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THE CONSTRUCTION PROCESS OF NEW CONCEPT BASED ON APOS THEORY: MALE VS FEMALE IN DIRECT PROPORTION

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Abstract

The concept construction process makes students' mathematical knowledge develop better than before. It's because the concept construction process involves the relationship of one concept to another. In constructing a mathematical concept, gender is influential in process. This qualitative research aims to describe the process of constructing new concept of male and female students. The subjects were two sixth grade elementary school students (one male, one female). The instruments were test and interview. The data analyzed using APOS theory (Action, Process, Object, Schema). At action stage, they can solve problems related to direct proportion concept. At process stage, they can interpret direct proportion problem into various representations and explain the characteristics. At object stage, they can provide other examples of direct proportion concept and identify a problem including direct proportion concept or not. At schema stage, they can define direct proportion but female student was clearer in defining it than male student. They can also conclude its relationship with some concepts. They can construct new concept well, although there are errors in the process. Female student is better than male student at conveying the results of her thoughts both in writing and verbally in the process of constructing new concept.

Keywords: APOS theory; concept construction process; direct proportion.

Abstrak

Proses konstruksi konsep menjadikan pengetahuan matematika siswa berkembang lebih baik dari sebelumnya. Hal ini karena proses konstruksi konsep melibatkan hubungan antara satu konsep dengan konsep lainnya. Dalam membangun konsep matematika, jenis kelamin berpengaruh dalam prosesnya. Penelitian kualitatif ini bertujuan untuk mendeskripsikan proses konstruksi konsep baru siswa laki-laki dan perempuan. Subjek penelitian adalah dua siswa kelas VI SD (satu laki-laki, satu perempuan). Instrumen yang digunakan adalah tes dan wawancara. Data dianalisis menggunakan teori APOS (Aksi, Proses, Objek, Skema). Pada tahap aksi, mereka dapat memecahkan masalah yang berkaitan dengan konsep perbandingan senilai. Pada tahap proses, mereka dapat menginterpretasikan masalah perbandingan senilai ke dalam berbagai representasi dan menjelaskan karakteristiknya. Pada tahap objek, mereka dapat memberikan contoh lain dari konsep perbandingan senilai dan mengidentifikasi suatu masalah termasuk konsep perbandingan senilai atau bukan. Pada tahap skema, mereka dapat mendefinisikan perbandingan senilai tetapi siswa perempuan lebih jelas dalam mendefinisikannya daripada siswa laki-laki. Mereka juga dapat menyimpulkan hubungannya dengan beberapa konsep. Mereka dapat mengonstruksi konsep baru dengan baik, meskipun ada kesalahan dalam prosesnya. Siswa perempuan lebih baik daripada siswa laki-laki dalam menyampaikan hasil pemikirannya baik secara tertulis maupun lisan dalam proses mengonstruksi konsep baru.

***Kata kunci**: perbandingan senilai; proses konstruksi konsep; teori APOS.*

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INTRODUCTION

The construction process occurs when a person learns a new concept. Ni'mah et al., (2018) stated that concept construction means active activities to form a new knowledge or concept. Anggraini et al., (2018) stated that the concept construction process is the activity of building a concept through attribution from one concept to another. Based on these two definitions, the concept construction process is the stage that a person takes to form a new concept in his/her mind.

The construction process experienced by a person is expected to lead to the understanding of the concept. Mumu et al., (2017) states that a person's understanding of a concept is the result of the construction or reconstruction of an object being studied. It is said to be the result of construction if the concept being studied has never been studied before (a new concept), while the result of reconstruction if it has been studied before.

There are several theories related to the concept construction process, that is the APOS Theory by Dubinsky and the Five E's by Roger Bybee. Based on the APOS theory, a person will go through four stages in constructing concepts, that is the stages of action, process, object, and schema (Tatira, 2021). On the other hand, the stages in the concept construction process through the 5E approach are Engage (apperception), Explore (investigation), Explain (explainning/discussing), Elaborate (connecting concepts), and Evaluation (Setyawan & Rahman, 2013).

Dubinsky's theory of APOS and Five E's both reveals the stages in constructing concepts. The difference lies in the time of the progression of the concept construction process. APOS theory studies individuals in constructing concepts and can be implemented to help the learning process (Syamsuri & Santosa, 2021). Setyawan & Rahman (2013) stated that Five E's were carried out by students during learning. Therefore, researcher choose to use APOS theory in this research because the theory is more flexible in its implementation.

The framework of the APOS theory in the process of concept construction is as follows. An action is reactions to external stimuli. A process is the behavior of an individual in examining and contemplating an action or a series of actions. If someone is aware of a process of repeated action then he/she will be able to summarize the process into a cognitive object. A collection of actions, processes, objects, and other schemas that have been built previously whose structure is schema (Listiawati & Juniati, 2021)

The process of concept construction rests on the theory of constructivism (Permata et al., 2018). So far, constructivism is recognized as good theory because one of the principles is that students are actively constructing continuously so that there is always a change in concepts towards more detailed, complete concepts, and in accordance with scientific concepts (Husamah et al., 2015). Even so, the teacher did not believe much that the child could construct concepts. The evidence, based on the observations of Indrasari et al. (2022), until now mathematics learning in the classroom is still often centered on the teacher as a material delivery. It means, so far the concept is still given by the teacher, not the construction of the students themselves. This could be because there are not many articles that discuss the depiction of the concept constructing process of students.

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In previous studies, APOS theory was more widely used to describe the reconstruction of mathematical concepts (Kurniawan et al., 2018); (Anam et al., 2020); (Israhayu et al., 2021); (Listiawati & Juniati 2021); (Puspitasari et al., 2021); (Tatira, 2021), and used to underlie the development of worksheets (Fatimah et al., 2017); (Arnawa et al., 2019); (Kamid et al., 2021). In addition, the research from Imamuddin et al., (2019) focuses on concept understanding. Ummah & Azmi, (2020) focuses on construction concept through learning media while Ni'mah et al., (2018) and Inganah et al., (2021) focuses on mistake in the construction mathematics concept. This research focuses on the construction process of the student in learning new concepts that she/he has never learned before. This research is important because it can be one of the references for teachers to guide students to construct concepts.

The concept construction process is closely related to a person's thinking pattern (Setyawan & Rahman, 2013). A person's thinking pattern will affect during the concept construction process. Imamuddin et al., (2019) stated that male and female have differences in terms of patterns or ways of thinking. This way of thinking is caused because the male brain is designed to be superior in visual-spatial ability and the female brain is designed to be superior in verbal ability (Imamuddin et al., 2019). As a result, female students are more detailed in conveying information than male students (Imamuddin et al., 2019). Therefore, studies related to the perspective of gender in analyzing the process of constructing concepts of students are interesting to study.

Sari (2020) stated that one of the concepts that is considered difficult for students to understand in seventh grade is the concept of direct proportion. Furthermore, Sari (2020) stated, students only memorize formulas and work procedures without understanding concepts. On the other hand, direct proportion is one of the concepts close to the daily life of students (Hamidah et al., 2018).

This research is expected to give a complete description regarding the construction process of direct proportion of male and female students based on APOS theory. So, the aim of this research is to describe the construction process of male and female students of direct proportion topic based on the APOS theory.

METHODS

This research is a case study research with a purposive sampling technique with the condition that the subjects chosen indicate each stage of APOS theory. The subjects in this research were two students (one male and one female students) on sixth grade at one of schools in Sidoarjo for the 2021/2022 academic year. The subjects of this research have not studied the direct proportion topic. Two subjects have medium mathematical ability.

The instrument of this research is interview based task (test). The test in question is a concept construction test that requires the subject to obtain the concept of direct proportion through contextual problem. Interview based task (test) are conducted to clarify and explore the process of constructing the concept of direct proportion that the subject performs based on the APOS theory. The test of the concept construction used can be seen in Figure 1. Data on test results and interviews were analyzed using the APOS theory and stages listed in Table 1.

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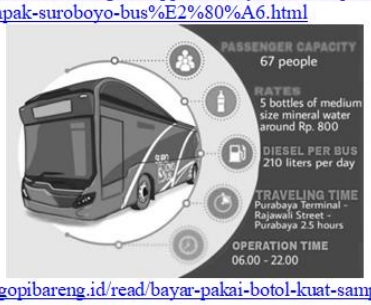
Suroboyo Bus is a bus transportation service with modern facilities owned by the Surabaya City Government. Information about the suroboyo bus boarding ticket, passenger capacity, the amount of fuel required, etc are in figure 1 and 2.

Sumber: http://www.djpb.kemenkeu.go.id/kppn/surabaya1/id/data-publikasi/artikel/2894-ingin-berhemat-yuk-rek,-numpak-suroboyo-bus%E2%80%A6.html



Sumber: https://www.ngopibareng.id/read/bayar-pakai-botol-kuat-sampai-kapan-2277075/amp

Figure 1. Test of the concept construction

Table 1. Indicators of constructing students' mathematical concepts based on apos theory in direct proportion topic

APOS Theory Stage	Indicator	Code
Action	a. Students are able to know what are known and is asked on contextual questions of direct proportion.	A_1
	b. Students are able to determine the value of a variable on a direct proportion.	A_2
	c. Students are able to explain the steps of finding the value of a magnitude on a direct proportion.	A_3
Process	a. Students are able to present contextual problem of direct proportion into various representations.	P_1
	b. Students are able to show that the direct proportion has certain characteristic, if the value of a variable increases, then other variable that is compared also increase.	P_2
Object	a. Students are able to give examples of contextual problems in which there is a concept of direct proportion.	O_1
	b. Students are able to classify a problem related to a direct proportion or a inverse proportion.	O_2
Schema	a. Students are able to define a direct proportion.	S_1
	b. Students are able to draw a chart related to relationships of fractional, ratios, direct proportion, and inverse proportion.	S_2

RESULT AND DISCUSSION

The following is the description of the results of the analysis and discussion of the data obtained.

Male Subject (MS)

Table 3 is the results of the male subject answers in the Part A of Concept Construction Test (questions a, b, c, and d).

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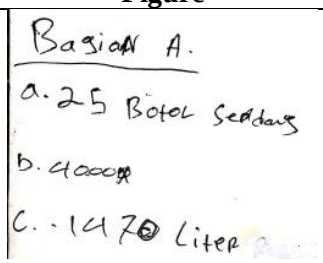
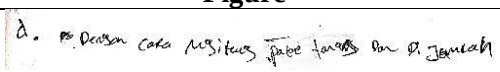
Table 3. Male subject answer in part A

Figure	Code	Figure	Code
	A_2	 Translation: By counting using hand and adding up.	A_3

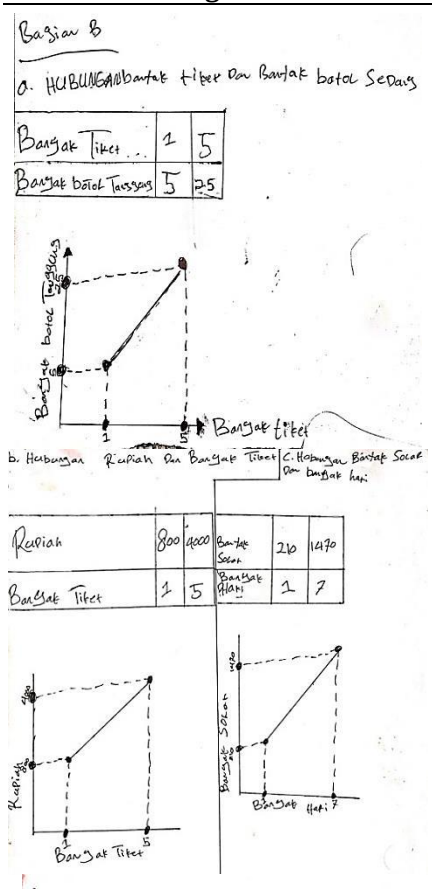
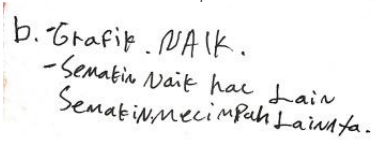
Action Stage

R : What is known?
MS1 : The number of bottles that must be exchanged, passengers, etc. ***(A_1)***
R : What are asked?
MS2 : The number of bottles to exchange, fares, and a lot of diesel. ***(A_1)***
R : What information do you use to get the results of (a) until (c)?
MS3 : The number of medium bottles to be exchanged, fares, a lot of diesel. ***(A_2)***
R : How do you get results on questions (a) until (c)?
MS4 : In the question (a) is 1 ticket is 5 medium bottles, if Ana needs 5 tickets, I added up 5 bottles 5 times. ***(A_3)***

From the results of the work of the male subject in table 3 and the interview conducted, it was obtained that MS was able to mention the known and asked on the concept construction test questions (MS1; MS2). MS is also capable of determining the value of a variable in the direct proportion and he can also explain the information he used to get the results (A_2; MS3). MS is also able to explain the steps of finding the value of a magnitude in direct proportion (A_3; MS4).

Table 4 is the results of the answer of male subject on the concept cons-truction test part B (questions a and b).

Table 4. Male subject answer in part B

Figure	Code
	P_1
 Translation: • The graph goes up • The more something rises, the more something else rises.	P_2

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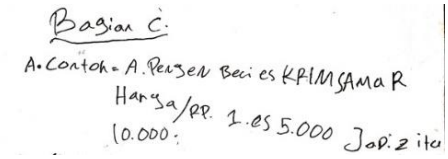
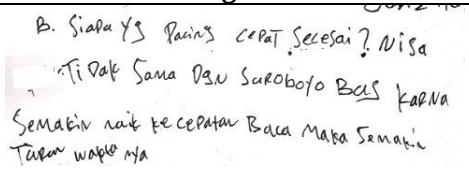
Process Stage

R : How do you make a table for Suroboyo Bus problem?
MS5 : I made two rows of tables for the number of tickets and medium bottles. ***(P_1)***
R : How do you draw a graph of Suroboyo Bus problem?
MS6 : I made it according to the data in the table. ***(P_1)***
R : What can you say based on the tables and graphs you make?
MS7 : The graph goes up. The more other things go up, the more abundant the another. ***(P_2)***

At this stage, MS is able to present contextual problems of direct proportion into various representations. From the results of the work on the concept constructing test and interview, MS was able to draw tables and graphs from direct proportion even though the graphs he drew were not quite right (P_1; MS5; MS6). The graph in this case should be dots instead of straight lines because this problem is a discrete case. In addition, MS is also able to show that the direct proportion has certain characteristic (P_2; MS7).

Table 5 is the results of the male subject answer on the Part C of concept construction test (questions a and b).

Table 5. Male subject answer in part C

Figure	Code	Figure	Code
	O_1		O_2
Translation: A wants to buy ice cream with B, the price of 1 ice cream is Rp5.000. So, 2 ice cream is Rp10.000.		Translation: The fastest to finish Nisa. This problem is not the same a the Suroboyo Bus concept because th higher the reading speed, the lower th time.	

Object Stage

R : What is an example of the same problem with the concept of Suroboyo Bus?
MS8 : We buy ice cream. ***(O_1)***
R : Why can your example be said to be the same as the Suroboyo Bus problem?
MS9 : Because it's like the previous one if 1 ice cream is Rp5.000, so if 2 ice cream means Rp10.000. ***(O_1)***
R : Why do you say that the relationship between a person's speed in reading book and that time is not the same as the Suroboyo Bus problem?
MS10 : Because this is a problem of reading speed of book. That was the suroboyo bus problem. So it's different. ***(O_2)***
R : I mean the characteristic of the problem?
MS11 : The faster we read it, the less time to finish it. ***(O_2)***

At the object stage, MS was able to provide an example of a direct proportion concept, that is in the purchase of ice cream (O_1; MS8). In the interview, he was able to explain why the example given was related to the direct proportion (O_1; MS9). In addition, MS is also able to classify a problem related to a direct proportion or inverse

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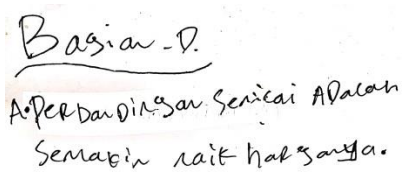
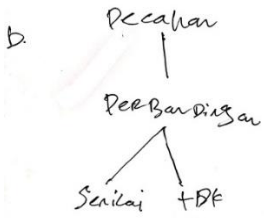
proportion. This can be seen from the results of the work on the concept construction test and strengthened during the interview (O_2; MS10; MS11).

Table 6 is the results of the answer of male subject on the Concept Construction Test Part D (questions a and b).

Table 6. Male subject answer in part D

Figure	Code
 Translation: Direct proportion is the higher the price.	S_1
	S_2

Schema Stage

R : What the definition of direct proportion?

MS12 : The direct proportion is the increasing price. ***(S_1)***

R : What is "the increasing price"?

MS13 : If one thing goes up, the another is getting more abundant. ***(S_1)***

R : Can you redefine a direct proportion?

MS14 : A direct proportion is a proportion that goes up one thing, then makes the more abundant the another. ***(S_1)***

R : What's the basis for you to make such a chart?

MS15 : I learned fractions first, and then learned proportion. Therefore, the fractions I wrote first above and then the proportion, then there are 2 kinds of proportion, that is direct proportion and not direct proportion. ***(S_2)***

R : Where did you know that the proportion was divided by 2 kinds?

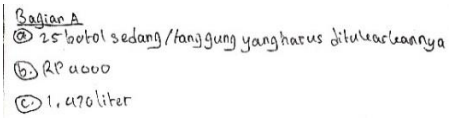
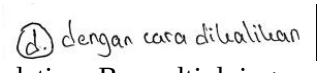
MS16 : In the previous question, there was a problem that was not the same as Suroboyo Bus, so there is likely to be a proportion that is not direct proportion. ***(S_2)***

At the schema stage, MS was able to make a definition of the direct proportion even though it still seemed difficult to say it (S_1; MS12; MS13). In the interview, he looks better at defining direct proportion (MS14). In addition, MS is also capable of drawing a chart for relationships of fractional, ratios, direct proportion, and not direct proportion/inverse proportion (S_2). This was also reinforced during the interview, although the reasons behind the charting had nothing to do with the similarity of the material (MS15; MS16).

Female Subject (FS)

Table 7 is the results of the female subject answer in the Part A of Concept Construction Test (questions a, b, c, and d).

Table 7. Female Subject Answer in Part A

Figure	Code
	A_2
 Translation: By multiplying.	A_3

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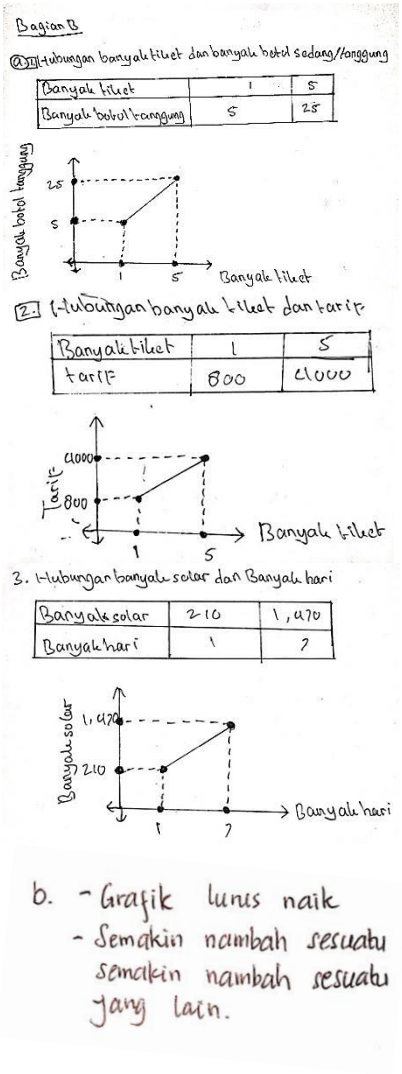
Action Stage

R : What is known?
FS1 : The number of bottles to exchange for tickets, diesel buses, fares, passengers, and others. ***(A_1)***
R : What is asked?
FS2 : The number of medium bottles have to be exchanged for tickets, fares in rupiah, and diesel fuel used by bus. ***(A_1)***
R : What information did you use to get the results of questions (a) until (c)?
FS3 : The number of medium bottles that Ana has to exchange, fares in rupiah, and diesel fuel used by bus. ***(A_2)***
R : How do you get results on questions (a) until (c)?
FS4 : I multiply it. ***(A_3)***

From the results of the work of the female subject in Table 7 and the interview conducted, it was obtained that the FS was able to know what was known and asked on the contextual question of the direct proportion (FS1; FS2). FS is also capable of determining the value of a variable in a direct proportion and she can also explain the information she used to get the results (A_2; FS3). FS is also able to explain the steps of finding the value of a magnitude on a direct proportion (A_3; FS4).

Table 8 is the results of the answer of the female subject on the Concept Construction Test Part B (questions a and b).

Table 8. Female subject answer in part B

Figure	Code
	**P_1** **P_2**

Translation:
- Straight up graph
- The more something, the more something else.

Process Stage

R : How do you make a table of this Suroboyo Bus problem?
FS5: I created a simple table whose the content was based on the relationships in the previous question. ***(P_1)***
R : How do you draw a graph of this Suroboyo Bus problem?
FS6: I made it like coordinates, the horizontal and vertical line

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were named based on the question of part A. ***(P_1)***

R : What can you say based on the tables and graphs you make?

FS7: The chart is straight up. But, now I think that the chart is down. If we look at it from 5 tickets, it means that the graph is down, but because 1 is smaller than 5 so it is true that I wrote, the graph is straight up. ***(P_2)***

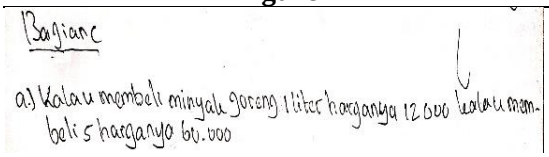
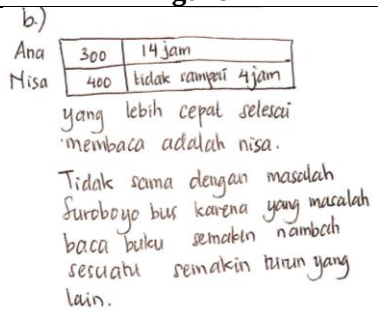
R : Another conclusion?

FS8: The point is that the more we add something, the more something else is also added. ***(P_2)***

At this stage, the FS was able to draw tables and graphs from direct proportion even though the graphs she drew were not quite right and she was also able to explain how to create tables and graphs of direct proportion (P_1; FS5; FS6). The graph in this case should be dots instead of straight lines because this problem is a discrete case. FS was also able to show that the direct proportion has certain characteristic (P_2; FS7; FS8) although there was a little doubt at the time of the interview (FS7).

Table 9 is the results of the female subject answer on the Part C of Concept Construction Test (questions a and b).

Table 9. Female subject answer in part C

Figure	Code	Figure	Code
 Translation: If we buy 1 liter of cooking oil for Rp12.000, then 5 cooking oils are Rp60.000.	O_1	 Translation: The one who reads faster is Nisa. The problem of book reading speed versus time is not the same as the Suroboyo Bus problem because the more something, the less something else.	O_1

Object Stage

R : What examples of everyday problems which are the same as the Suroboyo Bus problem?

FS9 : Buying cooking oil. ***(O_1)***

R : Why can your example be said to be the same as the Suroboyo Bus problem?

FS10 : Because the point is that the more things, the more something else. ***(O_1)***

R : Why do you claim that the problem of relationship between a person's speed when reading a book and that time is different from the problem of Suroboyo Bus?

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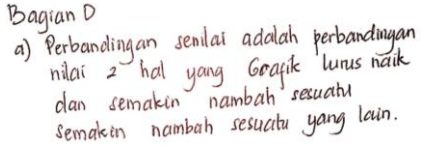
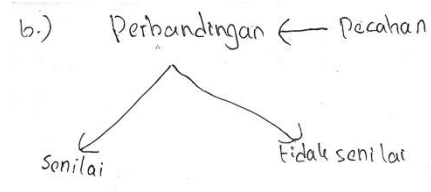
FS11 : Ana has a reading speed of 300 words per minute, she is finished within 4 hours. If Nisa has a reading speed of 400 words per minute, she is faster than Ana, if it is faster, Nisa will definitely finish before Ana. ***(O_2)***

At the object stage, the FS was able to provide an example of a direct proportion concept, that is in the purchase of cooking oil and she can explain the reason for the example of purchasing cooking oil related to the concept of direct proportion (O_1; FS9; FS10). FS was also able to classify a problem related to a direct proportion or a inverse proportion (O_2; FS11).

Table 10 is the results of the answer of female subject on the Concept Construction Test Part D (questions a and b).

Table 10. Female subject answer in part D

Figure	Code
 Bagian D a) Perbandingan senilai adalah perbandingan nilai 2 hal yang Grafik lurus naik dan semakin nambah sesuatu semakin nambah sesuatu yang lain. Translation: Direct proportion is a comparison of the values of 2 things whose the graph goes straight up and the more some-thing, the more something else.	S_1
	S_2

Schema Stage

R : What the definition of direct proportion?

FS12 : A direct proportion is a proportion of 2 things whose graph goes straight up and the more something is added, the more something else is added. ***(S_1)***

R : What is mean "proportion of 2 things"?

FS13 : There are 2 mentions such as the number of tickets and medium bottles. ***(S_1)***

R : How do you make conclusion regarding that definition?

FS14 : First, I looked at the characteristics which are obtained from looking at tables and graphs, and then I tried to make up the words to make a definition of direct proportion. ***(S_1)***

R : What's the basis for you to make such a chart?

FS15 : The fraction is similar to the proportion. Therefore, I put a fraction next to the proportion, then the proportion itself there are a direct proportion and not direct proportion. ***(S_2)***

R : Where did you know that the proportion was divided by 2 kinds?

FS16 : From the previous question, Ana-Nisa's case is not the same as Suroboyo Bus, so I think there is a proportion that is not a direct proportion. ***(S_2)***

At the scheme stage, the FS was able to make a definition of the direct proportion very well (S_1; FS12; FS13; FS14). FS was also capable of draw a chart related to the relationships of fractional, ratios, direct proportion, and not direct proportion/ inverse proportion and she was able to give a fairly rational reason (S_2; FS15; FS16).

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From the results of the research analysis that has been described, a summary of the concept construction process of male student and female student can be presented in the Table 11.

Table 11. Description of the concept construction process of male student and female student

Stage	Male Student	Female Student
Action	He is able to explain what is known and asked quite well, but ***not in great detail***. He is also able to determine the value of the direct proportion ***correctly.*** The last, he is able to explain the steps of finding the value of a magnitude on a direct proportion, that is ***using iterative summation***.	She is able to explain what is known and asked ***in detail***. She is also able to determine the value of the direct proportion ***correctly.*** The last, she is able to explain the steps of finding the value of a magnitude on a direct proportion, that is ***using multiplication***.
Process	He is able to present contextual problem of direct proportion into various representations although there is ***a little mistake***. He is also able to show that the direct proportion has certain characteristics, but ***not in great detail***.	She is able to present contextual problem of direct proportion into various representations although there is ***a little mistake***. She is also able to show that the direct proportion has certain characteristics ***in detail***.
Object	He is able to give examples of contextual problem in which there is a concept of direct proportion, that is in the ***purchase of ice cream***. He is also able to classify a problem related to a direct proportion or a inverse proportion with ***the wrong reason***.	She is able to give examples of contextual problem in which there is a concept of direct proportion, that is in the ***purchase of cooking oil***. She is also able to classify a problem related to a direct proportion or a inverse proportion with ***the appropriate reason***.
Schema	He is able to define a direct proportion with ***simple and incompatible sentences***. He is also able to draw a chart related to relationships of some material with ***the wrong reason***.	She is able to define a direct proportion with ***complex sentence***. He is also able to draw a chart related to relationships of some material with ***the rational reason***.

Based on the analysis of research results that has been carried out with 2 subjects, In brief, their concept construction process are illustrated in flowchart in Figure 3 and Figure 4.

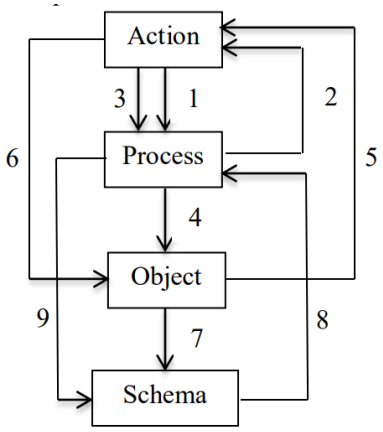

Figure 3. The concept construction process of male student

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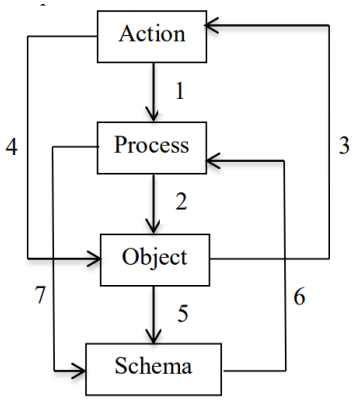

Figure 3. The concept construction process of female student

Action Stage

From the results of data analysis, it was obtained that there are similarities and differences between male and female student. At the action stage, there are similarities between the two students, that both are able to know what is known and asked in the concept construction test of direct proportion. Flowchart (1a,1b) so there are no constraints at this stage. Both identify using their own language, but female student is more detailed in delivering it. This reinforces the findings of (Imamuddin et al., 2019) that during understanding the concept being constructed, female student convey more detailed information than male student. At the action stage, both students are also able to determine the value of a variable at a direct proportion correctly. Flowchart (1a,1b) so there are no constraints at this stage.

The difference in the action stage occurs when explaining the steps of looking for the value of a magnitude on a direct proportion. Male student used iterative summation to get results from the direct proportion question, whereas female student immediately recognized that it was related to multiplication, without first using the concept of iterative summation. This reinforces the findings of (Imamuddin et al., 2019) that as long as they understand the concept being constructed, it is easier for female student to discuss something that is in their minds.

Process Stage

At the process stage, the similarities of the two students were found, that both were able to draw tables and graphs from direct proportion even though the graphs they drew were not quite right. Flowchart (2a,3a,1b) so there are no constraints at this stage. Both students clarified that they connected the coordinate points into a straight line to make it easier for them to see the characteristics of the graph. This reinforces the findings of (Ni'mah et al., 2018) that students can make *"false" pseudo construction* mistakes when constructing concepts. *"False" Pseudo Construction* is the student giving the wrong answer to a problem. However, when traced, student has the right way of thinking and can give the right answers (Ni'mah et al., 2018). Then, at the process stage, both are equally able to show the characteristics of the direct proportion very well.

Object Stage

At the object stage there are similarities and differences in male and female student. Both are able to give examples of direct proportion in everyday life properly. Differences occur when students classify a problem related to a direct proportion or inverse proportion. Male student when interviewed made a *"true" Pseudo Construction* mistake. He was able to determine that a problem was not a direct proportion, but he was wrong in clarifying the answer (4a,5a,6a). This reinforces the findings of (Inganah et al., 2021) that students can make *"true" Pseudo Construction* mistakes when

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constructing concepts. *"True" Pseudo Construction* is the student giving the correct answer to a problem. However, when traced, it turns out that student is wrong in providing clarification of answers (Inganah et al., 2021). Flowchart (2b,3b,4b) of female student so there are no constraints at this stage.

Schema Stage

At the schema stage, there are also similarities and differences in male and female students. Both are able to define a direct proportion very well. The difference is that female student is better than male student at making definitions. This also reinforces the findings of (Imamuddin et al., 2019) that as long as they understand the concept being constructed, female student convey more detailed information than male student.

At the schema stage, the two students are also able to draw a chart related to the relationships of fractional, ratios, and proportion. The difference lies in the reasons underlying the formation of such charts. Male student gives reason that have nothing to do with the characteristics of the material (7a,8a,9a), while female student gives rational reason related to the characteristics of each material (5b,6b,7b). This means that male student experience *construction holes*. This is in accordance with the findings of (Ni'mah et al., 2018) that when constructing concepts, students can make *construction hole* mistakes. *Construction hole*, that is students give correct answers, but there is a concept construction process in students that is not appropriate (Ni'mah et al., 2018).

The advantage of this research is that it provides a complete description regarding the construction process of direct proportion of male and female students based on APOS theory. However, only two research subjects, one male and one female may not represent all the characteristics of males and females, so it is possible for other research to produce a concept construction process that is different from the results of this research.

CONCLUSION AND SUGGESTION

Based on the results of data analysis and discussion, conclusions can be made regarding the construction process of students on new concepts based on their gender as follows.

1. Male student is able to construct new concept quite well, although there are some errors in the process. The mistakes were not fatal so that the new concept that became the focus of this research was well illustrated in the mind of male student. In the process, male student seems to have difficulty in discussing the results of their thoughts.
2. Female student is also able to construct new concept well, even though there are errors in the process. The mistakes were not fatal, so the new concept that became the focus of this research was well illustrated in the mind of the female student. Female student in the process of constructing new concept is quite good at conveying the results of her thoughts both in writing and verbally.

The results of this research strengthen the opinion that students are able to construct new concepts as expected by constructivist theory. However, the use of the right context also determines the construction process.

In learning mathematics with a constructivist approach, the results of this research suggest that different

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attention is needed when guiding male student and female student when they work on constructing concepts. For male student, mentoring places more emphasis on collecting students' argument at each stage of the concept construction process with the aim of training student to convey something that is on their minds while mentoring for female student is emphasized on providing instructions to direct the formal definition of a mathematical concept.

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