Students' New Concept Construction Process Based on APOS Theory: Introvert versus Extrovert

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Abstract

This study aims to describe the process of constructing new concepts for students with introverted and extroverted personalities. The research subjects were two students of grade VI in one of the elementary schools with different personalities (introverts and extroverts). Data collection techniques using personality test questionnaires, tests, and interviews. Analysis of the data from the proportion concept test results refers to the APOS indicator (Action, Process, Object, Schema). The results showed that there were differences between introverted and extroverted students in the process of constructing students' new concepts on proportion concept. At the Action stage, they can solve problems related to the concept of worth comparison. The two subjects used a similar strategy, namely the multiplication operation. At the Process stage, introverted subjects can interpret the value comparison problem into various representations, both tables and graphs, and can explain its characteristics. While the extrovert subject is only able to represent the problem of value comparison in the form of a table only and experiences doubts in explaining its characteristics. At the Object stage, they can provide other examples of the concept of value comparison, but introverted subjects are more creative in this regard. In addition, they are also able to classify whether a problem includes the concept of valued comparison or not. At the Schema stage, they can define worth comparison and can infer its relationship with several concepts even though the extroverted subject has not fully concluded its relationship with the classification of comparison. This description can be used as input for teachers in choosing learning methods or strategies to convey material that is well received by each student.

Keywords: Concept Construction, APOS Theory, Personality Type.

Abstrak

Penelitian ini bertujuan untuk mendeskripsikan proses konstruksi konsep baru siswa dengan kepribadian introvert dan ekstrovert. Subjek penelitian adalah dua siswa kelas VI di salah satu sekolah dasar dengan kepribadian yang berbeda (introvert dan ekstrovert). Teknik pengumpulan data menggunakan angket tes kepribadian, tes, dan wawancara. Analisis data hasil tes konsep perbandingan mengacu pada indikator APOS (*Action, Process, Object, Schema*). Hasil penelitian menunjukkan bahwa terdapat perbedaan antara siswa introvert dan siswa ekstrovert dalam proses konstruksi konsep baru siswa pada materi perbandingan. Pada tahap Aksi, mereka dapat memecahkan masalah yang berkaitan dengan konsep perbandingan senilai. Kedua subjek menggunakan strategi yang mirip, yaitu dengan operasi perkalian. Pada tahap Proses, subjek introvert dapat menginterpretasikan masalah perbandingan senilai ke dalam berbagai represetasi, baik tabel maupun grafik, dan dapat menjelaskan karakteristiknya. Sedangkan subjek ekstrovert hanya mampu merepresentasikan masalah perbandingan senilai dalam bentu tabel saja serta mengalami keraguan dalam menjelaskan karakteristiknya. Pada tahap Objek, mereka dapat memberikan contoh lain dari konsep perbandingan senilai, tetapi subjek introvert lebih kreatif dalam hal tersebut. Selain itu, mereka juga mampu mengklasifikasikan apakah suatu masalah termasuk konsep perbandingan senilai atau bukan. Pada tahap Skema, mereka dapat mendefinisikan perbandingan senilai serta dapat menyimpulkan hubungannya dengan beberapa konsep walaupun subjek ektrovert belum sepenuhnya menyimpukan keterkaitannya dengan pengklasifikasian perbadingan. Deskripsi ini dapat sebagai masukan bagi pengajar dalam memilih metode atau strategi pembelajaran untuk menyampaikan materi dapat diterima baik oleh setiap siswa.

Kata kunci: Konstruksi Konsep, Teori APOS, Tipe Kepribadian.

Introduction

There is a connection between the acceptance of new concepts received by students and the concept construction process. Mathematical concept construction is an active activity carried out to build a concept in mathematics (Ni'mah et al., 2018; Suryaningrum et al., 2020). The process of building knowledge in the context of learning mathematics is carried out continuously so that it becomes knowledge for students. Students will find it difficult to understand new concepts if the previously learned concepts have not been understood by the students (Safitri et al., 2021; Israhayu et al., 2021; Suriyah et al., 2022). Concept construction oriented learning will try to involve the role of students in linking mathematical concepts. This will provide added value to students' cognitive development (Umam & Azhar, 2019).

Although the construction process is an important part of mathematics learning, until now, mathematics learning in the classroom is still often teacher centered in the delivery of material (Indrasari & Sarjana, 2022). In particular, the learning process does not develop students' thinking so that reasoning is not well constructed. In other words, mathematics learning in the classroom is still centered on the teacher who is in full control during learning as well as the main material provider. Whereas research shows the success of student-centered learning compared to conventional learning (Hidayat & Taufiqurrahman, 2022). In this case, students can be active in every stage of learning to provide, so the role of the teacher is recommended to be able to create a comfortable learning atmosphere and attract students to participate in every phase of learning. This may be due to the fact that there are not many articles discussing the description of students' concept construction process.

To find out how students construct new concepts, a theoretical framework is needed. According to Winarsih & Mampouw (2019), APOS theory is a constructivist theory of how the possibility of achieving a mathematical concept learning. APOS theory reveals that students construct their knowledge through four stages, namely Action, Process, Object, and Schema. According to Sunardi et al., (2022), APOS theory can be used as an analytical tool to describe how mathematical knowledge is formed in a person and can be used to see whether students' understanding of mathematical concepts has reached a certain stage or not. In its application, the use of this theory is considered more flexible to describe the construction process of students in understanding a mathematical concept (Kurrotul & Rosyidi, 2022).

APOS theory reveals that students construct their knowledge through four stages, namely Action (*Aksi*) is a reaction to an external stimulus. Process (*Proses*) is the behavior of students in reviewing and contemplating an action or series of actions. If students realize a repetitive action process then he will be able to summarize the process into objects (*Objek*) cognitive. A collection of actions, processes, objects, and other schemes that have been built and structured before is a Schema (*Skema*) (Listiawati & Juniati, 2021). One of the materials that require a strong construction process is proportion material. Proportion material requires a strong understanding of the concept because it is closely related to everyday problems. Some studies reveal that students have difficulty in classifying a problem in value proportion or inverse value due to low concept understanding. (Agnesti, Y., & Amelia, R., 2021; Puspithasari & Pujiastuti, 2021; Toha et al., 2018).

The process of constructing new concepts is related to a person's thinking process. Awaludin et al (2021) revealed that the thinking process will be related to the personality of the students. Yuliani et al., (2019) suggested two types of personality, namely introverts and extroverts. Sari et al., (2020) reveals that extroverted and introverted personalities also play an important role in students' thinking process activities. Someone with an extroverted personality is influenced from outside himself. Whereas someone with an introverted personality is influenced by something inside him where aspects of thoughts feelings and actions are determined by subjective factors (Sari et al., 2019). Based on this, it

can be said that different personalities are likely to produce different thought processes. In this case, the difference in the thinking process will result in a different construction process.

In previous studies, APOS theory was used in research that focused on concept understanding (Novianti & Pratama, 2022; Supratman et al., 2022; Winarsih & Mampouw, 2019). Other research findings focused on problem solving (Kazunga & Bansilal, 2020; Ulya et al., 2022). This study focuses on analyzing the process of students' new concept construction in terms of introverted and extroverted personalities. In relation to students' personality types, studies prove that students with extroverted personalities are closer to the truth when compared to introverted students in solving mathematical problems (Awaludin et al., 2021). Other findings also reveal that there are differences in terms of math anxiety between the two personalities (Azizah & Suhendra, 2020). These findings motivate researchers to further investigate whether between personality types of students have differences in the process of constructing students' new concepts. Thus, this study aims to analyze how students' new concept construction process based on APOS theory in terms of introverted and extroverted personality types.

Method

This type of research is descriptive qualitative research. The research subjects were two students of grade VI in one of the elementary schools in Lamongan in the 2022/2023 school year, with different personalities (introverts and extroverts), were selected based on purposive sampling technique. The subject selection was based on: 1) The selected subjects have not learned the proportion topic; 2) The selected subjects consisted of two different personalities, namely introverts and extroverts. Subject selection data to determine students' personality types were taken from the results of personality questionnaires. To determine students' personality type, the personality type questionnaire instrument was adapted from Noviani's research (2016). The selected subjects were ES with extroverted personality and IS with introverted personality. Both subjects have the same math ability and gender to avoid the influence of other variables.

The instruments used in this study were personality type questionnaire, concept construction test questions and interview guidelines. The personality questionnaire was used to classify students according to their personality type. Subjects who have been selected to represent each personality type are given concept construction test questions to find out the construction process of students in understanding the concept of proportion. The concept construction test questions used were modified from Kurrotul & Rosyidi's research (2022) which can be seen in Figure 1. Meanwhile, interviews were conducted to obtain deeper information about the results of student work in constructing the concept of proportion. The test and interview data were analyzed using APOS theory with concept construction indicators which can be seen in Table 1.

Figure 1. Test of the Concept Construction

Tabel 1. Indicators of Construction Student's Mathematical Concepts Based on APOS Theory in Proportion Topic.

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

(Adaptation : Kurrotul & Rosyidi, 2022)

Result and Discussion

Based on the analysis, the students' construction process on proportion material based on APOS theory obtained the following results.

A. Construction Process of Proportion Concept by Introverted Students (IS)

Translastion:
a. It is known that Mrs. Priya wants to make 3 servings of ice cendol. 1 portion requires 300 grams of brown sugar. Asked: how many grams of brown sugar are needed to make 3 servings of es cendol. Solution: $3 \times 300 = 900$. So the brown sugar needed for 3 pores of ice cendol is 900 grams.
b. It is known that the price of 1 portion of es cendol is Rp 5000. Hanif bought 5 servings. Asked: how much should Hanif pay? Solution: $5 \times 5000 = 15000$. So the price Hanif has to pay is Rp 25.000,00.
c. I multiplied many grams of brown sugar by many servings.

Figure 2. Introverted Subject Answer in Part A

P   : *"What is known and asked in question a?"*
IS1   : *"Ms. Priya wants to make 3 servings of es cendol. 1 portion requires 300 grams of brown sugar" (A1)*

P   :   *"Okay, so what does the question ask?"*
IS2   :   *"How many grams of brown sugar does it take to make 3 servings of es cendol" (A1)*
P   :   *"What information did you use to get the results of problem a and problem b?"*
IS3   :   *"For question a, there are many portions and brown sugar, for question b, there are many portions and the price of the ice cendol" (A2)*
P   :   *"How do you get the result of problem a and problem b"*
IS4   :   *"I multiply the grams of brown sugar by the portion" (A3)*

The results of the answers of subjects with introverted personalities on concept construction questions part A (questions a, b, and c) are shown in Figure 2. The results of the introverted subject's work in Figure 2 and the results of the interview show that the subject with introverted personality, IS, successfully fulfills the Action indicators (A1, A2, and A3). IS subject was able to identify and write down the known and questionable elements in the problem correctly (A1; IS1; IS2). IS subject also mentioned the information used to get the result (A2; IS3). In addition, at the interview stage, IS explained how to get the results obtained (A3; IS4).

Translation:
The graph increases upwards, the more portions the higher the point
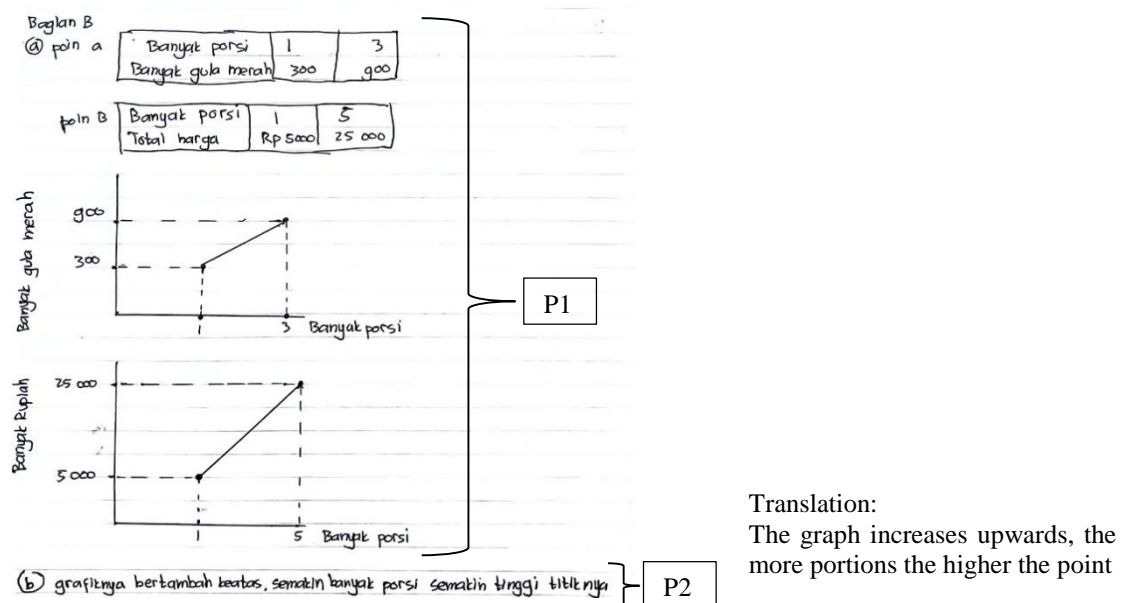
Figure 3. Introverted Subject Answer in Part B

P   :   *"How did you set up the table for this cendol drink recipe problem?"*
IS5   :   *"One serving is 300 grams of brown sugar, so 3 servings multiplied by 3 is 900 grams of brown sugar" (P1)*
P   :   *"How did you graph this problem?"*
IS6   :   *"How did you graph this problem?"*
P   :   *"Are there any special characteristics of the tables and graphs you made?"*
IS7   :   *"There is, if the more portions the higher the point" (P2)*

Figure 3 is the result of the subject's answer with extroverted personality in the concept construction text part B (questions a and b). In part B, the results of IS's work show that he has gone through the process stage by presenting the problem in various representations. IS subject in the process has been able to describe the table and graph of the value proportion problem (P1; IS6). In addition, the IS subject in the results of the work and interviews has also shown that proportion has certain characteristics (P2, IS7).

Figure 4. Introverted Subject Answer in Part C

P	:	*"Try to give an example of a problem that is similar to the concept in this problem"*
IS8	:	*"For example, a recipe for making jelly"(O1)*
P	:	*"Why is the example you gave the same as the ice cendol problem?"*
IS9	:	*"Because it's like before. For example, 1 serving requires 2 ounces of sugar so if 2 servings require 2 ounces of sugar"*
P	:	*"For this second problem (about reading speed), is the concept the same as the ice cendol problem?"*
IS10	:	*"Not the same, because the more words that can be read the less time. So Rahma finished faster" (O2)*

The results of IS with extroverted personality in the concept construction text part C (questions a and b) are shown in Figure 4. From the results of the work and the results of the interview, IS subject can provide an example of the concept of proportion, namely with the context of the recipe for making agar-agar (O1; IS8). This was accompanied by supporting arguments at the interview stage (IS9). In addition, ES in the process was also able to classify the problem in problem b with the problem of problem a. This can be seen from the results of the concept construction test and strengthened during the interview (O2; IS10).

Figure 5. Introverted Subject Answer in Part D

P	:	*"If the ice cendol recipe problem was mentioned earlier as an example of a case of direct proportion. What do you think a direct proportion is?"*
IS11	:	*"If one goes up, the other goes up too"*
P	:	*"How did you come to that conclusion about the definition?"*
IS12	:	*"Because if you increase the portion, the brown sugar also increases" (S1)*
P	:	*"Why did you draw up the chart the way you did?"*
IS13	:	*"Because fractions show proportion. There are fractions that are equal and fractions that are not equal, just like the concept of proportion" (S2).*
P	:	*"Can you give an example of what is not the same?"*
IS14	:	*"If it's not the same as the reading speed question earlier"*

The test results of IS with introverted personality in the concept construction text part D (questions a and b) are shown in Figure 5. IS subject at the schema stage is shown when IS subject is able to compile the definition of proportion (S1; IS12). In addition, the process of drawing a chart related to the relationship between fractions, value proportion, and inverse value proportion was fulfilled by subject IS as shown in the results of his work (S2; IS13). When an in-depth explanation was conducted about the underlying reason why the chart drawn was so, subject IS connected it with the classification of fractions that he had learned.

B. The Construction Process of Proportion Concept by Extroverted Students (ES)
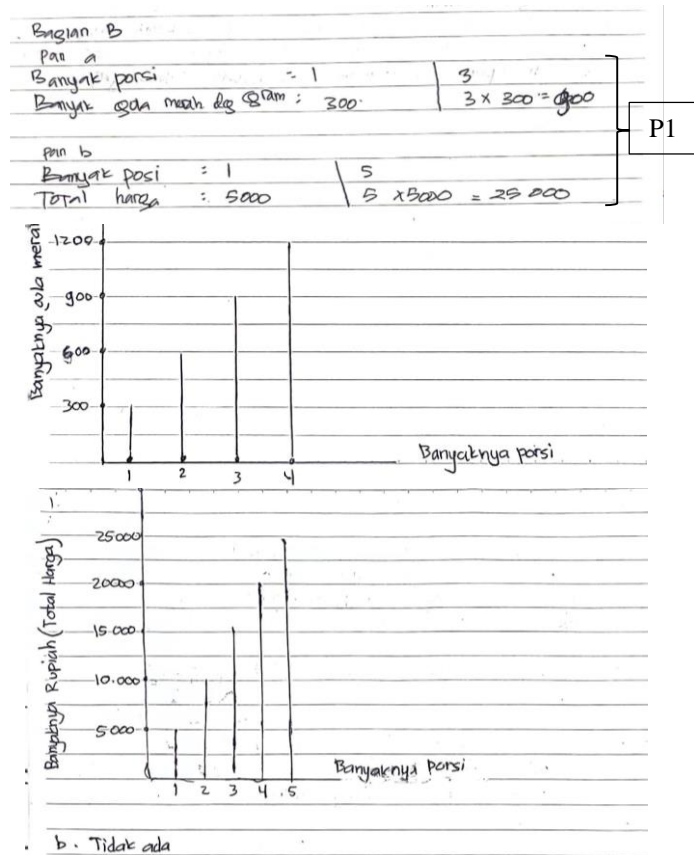

Translation:

- Problem a asked to determine the number of grams of brown sugar for 3 servings of ice cendol. So I multiplied the brown sugar made for 1 serving so that it was multiplied by 3. So $300 \times 3 = 900$
- Problem b asked to determine the total price Hanif paid to buy 5 servings of es cendol. So I multiplied the price for 1 serving. So $5 \times 5000 = 25000$

Figure 6. Extroverted Subject Answer in Part A

P   : "What is known and asked in question a?"
ES1   : "The es cendol recipe and Ms. Priya will make 3 servings of es cendol" (A1)
P   : "Okay, so what does the question ask?"
ES2   : "Asked how much brown sugar is needed to make 3 servings of es cendol" (A1)
P   : "What information did you use to get the results of problem a and problem b?"
ES3   : "The amount of brown sugar, the number of portions, and the price of the ice cendol" (A2)
P   : "How did you get the results of problem a and problem b?"
ES4   : "For point a, we are looking for the number of grams of brown sugar needed for 3 ice cendol. So just multiply the brown sugar made for 1 serving which is 300 grams so multiply by 3 to 900 grams" (A3)
P   : "For problem b, how did you get the result?"
ES5   : "The same, multiplied too. The price is Rp. 5000. Because I bought 5 servings so I multiplied it by 5, the result is Rp. 25,000" (A3)

Figure 6 shows the results of the answers of subjects with extroverted personalities on the concept construction text part A (questions a, b, and c). The results showed that the subject with extroverted personality, ES, in the process was able to identify and mention what was known and asked in the problem. Although ES subject did not write it down in writing, during the interview ES subject could explain it well (ES1). Subject ES could also explain the information she used to obtain the result (A2; ES2). In the interview, subject ES explained how he obtained the result of

solving the problem correctly (A3, MS3). Based on the results of the interview, the method used to obtain the result is the same as that used by Subject IS.


Translation : There is no difference from both graphs

Figure 7. Extroverted Subject Answer in Part B

P   : *"How do you construct the table for this cendol drink recipe problem?"*
ES6   : *"From the previous question, it is known that 1 serving is 300 grams of brown sugar and 3 servings are 900 grams of brown sugar. So just put it in the table" (P1)*
P   : *"How did you draw the graph for this problem?"*
ES7   : *"The amount of brown sugar and the total price are adjusted according to the number of servings"*
P   : *"Are there any special characteristics of the tables and graphs you made?"*
ES8   : *"Nothing"*
P   : *"Why not?"*
ES9   : *"The picture is the same graph"*
P   : *"What does the graph look like?"*
ES10   : *"It's getting higher and higher"*
P   : *"Does that mean there are no characteristics? What can you tell from the graph you made?"*
ES11   : *"There is, the higher to the right"*
P   : *"So, what can you deduce from the graph?"*
ES12   : *"The more portions, the higher the graph"*

The results of the answers of subjects with extroverted personalities on the concept construction test part B (questions a and b) are shown in Figure 7. At the process stage, ES

subjects in the process can compile a table of the problems given even though in writing ES does not really describe in tabular form (P1). This was verified from the interview results which explained the meaning of his written answer (ES6). However, in terms of drawing graphs, ES subject is still not precise. In addition, in terms of explaining certain characteristics of the two problems in part A, in his written test, ES subject concluded that there were no certain characteristics of the two problems. When traced further at the interview stage, subject ES seemed to change in making conclusions. Subject ES when asked again whether there is a special characteristic of the graph drawn, he can explain that the two graphs drawn have a characteristic, namely the more portions the more the graph rises (ES11; ES12).
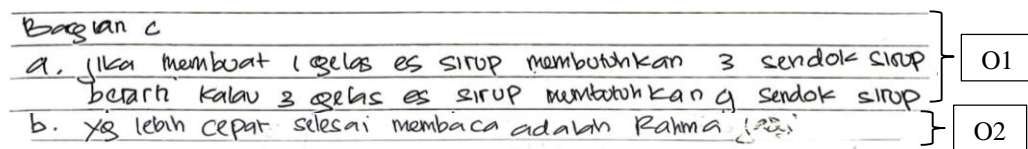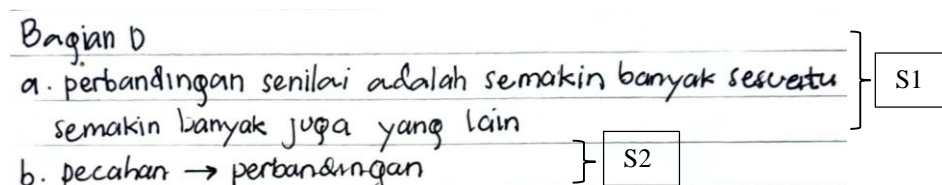

Translation :
a. If 1 glass of ice syrup requires 3 spoons of syrup then 3 glasses of ice syrup requires 9 spoons of syrup.
b. The one who finishes reading faster is Rahmah

Figure 8. Extroverted Subject Answer in Part C

P : *"Can you give an example of a problem that is similar to the concept in this problem?*
ES13 : *"If 1 glass of ice syrup requires 3 spoons of syrup, then 3 glasses of ice syrup require 9 spoons of syrup" (O1)*
P : *"Why is the example you gave the same as the ice cendol problem?"*
ES14 : *"Because the more the portion, the more syrup is needed. Just like the cendol one earlier"*
P : *"For this second problem (about reading speed), is the concept the same as the ice cendol problem?"*
ES15 : *"No."*
P : *"Why isn't it the same?"*
ES16 : *"Because with the ice cendol one, if you add more of something, you add more of something else. For this one, the more words you can read, the less time you have to read it" (O2).*

Figure 8 shows the answers of subjects with extroverted personalities on the concept construction test part C (questions a and b). At the object stage, ES subject can provide another example of the same proportion concept as the problem presented (O1; ES13). Subject ES gave an example on the problem of making syrup drinks. Subject ES in the interview stage could also explain the reason why she concluded that the example given was the same as the problem in the problem (ES14). In addition, subject ES could also classify problems related to inverse value proportion as different from the ice cendol problem (O2; ES16).

Translation:
  a. Direct proportion is the more of one thing the more of another
  b. Fractions → proportion

Figure 9. Extroverted Subject Answer in Part D

P	*:*	*"If the ice cendol recipe problem was mentioned earlier as an example of a case of direct proportion. What do you think a direct proportion is?"*
ES17	*:*	*"If one increases, the other increases" (S1).*
P	*:*	*"How did you come to that conclusion about the definition?"*
ES18	*:*	*"Because if you add more portions, the total price will also increase"*
P	*:*	*"Why did you draw up the chart the way you did?"*
ES19	*:*	*"Because I learned fractions in the past, and it seems like proportion can be written in fraction form"*

The test results of subject ES on the concept construction test part D (questions a and b) are shown in Figure 9. At the Schema stage, Subject ES can make a definition of proportion (S1; ES17; ES18). However, Subject ES was not able to draw a complete graph related to the relationship between fractions, ratios, and proportion, which was supported by his argument about what was the basis for making such a chart (ES19). Although the chart he drew did not fully conclude the relationship with the classification of proportion into two types (direct proportion and inverse proportion).

Based on the results of the study, it shows that there are differences in the construction process between introverted and extroverted students in the Action, Process, Object, and Schema stages. Students with introverted personality are better than students with extroverted personality in constructing the concept of proportion. At the process, object, and schema stages, extroverted subjects do not seem to fully fulfill all the indicators. Introverted subjects are more complete in compiling charts and in providing arguments about examples of concepts that are different from the previous problem. In contrast to extroverted students who in answering questions tend not to write them in detail and do not complete them. Thus, in line with research conducted by Bahrudin (2019) that extroverted students do not write answers in detail while introverts look careful in solving problems and are able to write complete answers.

In the process of constructing the concept of proportion, students with introverted personalities begin by inferring the concept of comparison worth from the problems given, as well as extroverted students. As for describing the relationship between fractions and proportion, extroverted students have not fully concluded the relationship with the classification of proportion. In general, the process of constructing the concept of proportion shows that students with introverted personalities in the process of constructing concepts have less difficulty when compared to extroverted students. This is shown when extroverted subjects have difficulty in identifying the characteristics between the two graphs they draw. Initially the extroverted subject revealed no significant characteristics of the two graphs, but when traced in the interview process the extroverted subject seemed to change his previous answer. In contrast to the introverted subject who can explain the characteristics of the two graphs. This is in accordance with the opinion of Zuniana & Rahaju (2019) who said that one of the characteristics of extroverts is that they have a tendency not to stick to their stance, and generally they are fast but not thorough. Likewise, according to Zuniana & Rahaju (2019) said that the characteristics of extroverted personalities are behaving without thinking first, always ready to answer, usually like change, and not much consideration.

Conclusion

Based on the results of the analysis and discussion that has been described, it can be concluded that there were differences in the process of constructing students' new concepts on proportion concept between introverted and extroverted students in the Action, Process, Object, and Schema processes. Subjects with introverted personalities can construct new concepts well. In contrast to students with extroverted personalities who have not fully met the process, object, and scheme stages. At the action stage, both students use the same strategy, namely using multiplication operations in solving problems. Meanwhile, the process stage can both present the problem in tabular form. The difference between the two students can be seen in the preparation of the graph where the extroverted subject is still not correct. Extroverted subjects also have difficulty in identifying the characteristics of the two graphs they draw. The object stage can be fulfilled by both subjects by presenting examples of the same problem as the context of the problem. While in the scheme stage, both subjects have been able to define the concept of proportion well. However, in terms of drawing a linkage chart between concepts, introverted students are better than extroverted students.

This research does not rule out the possibility of producing different research results because there are only two subjects used so that it may not represent all the characters of introverted subjects or extroverted subjects. Based on these conclusions, each student with a different personality type has a different concept construction process based on APOS theory. Therefore, teachers need to pay attention to the understanding process of each individual so that the learning method or strategy chosen to deliver the material can be well received by students. This research can be continued by focusing on concept construction by students based on APOS theory on other materials or by considering other variables.

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