the strategy to obtain the result of 2a + 2b + 4 by multiplying the value of a + b by 2. So the result was 54. Based on the results of the interview and the analysis of the student's answer to question number 2, it can be concluded that AC1 is able to solve problems related to generalization problem using a simplification strategy.

Furthermore, Figure 5 showed the solution steps of RO1 in solving problem number 2.

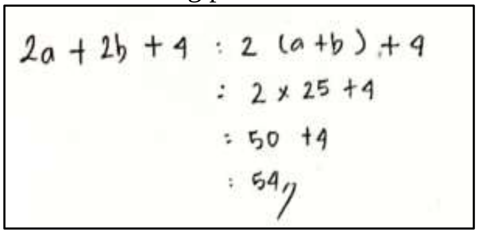


Figure 5. AE1 answer to question number 4

Based on Figure 5, RO1 solves the problem by first manipulating equation 2a + 2b + 4 to 2 (a+b) + 4. Then, a + b is replaced by 25 then it becomes 2 times 25 plus 4. Thus, RO1 can solve the problem by obtaining a result of 54. Based on Figure 5, it can be concluded that RO1 is able to solve the generalization problem using a simplification strategy. RO1 strategy is alike the AC1 strategy by using simplification but with different steps. RO1's understanding of the solution steps is supported by the excerpt of the interview.

R : Try to explain what you understand from question number 4?

AE1 : determines what the value of 2a + 2b + 4 is

R : How do you solve question number 2?

AE1 : the two are separated first the same a + b then a + b is locked up plus 4, because a + b equals 25 so 2 times 25 added 4 equals to 50 plus 4 the result is 54.

R : Why do you use that method to solve it?

AE1 : yes, because initially I changed it first by removing 2, namely 2 (a + b + 2) but what is known is only a + b = 25.

Based on the interview results, RO1 can explain the strategy to determine the value of 2a + 2b + 4 by changing the algebraic form 2a + 2b to 2 (a + b). Then, substituting the value of a+b=25 to obtain 54. Based on the results of the interview and the results of the analysis of the answer to question number 2, it can be concluded that RO1 is able to solve the problem by simplification strategy.

The results of the data analysis showed that all subjects have the ability to solve the generalization problem. Subjects are able to use the simplification strategy to solve the problem. However, there are differences in their strategy in solving generalization problems. The first strategy is shown by CE1, CE2, and RO2. In this strategy, subjects used the substitution method to solve the problem. Firstly, subjects were changing the a+b=25 to a=25-b. Then, subjects were substituting the value of *a* to 2*a* + 2b + 4 to obtain the solution. The second strategy is demonstrated by AC1, AC2, AE1, AE2, and RO1. In the second strategy, the subjects firstly simplify the 2*a* + 2b + 4 to 2(*a* + b) + 4. Then, the subjects substitute the discovered value of a+b=25 to 2(*a* + b)+4.

3.2 Discussion

The analysis data showed that all subjects with different stages of learning styles have the ability to solve the generalization problems. However, there are different strategies used by subjects in solving problems. In the first problem, which aims to explore the students' ability to recognize the pattern and solve the problem using the discovered pattern, the solving strategy used by CE and AE learning style stage is conducted by determining the pattern of the number of black tiles by converting the number of black tiles into a form of power. Then, the subject determines the difference or difference in the number of gray tiles on each tile shape. The number of black tiles is obtained by adding the difference of +4 with the number of black tiles in the previous tile shape. The total tiles in the 6 x 6 tile shape are obtained by adding the number of gray tiles and the number of black tiles. A similar strategy is to determine the number of black tiles and the total tiles on a 7 x 7 tile shape. Subsequently, for the subjects with RO and AC learning style stages, there are two different steps to complete. In the first strategy, the subject solves the problem by determining the total tiles first. To obtain the total tiles, the subject multiplies the shape of the tiles by 6 x 6. Then, to obtain the number of gray tiles by subtracting the total tiles and the number of black tiles. A similar strategy is used to complete the 7 x 7 tile shape. In the second strategy, the subject first determines the pattern of the number of gray tiles. To obtain the number of gray tiles on a 6 x 6 tile shape by summing the pattern obtained with the number of gray tiles on a 5 x 5 tile shape. A similar strategy for determining the number of gray tiles on a 7 x 7 tile shape. Then, to determine the total tiles, the subject sums the number of black tiles with the number of gray tiles.

Based on the description of the steps to solve each subject, there are differences and similarities in solving generalization problems. The difference is that the subjects of the learning style stage CE and AE step to solve with an open mind but still apply a concept in solving generalization problems and are able to make plans to simplify the problem. For the learning style stage, AC and RO solve generalization problems with logical and systematic solving steps and are able to make conclusions from these generalization problems. While the similarities of all subjects in solving generalization problems are equally capable of generalizing activities using patterns and number operations in determining the number of gray tiles and the total tiles in each tile shape. And in the interview stage, both can explain how to determine the number of gray tiles and the total tiles.

In the second problem, which aims to explore the students' ability to solve problems using a simplification strategy, subjects have also different strategies for solving the problem. The first strategy, namely the substitution method, performed by CE and RO subjects, solves the problem by moving b to the right segment so that a = 25 -b. The subject obtains the results of the solution by substituting the value a to 2 (a + b) + 4. The second strategy, namely the simplification method, performed by AC, AE, and RO subjects, solves the problem by manipulating the problem into an algebraic form 2 (a + b) + 4. After that, the subject substitutes the value of a + b = 25 into algebraic form then the result is obtained.

The data analysis demonstrated that subjects with AC stage learning style solve the generalization problems logically and systematically. The subjects are able to understand the problem by understanding what is known, what is asked, and solving the problem sing the systematics steps. This is in accordance with the research by Ghufron and Risnawita (2012) which concluded that the students in the abstract conceptualization quadrant work vertically, consistently, systematically, and step-by-step to solve a problem. Ratnaningsih et al., (2019) also stated that the students with AC stage learning style learn by thinking and focusing on logical analysis of ideas, systematic planning, and theory development to solve problems. In learning from the abstract conceptualization stage, students use systematic and conceptualized planning. Subjects prefer to analyze something abstract, solving problems logical, step by step, starting from the premise and concluding with a solution. (Indahsari & Fitrianna, 2019). Students with AC stage learning style are able to understand various information and structure concisely and logically (Idkhan & Idris, 2021).

Subsequently, the students with the RO stage of learning style are able to reflect and interpret problems through observation and make a conclusion in solving generalization problems. This is in line with the research by Furqon et al., (2021) which concluded that the students in the reflective observation stage make observations and reflect on experiences to draw conclusions that can be used as lessons. The students solve the problem logically, and systematically, and are able to make conclusions. Indahsari and Fitrianna (2019) also showed that the subjects with assimilative learning styles learn through RO stages where subjects prefer to analyze something abstract, solving problems logical, step by step, starting from the premise and concluding with a solution. The subject of assimilation turns an idea into a rule through observation based on systematic planning. Handayani and Ratnaningsih (2019) stated that the assimilator style has RO stage of learning style as the most dominant abilities. Students with this learning style are able to understand various information and structure it concisely and logically (Idkhan & Idris, 2021).

Furthermore, the subjects with the CE stage learning style are able to solve problems in an open-minded way but still based on material concepts that are in accordance with their experience. The statement is in accordance with Madyaratri et al., (2019) which stated that the students with the CE stage learning style focus on student participation in everyday situations, concrete, innovative and imaginative experiences. Students with the CE stage learn based on their experience in the learning process (Eyyam, Menevis, Dogruer, & Cyprus, 2011). Meanwhile, the AE stage learning style solves the problems by trial and error. This is in accordance with research by Ghufron and Risnawita (2012) which stated that the students with AE quadrant often dabble in theory, technical, and ideas to do something, and prefer to try directly.

4. Conclusion

The finding showed that subjects with concrete experiences, reflective observation, abstract conceptualization, and active experimentation are able to solve generalization problems correctly. All subjects are able to recognize the pattern and use the discovered pattern to determine the next pattern. The subjects have also the ability to solve the problem using a simplification strategy. In other words, all subjects met the algebraic thinking indicators, especially in the generalization component. The finding also showed the different strategies used by students with different learning styles. The CE stage learning style tends to use their experience about the prior subject-matter had learned to solve the problem. Meanwhile, the AE, AC, and RO stage learning styles tend to use their logic by utilizing the information on the problem to solve the problem.

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