

Students' Concept Construction Errors in Online Learning

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ABSTRACT

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A well-constructed concept can aid pupils in comprehending any learning content. However, as seen by how students solve math problems, the construction process frequently encounters flaws. Students make various conceptual construction errors in online learning. This is a qualitative study conducted on Mathematics Education students of Universitas Papua. The purpose of this study was to determine the errors made by students in constructing concepts of functions during online learning. Five subjects were selected as the subjects. They were chosen by using the purposive sampling technique. The instrument was developed using material from online lectures on functions and has been validated by experts in the field of mathematics education. The findings indicated that there were five misconstruction concepts, i.e. pseudo construction, construction holes, mis-logical construction, mis-analogical construction, and misconstruction in problem-solving. For further research, to avoid unnecessary construction errors, it is recommended that before the learning process is carried out, the teacher should know the construction of students' concepts, so that the process of students' conceptual change in online learning can be known.



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A. INTRODUCTION

Mathematical concepts can be visualized as a house constructed by merging several types of relevant knowledge when applied to everyday life. As a result, the quality of the finished structure is determined by the development approach utilized. As a result of learning, it is critical for a student to develop accurate mathematical concepts. Therefore, students must acquire accurate mathematical conceptions based on critical result learning.

One of the important factors in learning is understanding the concept well and it is a basic goal in learning mathematics (Bartell, Webel, Bowen, & Dyson, 2013; Depdiknas, 2009). Concepts in learning mathematics are obtained through a long and continuous construction process (Subanji, 2015). Subanji (2015) asserts that students must develop their own knowledge independently rather than following the techniques determined by the teacher so that good mathematical concepts are formed. Through an active, effective and sustainable concept construction process, a good concept will be formed in students (Cahyo, 2013). Good concept construction will help students in solving mathematical problems they face (Wyrasti, Sa'dijah, As'ari, & Sulandra, 2018). It is clear that with a good mathematical concept construction, in addition to getting a good understanding, students are also able to solve the math problems they face (Ni'mah et al., 2018; Subanji, 2015).

Although a good concept construction provides many benefits to students, in fact there are still many students who experience conceptual errors which can be seen from how students solve mathematical problems (Brodie et al., 2010). These errors can be caused by previous mistakes so that there are inappropriate concepts (Wyrasti et al., 2018) and will also have an impact on students' understanding of the next mathematical concept (Ni'mah et al., 2018). These errors happened because students struggle alone to understand the concept during the learning process so that students often have difficulty in learning concepts, and also because of learning models of the teacher. Furthermore, Subanji (2015) describes the study of the structure of thinking in the construction process of solving mathematical problems. When the structure of the problem faced by students is much more complex than the structure of their thinking, students will experience errors in the construction process because students will have difficulty in the assimilation or accommodation process. The assimilation process is carried out when students do not yet have a schema that matches the problem at hand. While the accommodation process has not been carried out by students because they do not have enough schemes that can be used to form new schemes. This error indicates a concept construction error that occurs in students (Herna, 2020).

The conceptual construction errors above have been investigated by several researchers, including Subanji & Nusantara (2013), Subanji (2015), Ni'mah et al., (2018), Lestyanto et al., (2019), Wyrasti et al., (2018), Khasanah et al., (2019), and Herna, (2020) also the experience of researchers in carrying out the Introduction to the School Field programme or *Pengenalan Lapangan Persekolahan* (PLP) which was carried out at SMP YPK 1 Manokwari. Concept construction errors found in high school students include: pseudo-construction, mis-analogical construction, and mis-logical. Meanwhile, students also found, among others: pseudo-construction, misconstruction, misconnection, and logical thinking errors and some student errors in the construction process of other mathematical concepts. All of these studies have something in common, in which the constructs of students' concepts obtained are found during classroom learning in general. This means that the knowledge gained through direct learning with teachers and real learning environment. However, in the conditions of online learning that is carried out, are there still the same mistakes in students or are there more and more errors in concept construction?

Advances in information and communication technology currently provide many conveniences and possibilities in designing and developing an education system. Taking into account the health aspects of the spread of COVID-19, the Ministry of Education and Culture issued Circular No. 36962/MPK.A/HK/2020 regarding Online Learning and Working from home in the Context of Preventing the Spread of Corona Virus Disease (COVID-19). Online learning is learning that uses the internet network with accessibility, connectivity, flexibility, and the ability to create various types of learning interactions. Basically online learning is needed because it has become a demand in the world of education since the last few years (He et al., 2014) and is needed in learning in the era of the industrial revolution 4.0 (Pangondian et al., 2019).

Like other learning models, online learning also has some drawbacks. These shortcomings include, the lack of self-study initiative makes students wait for instructions or assignments from the teacher (Utami & Cahyono, 2020), students are more concerned with satisfying

grades not the abilities they should improve. There are even students who rarely evaluate the process of their learning outcomes (Pangondian et al., 2019). This was caused by several things, namely, the rapid and drastic change in the learning environment from face-to-face (direct) to online (Mustagfiroh, 2020). There is no social interaction that occurs during the learning process (Apsari et al., 2020). Until the difficulties that come from the teachers themselves (Liu, 2019) and also the internet network that is not strong, and the high cost of internet quota. This deficiency has a huge impact on the quality of learning, resulting in the emergence of learning loss (Zhao, 2021).

In general, learning loss is defined as a situation where the learning process carried out in schools is less than optimal (Huang et al., 2020; Donnelly & Patrinos, 2021). This will result in the results of the information obtained and student learning outcomes not being optimal (Huang et al., 2020). Several studies stated, Student learning outcomes during the pandemic experienced a drastic decline due to the learning process that was not optimal and lack of learning time (Maulyda et al., 2021). Unfavourable learning conditions due to the pandemic also affected students' comprehension of the material provided up to 50% (Hotimah et al., 2021). Thus, learning loss will be able to have an impact on the quality of human resources that will be born in the years during the COVID-19 pandemic (Cook-wallace, 2012).

Based on the explanation above, there are several interesting things between the construction errors of mathematical concepts and online learning that is carried out. First, the relationship between mathematical concept construction errors and online learning is that there is a very deep lack of online learning for students regarding concepts. For example, when students are given material and are required to work on assignments at the end of the material, students are only concerned with the answers compared to the concepts they must understand. Second, the occurrence of learning loss has a significant impact on the material and understanding of students who are considered lacking in understanding a material due to the limitations of online learning and provides an opportunity that the concepts obtained are not intact. Therefore, we are interested in exploring mathematical concept construction errors made by students in online learning. With this research, it is expected to get an overview of the concept construction of students after participating in online learning.

B. METHODS

A qualitative approach was employed to explain the types of errors that occur during the construction of function's concepts by Mathematics Education students enrolled in online learning in the Class of 2019. According to Sugiono (2017), the descriptive approach is used to ascertain the existence of independent variables, either on one or more variables, without comparing these variables or examining their correlations with other factors. The relationship's outcomes are expressed in words. And the primary data are gathered from the observed or interviewed subjects' behaviours. This study was conducted online using a device capable of doing it. The research procedures consisted of (1) research preparation, (2) research implementation, and (3) data analysis. Two experts were invited to validate the instrument developed during the preliminary stage, and the result is that the instrument used is valid and can be used to collect data. The instrument that had been validated by the experts is provided in Figure 1.

1. There are $x \in \mathbb{R}$ mapped by the function $f: x \rightarrow y = f(x)$. If $f(x_1) = f(x_2)$, is $x_1 = x_2$? Explain your opinion!
2. It is known that the "root of" relation relates all elements of \mathbb{Z}^+ to all members, of \mathbb{R} . Check if this relation is also a function? Explain your opinion!
3. Find a rectangle with a side length of 8 cm. If there is a function L in x , where L is the area and x is the length of the rectangle. Determine the limits of the length and area of the possible rectangle!

Figure 1. Research Instrument

The questions mentioned above were distributed to 22 students that consisting of 6 male students and 16 female students as respondent in this research. When working on these problems, the respondents were instructed to work independently for a specified amount of time. Then, the test’s activities were recorded for analysis. This study examined student concept construction errors using modified Subanji (2015) indicators, as shown in Table 1.

Table 1. Indicators of Concept Construction Errors in Mathematics

No	Concept Construction Errors	Indicators
1.	Pseudo Construction	<p>“True” Pseudo Construction: The subject seemed to give the appropriate answer, but when traced it turned out to be wrong.</p> <p>“False” Pseudo Construction: Although the answer was incorrect, when explored through interviews or contemplation, it was discovered that the subject’s thought process was correct. During the interview session, the subject could jot down the proper response.</p>
2.	Construction holes	Although the subject provided the proper response, the concept construction process in the subject’s mind was not completed.
3.	Mis-analogical Construction	The subject provided the incorrect response because he confused one concept with another.
4.	Mis-logical Construction	The subject provided the incorrect response due to a lack of thinking or comprehension of the topic. The subject provided the incorrect response due to his or her incapacity to think logically when answering the problem.

C. RESULT AND DISCUSSION

The expert-validated questions were distributed to 22 respondents through Whats-App. The examination lasted roughly 60 minutes. From all of the intended respondents, only six individuals collected responses to the test on time, while the other 16 students did not collect their answer sheet due to network constraints. Following an initial analysis of the students’ work, the six students were called to determine their availability for an interview. Five of the six students responded positively and agreed to be interviewed, while one student did not respond at all. Each subject was then assigned a code, namely $A_1, A_2, A_3, A_4,$ and A_5 .

1. Pseudo Construction

True pseudo construction is a scenario in which individuals appear to offer an accurate response that is actually incorrect. In-depth interviews found that true pseudo construction

happened when a subject accurately answered a question but mistakenly provided reasoning, justifications, and conclusions. True pseudo construction in this study happened to subjects A₁ and A₃. The subjects properly answered the question, namely: "The relationship between "the roots of" is a function." However, there was a concept construction problem in the process, as they did not consider the answer as a solution, but rather as a consequence of the square, not "root of." This finding indicated that the subjects were unable to comprehend the underlying relationship between the variables.

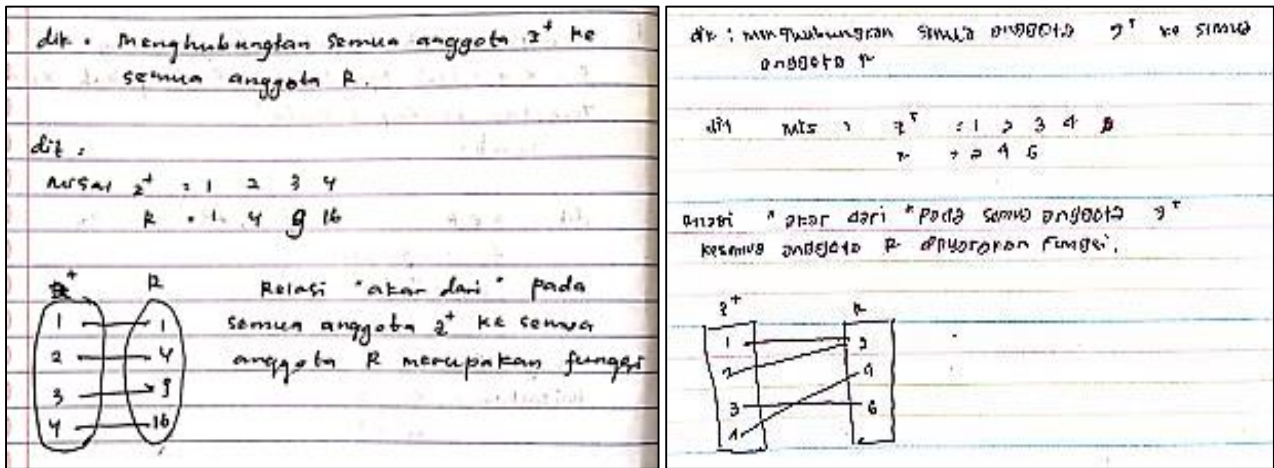


Figure 2. (a) Subject A₁'s Answer to Task No. 2 (b) Subject A₃'s Answer to Task No. 2

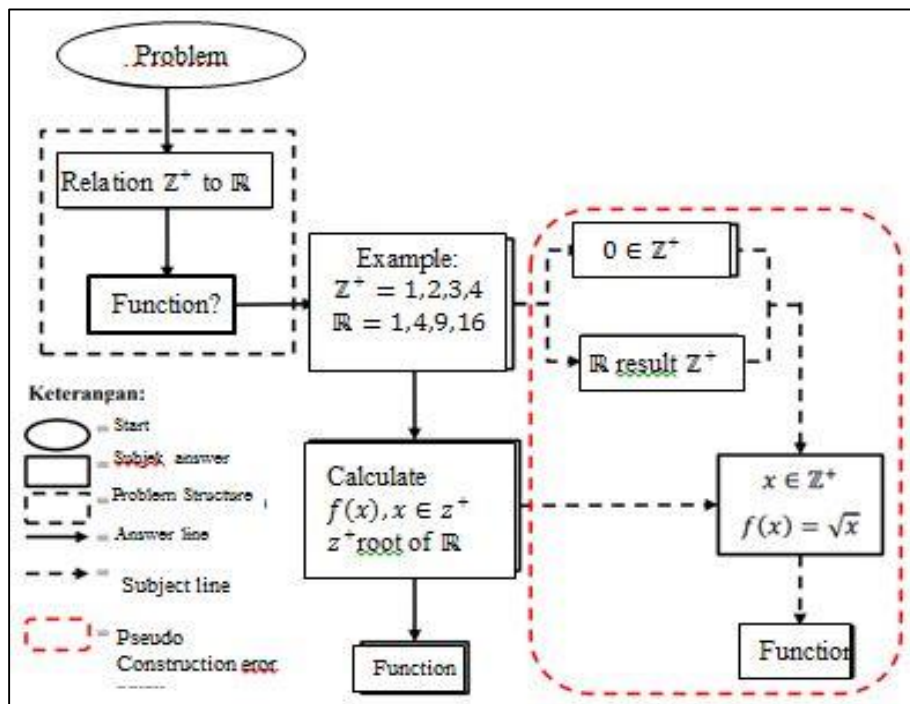


Figure 3. Structure of Construction Error in Task No. 2 (Subject A₁)

As illustrated in Figure 2 and Figure 3, what was done does not correspond to what the subject believed. The following interview excerpt demonstrates the subject's comprehension of the task:

R (Researcher) : Based on the answers you gave, 1 is the root of 1, 2 is the root of 4, 3 is the root of 9, and 4 is the root of 16. Is that so?

A1 : Yesterday I was wrong, the root of 1 is 1, the root of 4 is 2, the root of 9 is 3, and the root of 16 is 4. I considered the root but chose to write the square instead.

According to the sample from the interview, it appears as though the subject did not give much thought to the responses made throughout the examination. The subject clarified that the result provided was the square's product, not the "root of" (see other research findings). Thus, it can be said that the subject encountered pseudo construction in which the responses appeared to be correct but the subject's perceptions did not correspond to the truth.

According to Subanji (2015), Herna et al. (2016) and Anggraini et al. (2018) this occurs because students provide correct answers to the problems at hand, but after conducting interviews and analyzing the concept construction used to solve the problem, discrepancies and errors in the subject's thought process that contradict the conclusions of the answers become apparent. As a result, the subject above encountered true pseudo construction, even though the subject provided the right response.

False pseudo construction is characterized by the fact that an individual provides the incorrect response yet is able to correct his errors upon reflection. This happened to Subject A₅ when completing Task number 2.

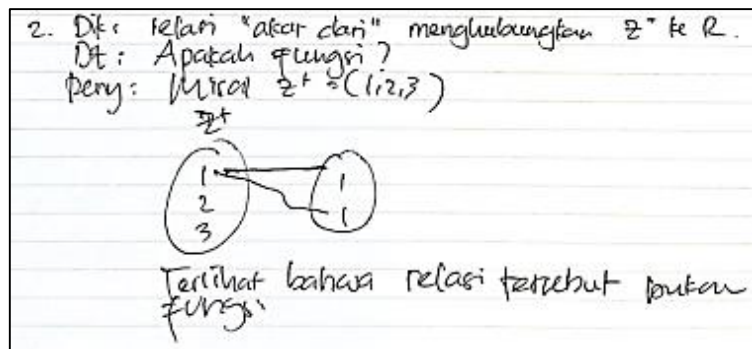


Figure 4. Subject A₅'s Answer to Task No. 2

The subject first answered wrongly because he did not understand the "root of" relationship. However, after reflecting on the activity, the subject was able to fix his errors by developing a grasp of the "root of" relation and then asserting that the connection was a function. The diagram below depicts the structure of concept construction errors that occurred in subject A₅.

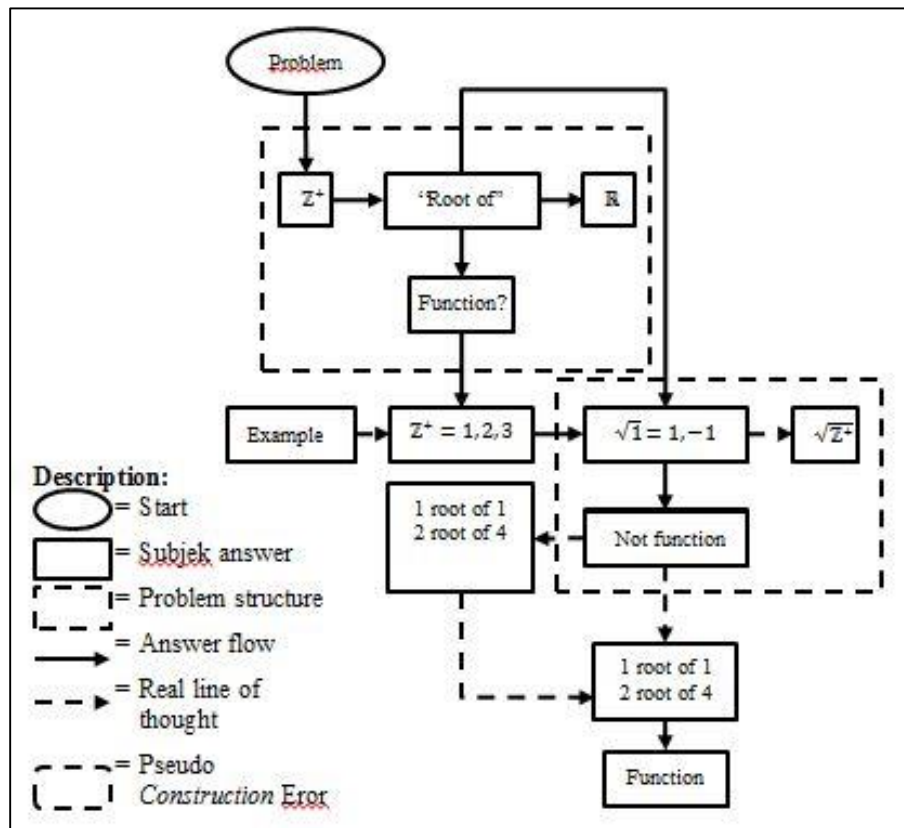


Figure 5. Structure of Construction Error in Task No. 2 (Subject A5)

Based on the phenomenon that occurred, the subject's answers were discussed through in-depth interviews as follows:

- R : What if "1 is the root of ..." "2 is the root of ..." , "3 is the root of ..." . When you consider this, what would happen?
 A5 : If that's the case, it looks like I'll have to find a number that takes the root of 1,2,3. Because 1 is the result of $\sqrt{1}$. 2 is the result of $\sqrt{4}$. 3 is the result of $\sqrt{9}$
 R : How do you calculate it?
 A5 : Because 1 results from $\sqrt{1}$. 2 results from $\sqrt{4}$. 3 results from $\sqrt{9}$ a so forth.
 R : Then, is it a relation or a function?
 A5 : This one looks like a function. Because all domains are paired with one co-domain.

Based on the interview above, the subject was capable of constructing the concept of the "root of" relation and stating that the relation is a function. The subject could also effectively match existing numbers using the given relation. Thus, the subject answered incorrectly at first due to construction problems in understanding the meaning of the "root of" relation. Subanji (2015) refers to the error above as false pseudo construction, in which the individual is initially incorrect but is able to fix the error upon reflection. In line with Lestyanto et al. (2019) research, subjects answered wrongly prior to the interview, but were then able to correct their responses following the interview.

2. Construction holes

Construction holes are identified in Subject A₁ and Subject A₃'s answers to task number 1. Figure 6 show that Subjects A₁ and A₃ in constructing the concept assumed that x_1 and x_2 were equal so that the specified function's value had the same value. This indicates a

construction hole in the process since the subjects believed that x_1 and x_2 must have the same value while x_1 and x_2 are actually members of different domains. Figure 7 illustrates concept construction errors made by the subjects.

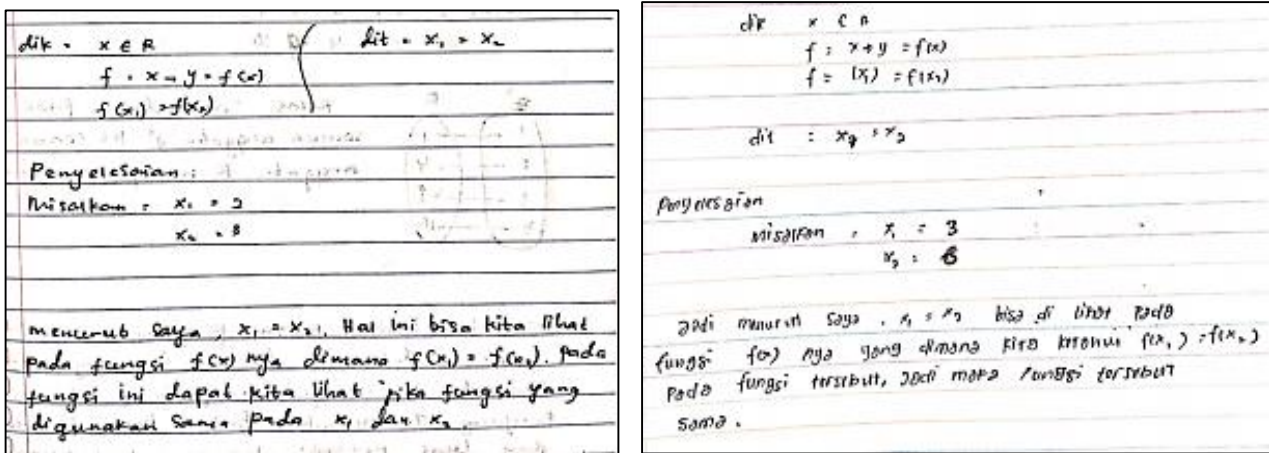


Figure 6. (a) Subject A₁'s Answer to Task No. 1 (b) Subject A₃'s Answer to Task No. 1

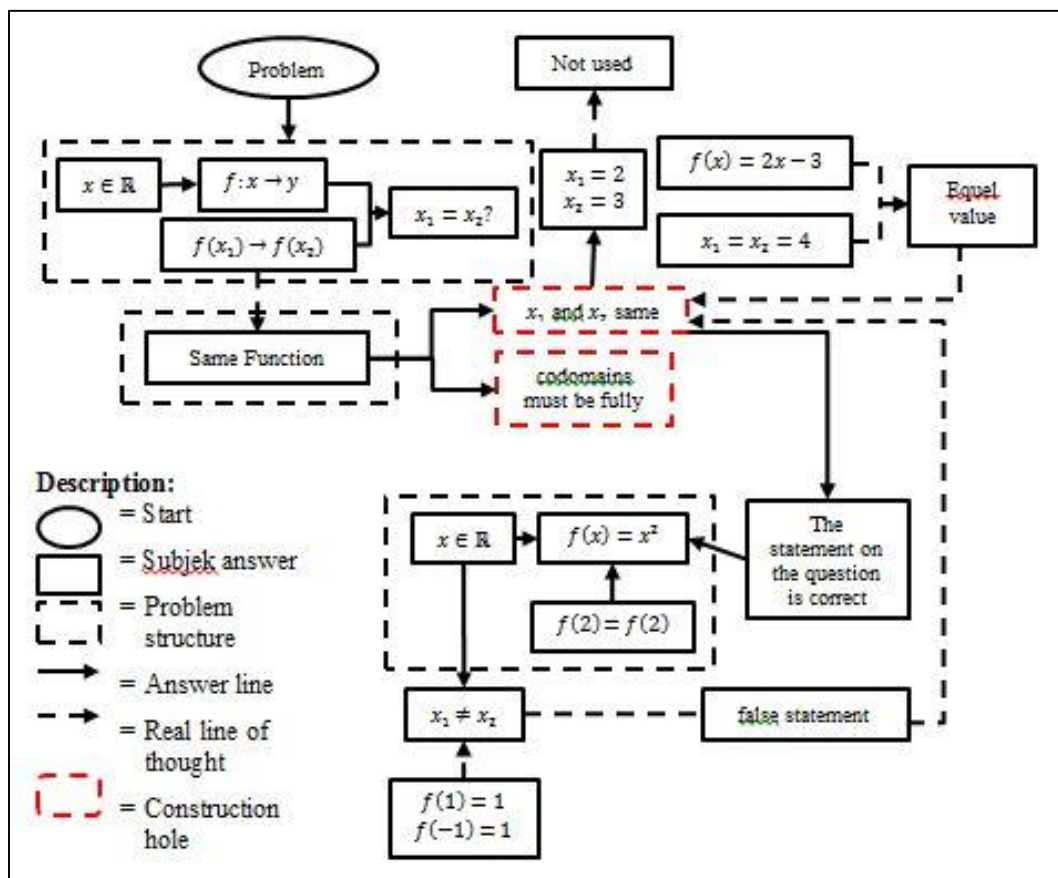


Figure 7. Structure of Construction Error in Task No. 2 (Subject A₅)

Similar construction holes were also found in the subjects' problem construction of function number 1. When Subject A1 stated that the equation $x_1 = x_2$ had the same value, he also agreed that $f(x_1) = f(x_2)$ was correct. In fact, x_1 and x_2 are actually members of different domains. The construction holes made by Subject A1 can be seen in the following interview excerpt.

R : Did you assume that x_1 and x_2 have the same value?

A1 : Yes. I figured out x_1 and x_2 to obtain $f(x) = 2x - 3$.

The subject encountered a construction hole in this problem as a result of unclear views about x_1 and x_2 so that the task's comprehension became partial and incorrect. Subanji (2015) refers to the above construction errors as construction holes. The subjects' errors were caused by insufficient thinking frameworks, which resulted in a failure to comprehend the task. Khasanah et al. (2019) discovered a similar conclusion: pupils occasionally make errors in constructing mathematical concepts as a result of inadequate thinking frameworks, or in other words, building holes in their thinking processes. In this situation, students need scaffolding to cover the holes that occur (Priyati & Lygia Mampouw, 2018).

3. Mis-logical Construction

The data of this study indicate that a participant provided the correct response with ambiguous justifications. When additional in-depth interviews were conducted, the subject was unable to articulate the connection between the concepts employed and the concept of proper function and issue resolution that should be performed.

The subject solved the assignment utilizing the idea of "injective function" rather than a clear idea. The subject based his response only on "coincidence" that the injective function's definition is identical to the problem at hand. He assumed that $f(x_1) = f(x_2)$ because of the equal sign. This error was found in Subject A_2 's answer to task number 1, such as shown in Figure 8.

<p>Ya, karena fungsi tersebut merupakan fungsi injektif (satu - satu), dimana jika $x_1 = x_2$ maka $f(x_1) = f(x_2)$.</p>
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Figure 8. Subject A_2 's Answer to Task No. 1

The construction error done by the subject above was confirmed by the following interview excerpt:

R : What relevance does this have to the task? How did you figure out that the task contained injective function?

A2 : From the statement, injective function can be written if $f(x_1) = f(x_2)$ then $x_1 = x_2$. I drew a conclusion based on this. Regarding the relevance, I am not sure about it.

As demonstrated in the interview excerpt above, Subject A_2 completed the task by utilizing the idea of an injective function. Rather than relying on a well-defined idea of solution, the participant relied solely on the similarity of the injective function's specification to the problem at hand. According to Subanji (2015) the construction error happened because the subject formed assumptions that he believed were true despite the fact that they were fundamentally incorrect and irrational. As evidenced by the subject's explanation, the answer was given only on the basis of a function definition's similarity to the existing situation. As a result, the problem-solving approach based on these assumptions is incorrect (Hidayanto et al., 2017). The respondent answered wrongly in this case because his assumptions did not

match the proper response. As a result, the subject committed a conceptual construction error known as mis-logical construction.

4. Mis-analogical Construction

The findings of this study also showed that Subjects A₄ and A₅ made mistakes by equating one concept with another concept. This is shown in Figure 9.

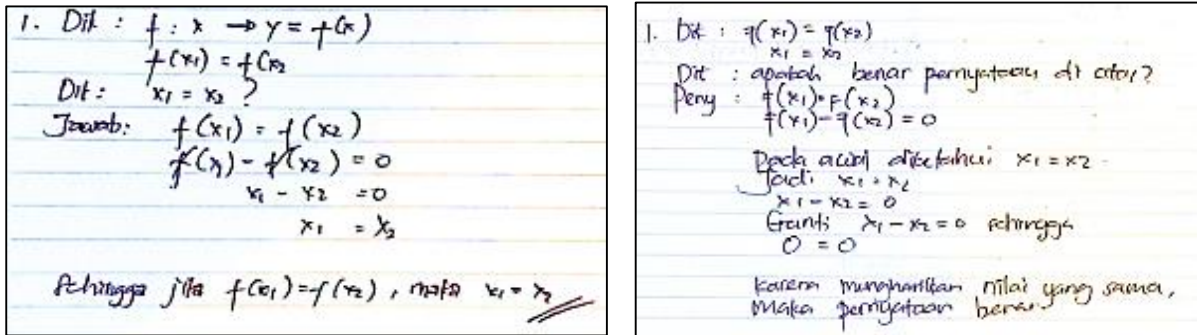


Figure 9. (a) Subject A₄'s Answer to Task No. 1 (b) Subject A₅'s Answer to Task No. 1

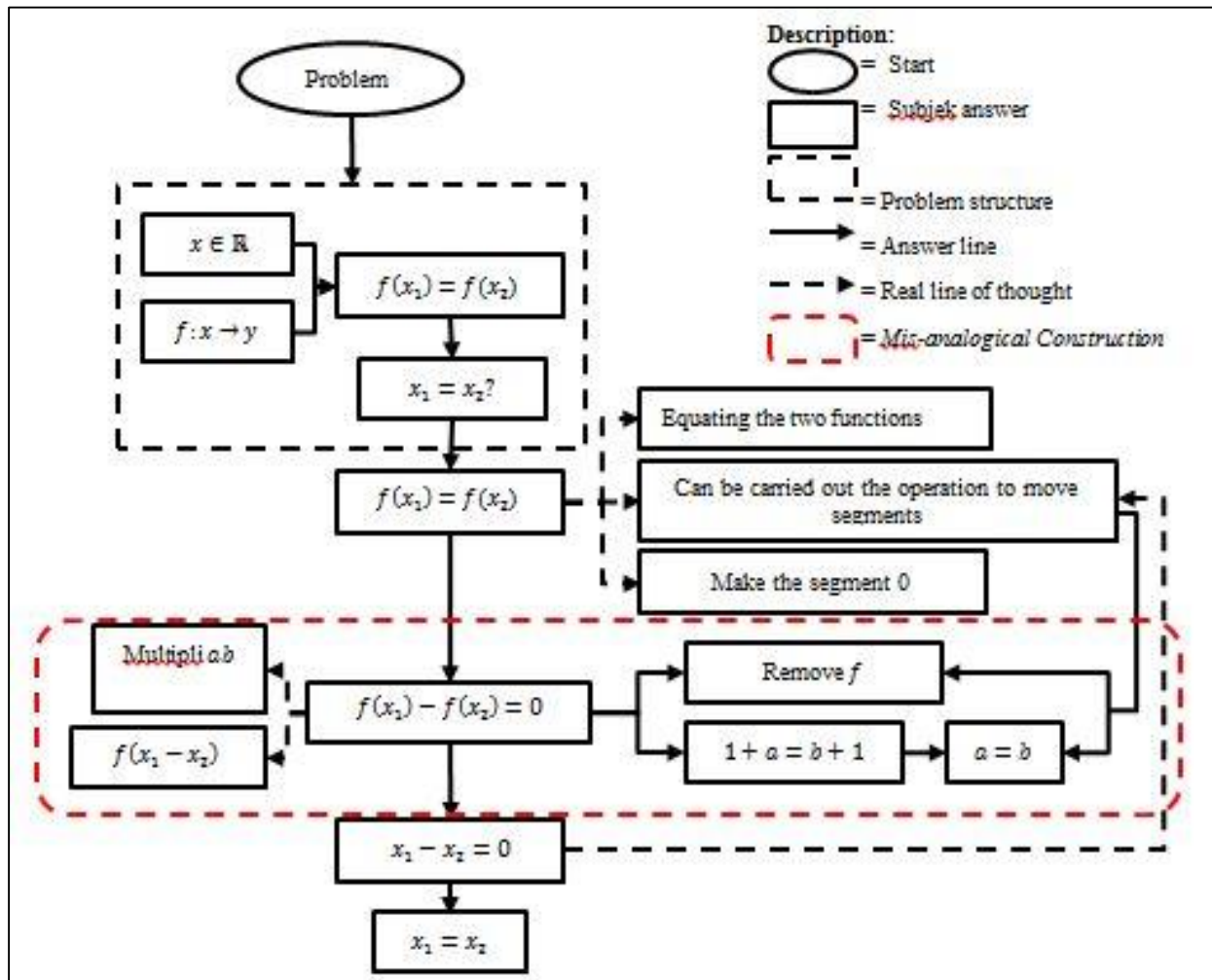


Figure 10. Structure of Construction Error in Task No. 1 (Subjects A₄ and A₅)

In Figure 9 and Figure 10, the subject assumed that the problem could be resolved by analogy f as a variable that can be operated as an algebraic operation through equating $f(x_1)$

and $f(x_2)$ in the ab algebraic multiplication, where f can be omitted. The following excerpt confirmed the finding:

R : How can you think of that solution?

A4 : If we have $1 + a = 1 + b$, the segment can be moved into $a = 1 + b - 1$ so $a = b$. That's more or less what I can applied in number 1.

The subject solved the task by assuming $f(x_1)$ and $f(x_2)$ as ab multiplication. As a result, he wrote $f(x_1) - f(x_2) = f(x_1 - x_2)$ and omitted f , moved in the equation $x_1 - x_2 = 0$ to obtain $x_1 = x_2$. The subject's error is a thinking error in making analogous assumptions (Hidayanto et al., 2017). The analogy drawn by the subject was to solve function problems using an algebraic operation, in which the subject removed the function as if it were a multiplication operation. Subanji (2015) states that analogy thinking errors might result in the inability to solve a problem. As a result, it can be determined that the subject made a concept construction error in the form of mis-analogical construction.

The subjects in this study made a variety of conceptual construction errors, including pseudo construction, construction holes, mis-logical construction, and mis-analogical construction. These construction errors continue to occur despite the fact that students' grasp of the content being studied is re-honed during the online learning period. Several of the errors committed during online learning, among others, are the result of the online learning process, which entails a high volume of task assignments, inadequate networks, and a dearth of pre-learning activities. This style of learning runs the risk of resulting in concept construction that is entirely focused on answering questions.

R : During the learning process, what new things did you learn?

A1 : In my opinion, the material presented is similar to that obtained in high school. In high school, we are taught about the meaning of functions and practice questions, while in college, students are taught definitions as well. However, as I recall, the material hasn't changed much.

R : No new material. You still remember the ways of working on the questions taught in high school?

A1 : Yes, I do. Not much has changed. I still can remember what was taught in high school.

R : How about the learning process? If I'm not mistaken, online learning had just been implemented, yes?

A1 : Yes. In my opinion, there were still many shortcomings in online learning at that time. Since we were still not familiar with online lectures, so we were still fumbling. Moreover, the internet network here is also not very good, but fortunately the lecturer can explain in a relaxed manner so that I can understand the material quite well. The rest, we are given a lot of practice questions or assignments to do.

R : Since the material remains the same, you still remember how to solve function problems, which you acquired in high school?

A1 : Yes.

Utami & Cahyono (2020) argue that the goal or target of online mathematics learning will be confined to gaining adequate grades rather than the skills that students should develop. According to Subanji (2015), students who solely follow problem-solving norms would struggle to understand concepts, abstract concepts, and relate mathematics to everyday life.

As a result, delivering assignments alone cannot motivate students to effectively create concepts during online learning. This is in line with the result of Alawamleh et al. (2020) which found that students prefer face-to-face learning directly (offline learning) than online learning, because of the many problems they face in online learning, i.e lack of understanding material. Kaffenberger (2021) also said that the long-run learning as the impact of the Covid-19 learning shock must be designed as actions more than mitigate the loss of students construction. So that concept construction can run well, teachers should provide meaningful learning and involve students during online learning Martin & Bolliger (2018). This means that the learning design must be packaged in such a way that students are involved in the learning process. This learning activity can be done by combining various methods, both synchronous and asynchronous with various combinations of active and cooperative learning methods (Rapanta et al., 2020; Lin et al., 2017).

The findings of this study showed that the construction of students' concepts of functions during online learning did not grow significantly. The students were, in fact, still using the construction of function concept that they acquired in high school. So that it can be said that students cannot construct well the concepts obtained during online learning and use them in solving problems. This resulted in the subject having a poor comprehension of the function, as seen by the test results. Furthermore, the conceptual flaws that are common outside of online learning also occur in online learning. Errors that were identified prior to participating in the online learning process are not remedied because the students failed to integrate the information gained with the concept being created. This due to the lack of understanding of the material due to the limited time for virtual face-toface meetings between students and lecturers, as well as students to the other students. As stated by Alawamleh et al. (2020) that one of factors that students do not like online learnig is the decrease in communication levels between the students and their teacher. Santoso et al. (2021) also said that students experience conceptual misunderstandings as well as misunderstandings about prerequisite concepts because they have difficulty in managing new information and relating it to previous ones. Khasanah et al., (2019) explains that when newly acquired knowledge is not linked to existing knowledge, pupils may struggle to understand new concepts.

When the concept construction error occurred, several individuals' comprehension of functions had already been developed. This can be seen when the research subjects tried to answer the question using the function definition, even though the solution was incorrect. Some subjects even linked the completion of a function with the completion of another mathematical concept. They failed to update their old conceptual structures because they were unable to relate prior knowledge to what was being studied in the online learning process. Thus, the concept construction in the subjects did not develop adequately in this situation.

This finding means that online learning conducted by lecturers is not effective in increasing the accuracy of students' conceptual structures for students in remote areas. Based on the findings of this study, we suggest that online learning can be packaged better, for example by involving students more in the learning process, making students think more in the learning process, with blended learning, and meaningful learning. In addition, this study

opens up opportunities for further researchers to further examine the factors that cause students to make mistakes in formulating mathematical concepts.

D. CONCLUSION AND SUGGESTIONS

The results and discussion of this study suggest that during online learning, Class 2019 students at Mathematics Education, Papua University, could not develop proper concept construction of functions. This can be seen from the various errors they made when answering the tasks. The first is true pseudo construction which describes a condition where the subjects seemed to answer correctly, but the answer was supported by a false "root of" theory (students considered the "root of" relation as the result of the root domain". These students also performed false pseudo construction, where their answer about "the root of" was wrong, but after being given scaffolding, they could correct the answer. In addition, construction holes also occurred in the students and resulted in incorrect construction of x_1 and x_2 as the members of different domains. The subjects also made mis-logical construction. This happened when they answered the question wrongly because they mistook the completion of the task for the fulfillment of the injective function. Besides, mis-analogical construction was identified in the subjects' answer when they applied the ab multiplication to the existing function task and eliminated f because they thought it was similar to common algebraic operations. Finally, the subjects also failed to apply the concept of function in the area of the rectangle in question. The results of the study have implications for online instructors, instructional designers, and administrators who wish students to have good concept construction in online learning.

Based on the findings of this research, we suggest that before learning is carried out, the teacher should know the construction of the concept of students, so that the process of students' conceptual change in online learning can be known. Online learning things are packed as well as possible by involving students in the learning process and providing meaningful learning for students.

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