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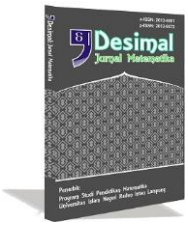

# Analysis of concept construction errors in mathematical problem solving based on the assimilation and accommodation framework in terms of student learning styles

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## ARTICLE INFO

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## ABSTRACT

*The forms of concept construction errors are divided into 4 forms, namely (1) Pseudo Construction, (2) Construction Holes, (3) Mis Analogical Construction, (4) Mis Logical Construction. This research aims to determine the process of concept construction errors in solving mathematical problems based on the assimilation and accommodation framework in terms of student learning styles. This research is qualitative descriptive research. The results showed that 1) students with visual learning styles experienced True Pseudo Construction, False Pseudo Construction, and Construction Pits. 2) Students with auditory learning styles experience True Pseudo Construction, False Pseudo Construction as well as Construction Pits and Mis Logical Construction. 3) Students with kinesthetic learning styles experience Construction Pits, True Pseudo Construction, False Pseudo Construction, and Mis Logical Construction. Concept construction errors in the material of a System of Linear Equations with Three Variables that are often experienced by students are Construction Pits caused by students' spontaneous thinking, irregularity of students' knowledge from previous knowledge concepts with new knowledge concepts.*

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## INTRODUCTION

Concept understanding is the ability shown by students to perform procedures (algorithms) in a flexible, accurate, efficient, and precise manner (Depdiknas, 2006). Understanding concepts is important for students because by understanding the correct concepts students can absorb, master, and store the material that has been studied (Muliawati, 2016). In learning mathematics, students must construct existing concepts in order to build their knowledge by actively participating in the learning process (R. Subanji & Maedi, 2015). The process of constructing mathematical concepts and connecting one concept to another is an interesting thing. Concepts in

mathematics are interrelated and sequential.

Students' problem-solving abilities will be influenced by students' conceptual understanding abilities (Hartati, 2013). Through a good understanding of mathematical concepts, students will also have good problem-solving skills so that students can solve problems in mathematics and use their abilities to solve problems in everyday life.

Lack of mathematical concepts mastery makes it difficult for students to solve mathematical problems (Lin et al., 2017). Understanding the concept starts by constructing the concept. One way to construct concepts is to learn, meaning that knowledge will be formed when students carry out the construction process actively (Subanji, 2015). The process of constructing mathematical concepts and connecting one concept to another is an interesting thing. Concepts in mathematics are interrelated between one concept to another (Jabareen, 2009; Pegg & Tall, 2005).

In learning mathematics, mistakes in learning the previous concept will affect the next concept understanding because mathematics is a structured lesson (Netriwati, 2016). The activity of analyzing students' concept construction errors in problem-solving needs to be done. The goal is that students' difficulties in understanding concepts can be known so that they can be followed up on these difficulties (Rosyida et al., 2016).

According to Subanji (2015) there are four kinds of students' mistakes in formulating concepts and solving mathematical problems, namely: 1) Pseudo construction is a construction that "as if the right" but students cannot provide justification or construction "as if wrong" but students can correct the error after reflection. 2) Construction Pits is concept constructions or problem-solving where the scheme formed in the construction process is incomplete. 3) Mis Analogical Construction is the construction of concepts or problem-solving wherein the construction process there is an analogy thinking error. 4) Mis Logical Construction is the construction of concepts or problem solving wherein the construction process there is a logical thinking error.

In solving mathematical problems, students carry out a thinking process until students get answers (Wahyu , 2019). One of the teacher's roles in learning mathematics is to help students express how the processes that run in their minds when solving problems, for example by asking students to tell the steps that are in their minds. By understanding students thinking processes, teachers can find out what conceptual construction errors are experienced by students so that student errors in problem-solving can be overcome (Babaee & Khoshhal, 2017).

When adapting to the learning process, a student experiences two cognitive processes, namely assimilation and accommodation (Sopamena, 2017; Bormanaki & Khoshhal, 2017). In the assimilation process, the thinking structure (scheme) possessed by students is in accordance with the information structure so that the stimulus can be linked to the schema in the student's mind. The accommodation process occurs when the schema that is owned is not in accordance with the structure of the problem faced by students so that there will be a process of modifying the old schema or the formation of a new schema so that the structure of thinking that is owned is in accordance with the structure of the problem.

Each student has their own way of behaving, receiving information, and solving problems. The differences that students have but have not paid attention to are differences in learning styles (Setiyanik, 2020). There are three types of learning styles, namely visual, auditory, and kinesthetic. Students learning styles

reflect the way information is received and processed by these students (Stoyanova, 2018).

The research that is relevant to this research is the research conducted by Tonda et al. (2020) entitled Analysis of Students' Mathematical Concept Errors in Solving Algebraic Operational Problems Based on Learning Styles. The results obtained indicate that students with visual learning style have conceptual errors that are unable to complete addition and subtraction operations on algebraic forms, types of conceptual errors in students with auditory learning style are students who cannot group similar terms, and types of misconception in students with kinesthetic learning styles, namely students are wrong in determining variables, coefficients, and constants.

Another relevant research is conducted by Marga (2017) entitled Analysis of Student Errors in The Construction of Algebraic Concepts Based on Accommodation Assimilation Theory. The research showed that the research subjects experienced pseudo construction, logical thinking errors, and construction Pits. This error is caused by a failure in the process of assimilating and accommodating the concept.

Based on the results of initial observations made by the authors in class XI MIPA 1 of SMAN 1 Jambi City. The researchers found that several students in class XI MIPA 1 still made many mistakes in concept construction in problem-solving. To see further errors and thinking processes of students who have visual, auditory, and kinesthetic learning styles in answering problem-solving questions, it is necessary to analyze students' conceptual construction errors in solving problems-solving questions. The purpose of this research is to analyze and describe students' conceptual construction errors in working on a System of Linear Equations with Three Variables questions based on the assimilation and accommodation framework in terms of student learning styles.

## METHOD

This research is qualitative descriptive research, with the case study research types. The sample in this research were students in class XI MIPA 1 of SMAN 1 Jambi City which consisted of 2 visual subjects (SV1 and SV2), 1 auditorial subject (SA), and 1 kinesthetic subject (SK). The sample was selected using a purposive sampling technique, namely the technique of determining the subject with certain considerations.

The research procedure was divided into three stages, namely (1) the Preparation Stage starting with initial observations in class XI MIPA SMAN 1 Jambi City, preparing a research proposal design, preparing a learning style questionnaire, designing research instruments, compiling test questions, and answer keys. (2) The implementation stage is distributing learning style questionnaires and determining research subjects based on student learning styles, giving test questions in the form of a System of Linear Equations with Three Variables questions to research subjects, documenting research subjects' activities when working on test questions, and conducting unstructured interviews to research subjects, to clarify the subjects' answers that have been given that aims to find out whether students' thinking processes are experiencing assimilation or accommodation. (3) The final stage is processing and analyzing data obtained from the results of the questionnaires, writing test answers, interviews, and documentation conducted on research subjects using qualitative descriptive analysis.

Before the data is analyzed, the researchers first collected the data obtained from the field, and then the data is transcribed. The data obtained from the writing test using the think-aloud method

and interviews are then reduced. The instruments used in this research are test questions, interview guidelines, and learning style questionnaires. The data collection techniques that will be carried out in this research consist of the test method, the questionnaire method, and the interview method.

## RESULTS AND DISCUSSION

Based on the results of the learning style questionnaire, it was found that the students in class XI MIPA 1 of SMAN 1 Jambi City had different types of learning styles. The dominant type of learning style in class XI MIPA 1 is the Auditorial learning style type. The percentage of overall learning style results for students in class XI MIPA 1 of SMAN 1 Jambi City can be seen in Table 1.

**Table 1.** Percentage of Achievement of Student Learning Style Results

| Learning Style | Frequency | Percentage |
|---|---|---|
| Visual | 11 | 38 % |
| Auditorial | 13 | 44.8 % |
| Kinesthetics | 5 | 17.2% |
| Total | 29 | 100% |

### Understanding the Problem

SV1, SV2, SA, and SK write down what is known and asked about. Subjects assume Andi, Budi, and Dion with a letter a, b, and c or x, y, and z with the intention of making it easier to answer and find what the question is asking.

The following is an interview of the researcher and the subject of SA

P : What information did you get from the questions?

SA: Andi, Budi, and Dion can paint a house together in 10 hours, Budi and Dion can paint together in 15 hours. Andi, Budi, and Dion worked on painting the house for 4 hours then Dion left so they needed another 8 hours.

P : Earlier you wrote Andi = a, Budi = b, and Dion = c, what do you mean by that?

SA : That's an assumption, ma'am, if it's not assumed, the equation will be long, ma'am.

P : What do you mean?

SA : If it's assumed as Andi = a, Budi = b, and Dion = c, then it is only a, b, and c that should be determined.

Based on the results of the interview, the subject of SA was seen experiencing a Construction Pits because he assumed Andi, Budi, and Dion were objects, not numbers. SV1, SV2, and SK also gave the same answer at the time of the interview, namely assuming Andi, Budi, and Dion as objects, not numbers. So, it can be said that the subject experiences an accommodation thinking process because the cognitive structure that has been owned is not in accordance with the structure of the problem faced. As a result, it is necessary to increase knowledge by modifying the structure to consider new experiences by going back to reading books and asking questions with researchers. This is because in the process of accommodation existing knowledge structures cannot directly absorb a new stimulus because it needs a phase to modify the structure to cope with a new stimulus and then it will be integrated (Subanji & Nusantara, 2013). Answer of SA is presented in Figure 1.

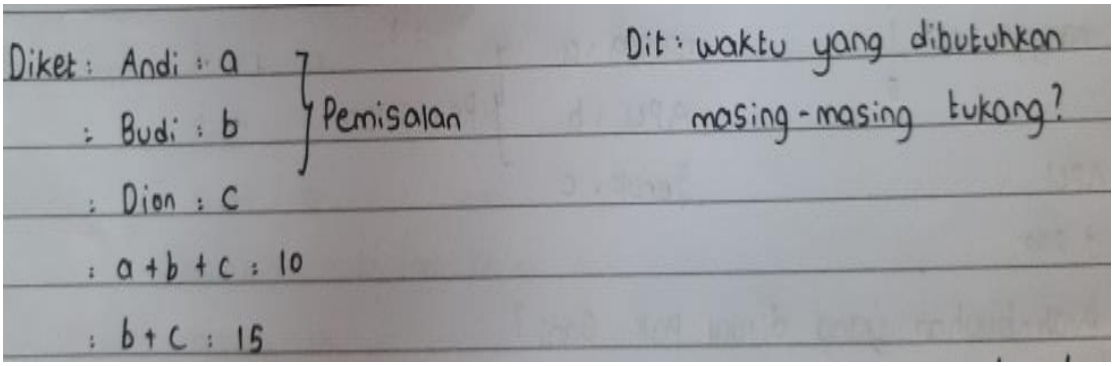


**Figure 1.** Answer of SA

**Planning Completion**

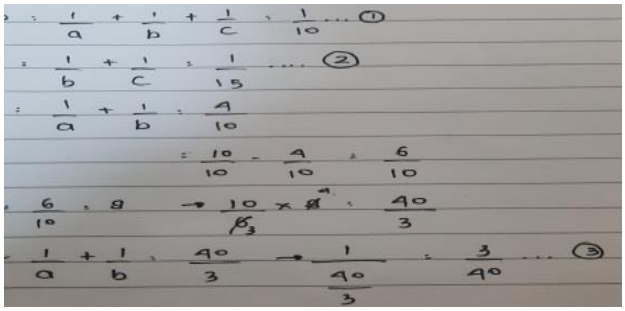

**Figure 2.** Answer of SA

SA and SK wrote almost the same solution plan to solve the problem, it looks like SA and SK wrote $\frac{1}{a}+\frac{1}{b}+\frac{1}{c}=\frac{1}{10}$ as equation (1) and $\frac{1}{b}+\frac{1}{c}=\frac{1}{15}$ as equation (2). SA and SK also wrote $\frac{1}{a}+\frac{1}{b}=\frac{3}{40}$ as equation (3). Following are the results of the researcher's interview with SA.

P : Please explain why write the answer $\frac{1}{a}+\frac{1}{b}+\frac{1}{c}$ ?

SA : To make it easier to make fractions.

P : Why are fractions made?

SA : To make it easier to determine what one is looking for, ma'am, because usually the timed questions are written in fraction form.

P : Have you ever learned the comparison of reverse values?

SA : Yes, already ma'am.

P : If we pay attention, the question in question uses the concept of the comparison of reverse values, right?

SA : Forgot ma'am.

From the results of the interview, it was known that SA experienced True Pseudo Construction, but SA was unable to explain why writing answers as written on the answer paper. In line with research conducted by Indri & Widiyastuti (2018) which states that pseudo-thinking students only care about the answer quickly, but they don't care whether the answer that has been done is correct or not. So, they don't realize that the answer they give is still wrong.

During the interview, SK also gave almost the same answer as SA. SK said that if there was a question in which there was a time problem, then it had to be reversed. SK also experienced True Pseudo Construction, because they could not explain what they wrote. So that SA and SK work based on an accommodation framework, because the problem structure is not the same as the cognitive structure in mind. Here are the written answers from SA and SK.

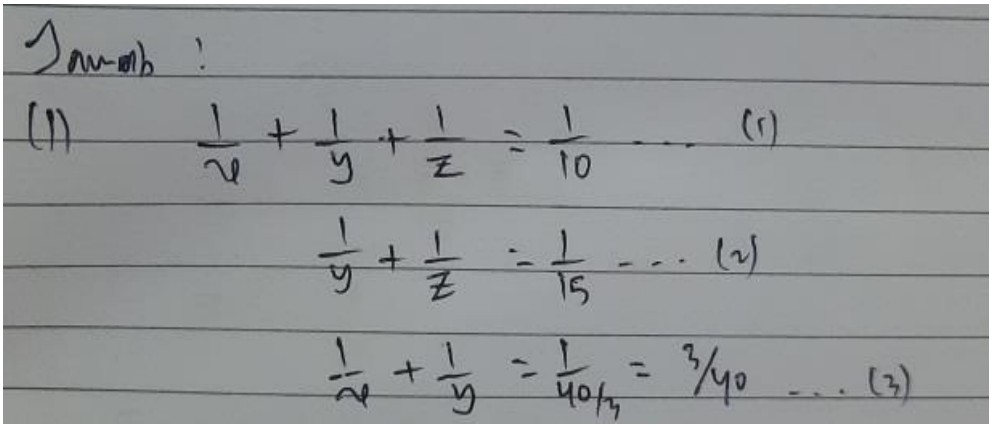


**Figure 3.** Answer of SK

SV1 at the stage of carrying out a settlement plan wrote A + B + D = $\frac{1}{10}$ as equation (1) and A + B = $\frac{1}{10}$ as equation (2). The following are the results of interviews between researchers and SV1.

P : Why did you write A + B + D = $\frac{1}{10}$ ?

SV1 : Because the question is a matter of comparison of reverse value ma'am, then $\frac{1}{10}$ is reversed

P : Why is A+ B+ D also not made $\frac{1}{A} + \frac{1}{B} + \frac{1}{C}$ ?

SV1 : Sorry, ma'am... I mean be reversed, ma'am. yes, the answer is as you said.

P : Next time be more careful.

SV1 : Yes, ma'am.

From the interview, it can be seen that SV1 has True Pseudo Construction because SV1 wrote A + B + D = $\frac{1}{10}$ which should have been written as $\frac{1}{A} + \frac{1}{B} + \frac{1}{C} = \frac{1}{10}$. When given time to reflect on the answers, it was seen that SV1 repeatedly read the questions. However, SV1 is able to correct the wrong answer. Therefore, SV1 undergoes an accommodation process.

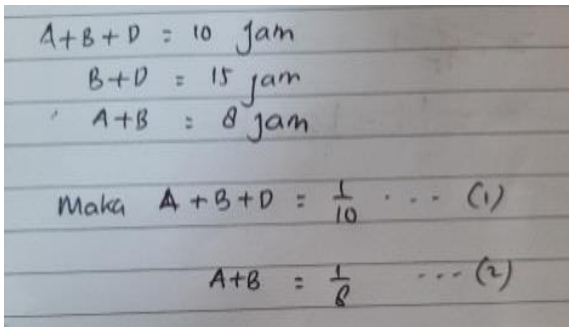


**Figure 4.** Answer of SV1

In planning the solution, SV2 wrote $\frac{1}{x} + \frac{1}{y} + \frac{1}{z} = \frac{4}{10}$ as equation (1) and $\frac{1}{b} + \frac{1}{c} = \frac{1}{15}$ as equation (2) then wrote $\frac{1}{a} + \frac{1}{b} = \frac{6}{10}$ as equation (3). Following are the results of SV2 interviews with researchers.

P : Why write this equation (1)? (Pointing to the subject's answer)

SV2 : Because if the question is like this, it must be written backwards like this, ma'am.

P : What concept are you using?

SV2 : hmm (thinking) forgot... ma'am.

P : Have you ever heard of comparison of reverse values?

SV2 : Oh yes ma'am, the concept of comparison of reverse values.

P : Why did you write $\frac{4}{10}$ ?

SV2 : Because Andi, Budi, and Dion worked together for 4 hours, now their total work is 10 hours, so it can be said that 4 hours out of 10 hours.

P : Are you sure?

SV2 : I'm not sure either ma'am, the sentence is difficult to understand, so I am confused to understand it.

From the results of the interview with SV2, it was found that SV2 had Mis Logical Construction because SV2 could not understand the question sentence perfectly. Based on the answer sheets and interview results, it is known that SV2 works based on an accommodation framework, it can be seen during the interview that SV2 is a little confused with the question sentences. The results of the SV2 answers can be seen in Figure 5.

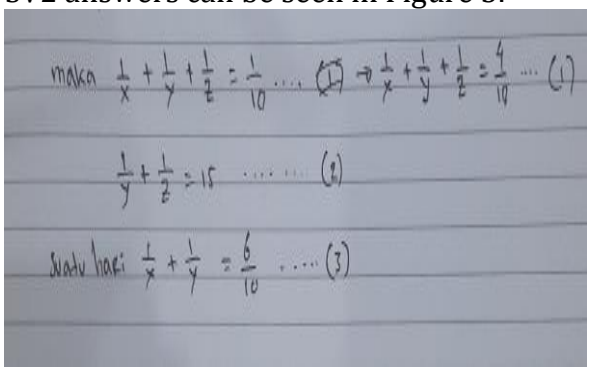


**Figure 5.** Answer of SV2

**Implementing the Completion Plan**

SV1 in implementing the settlement plan uses the substitution method. SV1 substitutes $\frac{1}{B}+\frac{1}{D}=\frac{1}{15}$ into equation (1), so that by moving the sides $\frac{1}{A}=\frac{1}{10}-\frac{1}{15}$ was obtained, then by equating the denominators $\frac{1}{A}=\frac{1}{30}$ was obtained. So, A = 30 hours. Next, SV1 substitutes $\frac{1}{A}$ into $\frac{1}{A}+\frac{1}{B}=\frac{1}{8}$, so that by moving the segment $\frac{1}{B}=\frac{1}{8}-\frac{1}{30}$ was obtained. Then cross multiplied to get $\frac{1}{B}=\frac{30-8}{240}$ then $\frac{1}{B}=\frac{22}{240}$ so that B = $\frac{240}{22}$ = $\frac{120}{11}$ to get the value of D, SV1 substitutes to $\frac{1}{A}+\frac{1}{B}+\frac{1}{C}=\frac{1}{10}$. The following is the researcher's interview with SV1.

P : What method did you use?
SV1 : Substitution method, ma'am.
P : What is the substitution method?
SV1 : hmm (thinking…) the same variables will be combined, ma'am.
P : Is that right?
SV1 : I think so ma'am… (thinking… because SV1 is not sure about the answer)

From think-aloud and the results of the SV1 interview, it was found that SV1 experienced a construction pits because SV1 could not explain the concept of the substitution method correctly, and SV1 said that $\frac{1}{A}=\frac{1}{10}-\frac{1}{15}$ was obtained by moving $\frac{1}{10}$ to the right-hand side. Laja (2020)in their research suggest that the rule of moving segment destroys the systematics of mathematics. The supposed concept is that the subject operates both sides with the opposite of the tribe to be eliminated (Khasanah, 2019).

SV1 has construction pits because SV1 said that to get a value of $\frac{1}{B}$, it is cross multiplied so that the denominators are the same which should equalize the denominators by finding the least common factor (LCM). This is in line with research conducted by Wiaan (2019) which states that conceptual errors in equating the denominator are the most common mistakes made by students. Similar to SV2, SA and SK are not much different from SV1.

From the results of think-aloud and interviews, the subject experienced construction pits when carrying out the completion plan, the subject carried out the operation of moving segments, equating the denominators as well as multiplying. Therefore, it is known that SV1, SV2, SA, and SK experienced accommodation, here is a written answer from SV1.

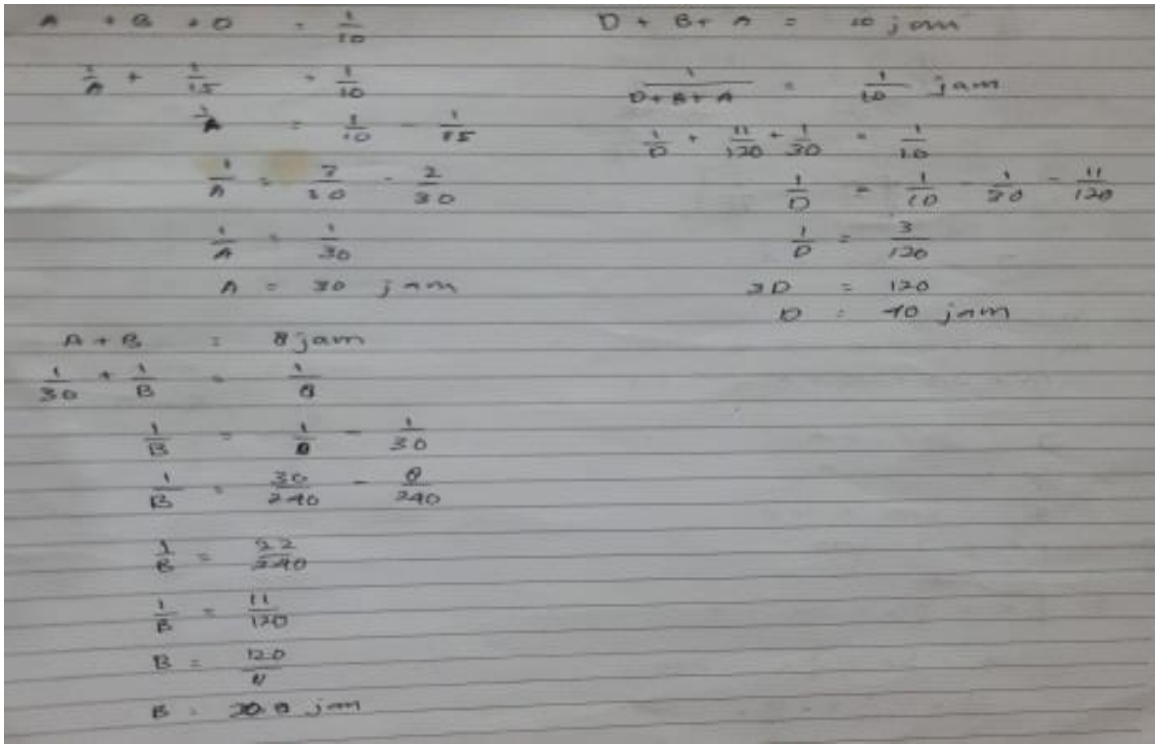

**Figure 6.** Answer of SV1

**Crosscheck**

From the results of the answers SV1, SV2, SA, and SK, a calculation error occurred in the final result, resulting in incorrect results. The answer of SA can be seen in Figure 7.

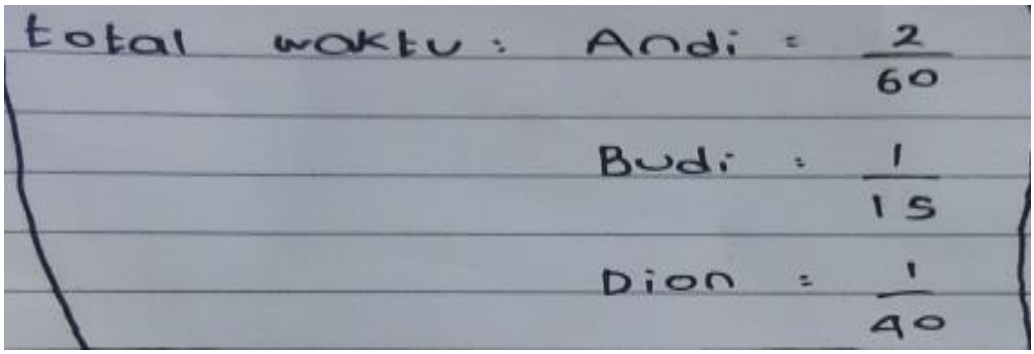


**Figure 7.** Answer of SA

From SA's answer, it can be seen that SA wrote down the time required for each painter, but SA was unable to prove the answer was correct or not. Likewise, SV1, SV2, and SK did not re-check the answers that had been obtained, but SV1, SV2, and SK experienced Pseudo Construction, which felt that the answer was right even though it was wrong or vice versa. Therefore SV1, SV2, SA, and SK can be said to have accommodation. This is because in the process of accommodation existing knowledge structures cannot directly absorb a new stimulus because it needs a phase to modify the structure to cope with a new stimulus and then it will be integrated (S. Subanji, 2016).

## CONCLUSIONS AND SUGGESTIONS

After conducting an analysis using a learning style questionnaire, a System of Linear Equations with Three Variables material test, interviews, and forced documentation, it can be concluded that the results showed that students with visual learning styles experienced True

Pseudo Construction, False Pseudo Construction, and Construction Pits. Auditory learning style students experience True Pseudo Construction, False Pseudo Construction as well as Construction Pits, and Mis Logical Construction. Students with kinesthetic learning styles experience Construction Pits, True Pseudo Construction, False Pseudo Construction, and Mis Logical Construction. Concept construction errors in the material of a System of Linear Equations with Three Variables that are often experienced by students are Construction Pits caused by students' spontaneous thinking, the irregularity of students' knowledge from previous knowledge concepts with new knowledge concepts. Concept construction errors made by students reveal that students work based on an accommodation framework.

It is recommended for further researchers to select samples that meet the criteria in order to be able to explain more broadly how the concept construction errors are. In addition, it is also recommended to choose materials other than a System of Linear Equations with Three Variables as well as at different school levels such as junior high school. In order for learning to run according to the lesson plan, it is necessary for researchers and teachers to manage the time as well as possible and choose the appropriate strategy.

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