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UNDERSTANDING THE CONCEPT OF ALGEBRAIC FORM USING APOS THEORY IN TERMS OF PERSONALITY TYPE

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Abstract

This research is based on descriptive research with a qualitative approach. The purpose of this study is to describe the understanding of the concept of algebraic form of junior high school students using APOS (Action, Process, Object, and Scheme) theory in terms of introverted and extroverted personality types. The instruments in this study are researchers (key instruments), personality type questionnaires, concept understanding tests and interviews (supporting instruments). Data collection techniques in this study using questionnaire, test and interview methods. The subjects in this study were one female student with introverted personality and one female student with extroverted personality. The results showed that the understanding of the concept of algebraic forms of introverted students based on APOS theory is at the action, process, object and scheme stages related to the concept of arithmetic operations of algebraic forms and is at the action stage related to the concept of solving contextual problems related to algebraic forms. While the understanding of the concept of algebraic form of extroverted students based on APOS theory is only at the action stage related to the concept of arithmetic operation of algebraic form and the concept of solving contextual problems related to algebraic form. Researchers hope that this research can be used as a consideration for teachers to pay more attention to the type of personality possessed by students, so that concepts can stick and reduce the occurrence of misunderstanding of concepts.

Keywords: concept understanding, algebraic form, APOS theory, personality type

1. Introduction

Research on understanding of mathematical concepts is one of the interesting topics to be studied, because it has been widely studied from various aspects, including on algebraic content (Kartika, 2018; Lestari, 2021; Mulyani et al., 2018), on learning style review (Liberna, 2018; Wijayanti et al., 2018), on personality type review (A'yun, 2021; Bahrudin, 2019; Siska et al., 2020). However, no research has been found related to understanding the concept of algebraic form with a review of personality types, specifically using APOS (Action, Process, Object and Scheme) theory, so researchers are interested in researching it.

Some previous research highlighting the problem of mathematical concepts shows that understanding concepts is important for students, because students will gain permanent concepts if there is an emphasis on the concept (Ansari, 2016). Understanding concepts will make it easier for students to choose the appropriate procedure or method, and can relate concepts that have been learned. One of the goals of learning mathematics according to the government of education and culture number 22 of 2016 is to understand concepts. Students easily solve math problems if they have understood related concepts, because understanding concepts has an important role for students to improve thinking skills and form positive attitudes (Annajmi, 2016). While understanding the concept is a vital factor that is the key to learning achievement (Hendriana, E. C., & Jacobus, 2017).

The activity of building and reconstructing mathematical objects can help students more easily understand concepts through the four stages of action, process, object and structured to the scheme (Arnon et al., 2014). One of the theories that can be used to assess students' concept understanding of algebraic forms is APOS (Mulyono, 2011). So learning based on APOS theory is a constructivist ideology that tries to empower students to produce their own knowledge and concepts of algebraic forms through mental and physical activities in the form of actions, processes, objects, and schemes (Dubinsky, 2001).

APOS theory has several characteristics that other theories do not have. These characteristics are supporting predictions, having the ability to explain, can be applied to a wide range, help organize thinking about learning phenomena, as an analytical tool, and provide a language to communicate about learning (Dubinsky, 2001). The existence of these characteristics makes a number of mathematics topics from several levels of education can use APOS theory. In addition, this APOS theory can be used for algebra topics (Dubinsky, 2001). Based on this statement, this study uses algebraic form material which is still within the scope of the algebra topic.

However, various difficulties in learning algebraic forms are experienced by many students. When learning mathematics students only listen and memorize explanations without understanding the purpose or content, do not understand the meaning of variables, coefficients, and constants, do not understand the concepts studied. Students find it difficult to understand the concept of variables, the concept of operations and find it difficult to understand contextual problems related to the concept of algebraic form (Pramesti & Retnawati, 2019). Students have difficulty in understanding the concepts of coefficients, constants, operations and difficulty simplifying equations of algebraic form (Purwanti & Pujiastuti, 2020).

Students' difficulties in overcoming a problem will be influenced by a lack of understanding of the concept (Kania & Arifin, 2020). Not only have difficulty learning algebraic forms, students also have difficulty when solving algebraic form problems. One of the difficulties experienced is difficulty operating the division of algebraic forms, because students do not understand the concept of algebraic form operations (Herawati & Kadarisma, 2021; Sugiarti, 2018).

Every student has their own challenges when it comes to grasping the material. Personality type is one of the things that affects it (Jung, 2016) divides two main personality types, namely introverted and extroverted. Personality type in students can affect the understanding of mathematical concepts. This is reinforced by research (Arini & Rosyidi, 2016) which shows that there are differences when connecting and making decisions in students with introverted and extroverted personalities. In addition, personality is one of the variables that contribute to variations in behavior. Different people have different understandings and perceptions of the same knowledge, depending on their ability to focus on facts related to their personality (Kiswanto, 2015). In addition, research by Puspita & Masriyah (2021) shows that there are difficulties in working on algebraic problems by seventh grade students when expressing concepts because they are less able to translate the problems they do. Based on the description of the previous background, the researcher wants to know the understanding of

seventh grade students on the concept of algebraic form using APOS theory in terms of introverted and extroverted personality types.

2. Method

Descriptive research with a qualitative approach was used in this study to describe the concept understanding of junior high school students with introverted and extroverted personalities using APOS theory on algebraic form material. According to Sugiyono (2013) qualitative descriptive research is one of the methods based on the philosophy of post-positivism examining natural object conditions and researchers being the main key. The use of this type of research is justified by the fact that the results are in the form of qualitative data described descriptively. Naturally, qualitative data is obtained by researchers through findings from the concept understanding test results, as well as interview results with a presentation not in numerical form. A thorough breakdown of the data is needed to get a description of how seventh grade junior high school students with introverted and extroverted personalities understand the concept of algebraic form using APOS theory.

The subjects in this study consisted of two seventh grade junior high school students in Bangkalan, namely one female student with introverted personality and one female student with extroverted personality. The selection of subjects is based on personality types with equal math ability (high), and the same gender. If there are differences in terms of understanding the concept of algebraic form, it is true because it is caused by differences in personality type.

The instruments used in this research are researchers (key instruments), personality type questionnaires, concept understanding tests and interviews (supporting instruments). The researches is the key instrument in qualitative research because the researcher has an important role when determining research subjects, collecting data, analyzing data, and drawing conclusions. Then the personality type questionnaire is used as a supporting to determine the personality type of the research subject, where the questionnaire used is the Myers Briggs Type Indicator (MBTI). Besides that, a concept understanding test was made to determine the understanding of the concept of student algebraic form, and the understanding of the concept of student algebraic forms is strengthened by interviews. Data collection techniques used in this study using questionnaires, tests and interviews. The personality type questionnaire used in this study adopted from the Myers Briggs Type Indicator (MBTI) personality type questionnaire. This questionnaire has been used by Zuniana & Rahaju (2019) and has obtained validation so that it can be directly used in selecting research subjects

The concept understanding test of algebraic form material in this study consists of two description questions, where the test is adjusted to the indicators of understanding the concept of algebraic form referring to APOS theory. Based on research (Lestari, 2021; Rofiq & Wijayanti, 2022) the indicators of understanding the concept of algebraic form using APOS theory developed in this study are listed in table 1.

Table 1. Indicator of Understanding the Concept of Algebraic Form Based on APOS

APOS Mental Structure	Code
ACTION	
Recall the concepts of algebraic forms (variables, constants, coefficients, terms, and similar or dissimilar terms) that have been learned.	A1
Determine the known and questionable information in algebraic form problems.	A2
PROCESS	
Determine the method and completion of arithmetic operations of algebraic forms (addition, subtraction, multiplication, and division).	P1
Identify and determine the elements of an algebraic form.	P2
Modeling contextual problems into algebraic form	P3
OBJECT	
Relate the properties of arithmetic operations of algebraic forms to solve problems of arithmetic operations of algebraic forms	O1
Simplify algebraic forms.	O2
Solve problems from model algebraic forms to simple forms.	O3

SCHEME	
Model a problem into an algebraic form and use it to solve the problem.	S1
Solve contextual problems related to algebraic forms.	S2

Through the previous concept understanding indicator table, students' understanding of the concept of algebraic form can be analyzed using the table which is adjusted to the APOS theory. Students are given tasks to complete in the form of written tests involving algebraic form material. In addition, students are asked from the results of the solution that has been written down. Thus, it can be determined and described the understanding of the concept of algebraic form in VII grade junior high school students using APOS theory.

3. Result and Discussion

Research data collection was carried out for two meetings, the first meeting distributing MBTI personality type questionnaires and the second meeting giving concept understanding tests and interviews to two selected subjects. Based on the subject selection criteria, the two research subjects listed in table 2 were obtained.

Table 2. Selected Subjects.

Name	Gender	Personality Type	Code
TKFM	Female	Introverted	SI
DAY	Female	Extroverted	SE

The two selected subjects were given an algebraic form concept understanding test consisting of two questions with an allocation of 60 minutes. Two questions of the form concept understanding test in this study are presented in table 3.

Table 3. Test Questions for Understanding The Concept of Algrebaic.

No	Question Items
1.	Determine the results of the arithmetic operations of the following algebraic forms to the simplest form, and identify the elements of the algebraic form from the results of solving each problem! a. $4q - r + 13p + qr + 12 - 3p - 2r$ b. $(3x + 7)(2x - 5)$ c. $\frac{a^2+10a+21}{a+3}$
2.	A tutoring group consists of female and male students. The number of male students is 4 less than the number of female students. If the number students is $\frac{7}{3}$ the number of male students, how many female students are in the group?

The results and analysis of concept understanding of algebraic form material using APOS theory on introverted and extroverted personality students in this study are described as follows.

a. Results and analysis of concept understanding of algebraic form material using APOS theory on subject with introverted personalities.

1) Action Stage

The written test results of understanding the concept of algebraic form using APOS theory at the action stage of introverted subject are as.

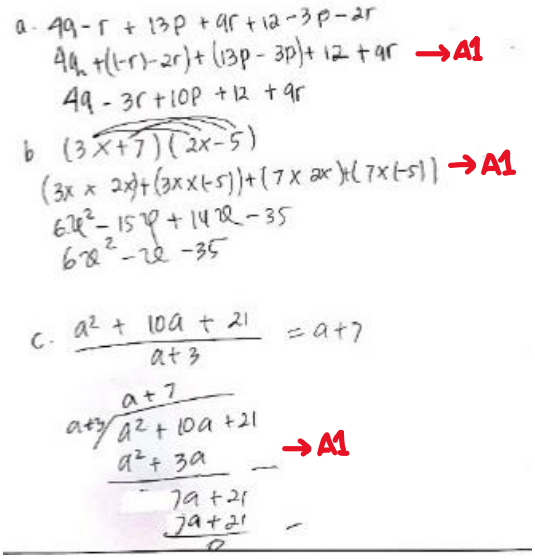

Figure 1. Introverted Subject Answer Question Number 1 at the Action Stage

In figure 1, introverted subject can recall the concept of similar terms and variables when operating the addition of algebraic forms by grouping similar terms, namely the same variable and then giving parentheses. Introverted subject can recall the concept of multiplying algebraic forms by multiplying each of their terms then similar terms are operated on. Introverted subject can recall the concept of division of fractions by means of porogapit, namely multiplying the divisor of the algebraic form by another algebraic form and then similar terms are operated. This shows that the understanding of concepts at the action stage (A1) related to the concept of algebraic forms (terms, similar terms, and variables) is understood by introverted subject.

When SI was asked about how to calculate algebraic forms, SI explained *"Adding up each similar term such as variables with the same rank and constants can be grouped and then added or subtracted, how to multiply two algebraic forms, namely by multiplying the rainbow each term is multiplied and then adding similar terms, dividing algebraic forms with porogapit, the method is like using this sign, the divider is divided outside the divider (while pointing to the form written in the solution to problem 1b) "*. Based on the written answers in figure 1 and the interview excerpts, SI has met the indicators of understanding the concept of APOS theory at the action stage because he can explain the concepts of variables, terms, similar terms, and constants.

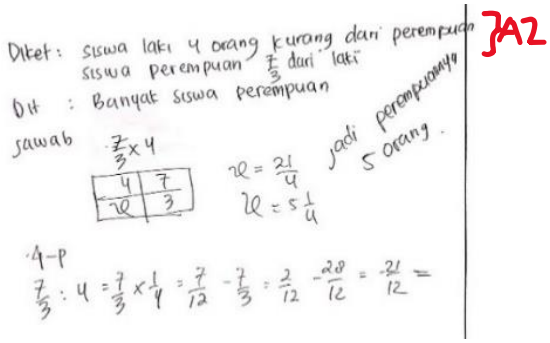

Figure 2. Introverted Subject Answer Question Number 2 at the Action Stage

In figure 2, introverted subject can determine the known and questionable information in algebraic form problems. Introverted subject wrote down the known information from the problem, namely male students 4 less than female students and female students $\frac{7}{3}$ of men. The introverted subject wrote down the information asked in the problem, namely asked many female students. This shows that the understanding of concepts at the action stage (A2) related to determining the known and questionable information in the problem of algebraic form is understood by introverted subject.

When SI was asked again about the information known and asked in contextual problems related to algebraic forms, SI explained the results that had been written down. Based on the written answers in figure 2 and the interview, it can be seen that SI can understand problem number 2 by mentioning the known and questionable information. So that SI has fulfilled the indicators of concept understanding at the action stage for problem number 2 because he can determine the information known and asked about the problem of algebraic form.

1) Process Stage

The results of the written test of understanding the concept of algebraic form using APOS theory at the process stage of the introverted subject as follows.

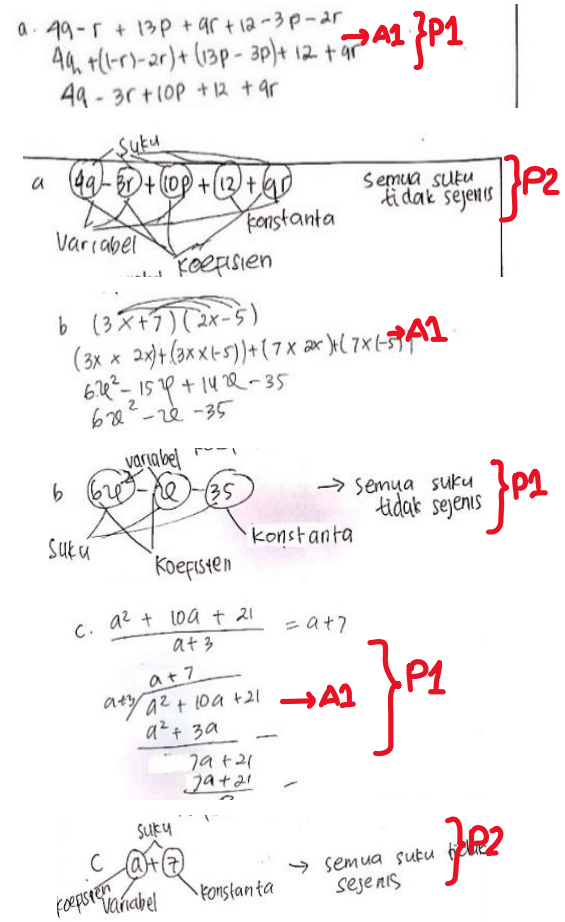

Figure 3. Introverted Subject Answer to Question Number 1 at the Process Stage

In figure 3, introverted subject can determine the method and solution of algebraic form operations. Introverted subject can identify the elements of algebraic form from the results of the solution to the problem of calculating the algebraic form, where all the elements are identified completely. This shows that the understanding of concepts at the process stage (P1) related to determining the method and completion of arithmetic operations of addition and subtraction of algebraic forms is understood by introverted subject. In addition, understanding of concepts at the process stage (P2) related to identifying and determining elements in an algebraic form is understood by introverted subject.

When SI was asked about what method was used to complete the calculation operation of algebraic form number 1, SI *explained "Number 1a, I first grouped the terms with the same variables -r and -2r then 13p and -3p then I operated to find the final result 4q -3r +10p +12 +qr (while pointing to the solution). Question 1b, 3x multiplied by the front 2x than added 3x multiplied by -5 then the +7 multiplied by 2x plus +7 multiplied by -5 operated to find 6x² -15x + 14x-35 then added the same variables to find the final result 6x^2-x-35, question 1c, a² +10a +21 divided by a +3, I wrote it in this porogapit (while pointing to the answer) then to eliminate a² inside then a + 3 is multiplied by written the result a² +3a which is inside minus 7a + 21, then eliminate 7a with a+3 multiplied by 7 to find the result 7a+21 which is inside minus so you get the final result a +7 ".* Based on the results of the written test in figure 3 and the interview excerpts, SI has met the indicators of understanding the concept of APOS theory at the process stage, namely being able to determine how to solve the arithmetic operations of addition, subtraction, multiplication and division of algebraic forms, and can identify and determine the elements of algebraic forms correctly. SI's concept understanding reached the process stage of APOS theory. If it is associated with the mental mechanism of APOS theory, SI experiences interiorization because he is aware of the conceptual understanding of the elements of algebraic form in the action stage. SI used the concept understanding in the action stage to solve the problems of addition, subtraction, multiplication and division of algebraic forms. In addition, SI determines and identifies the elements of algebraic form in the solution result by linking the understanding of concepts in the action stage.

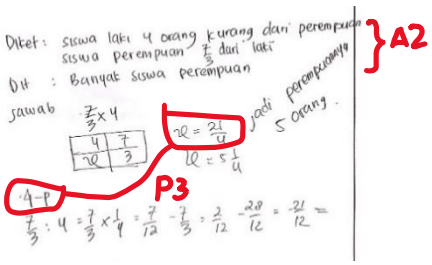

Figure 4. Introverted Subject Answer to Question Number 2 at the Process Stage

In figure 4, introverted subject cannot model the problem into algebraic form. The introverted subject was wrong in writing the permissiveness of the female student because it used two variables, namely p and x. This shows that understanding the concept at the process stage (P3) related to modeling contextual problems into algebraic form has not been understood by introverted subject.

When SI was asked about the method used and the equation made in the problem of algebraic form, SI explained that he used multiplication and division operations, and generalized the equation with variables x and p. Based on the written answers in Figure 4 and the interview, SI's concept understanding has not reached the process stage referring to APOS theory for problem number 2 because SI was wrong in making the equation and incorrectly completing the calculation operation on the problem of algebraic form.

2) Object Stage

The written test results of understanding the concept of algebraic form using APOS theory at the object stage of introverted subject as follows.

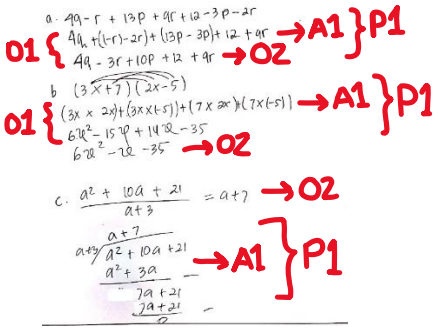

Figure 5. Introverted Subject Answer Question Number 1 at the Object Stage

In figure 5, introverted subject can relate the properties of the arithmetic operations of addition, subtraction, and multiplication of algebraic forms. Introverted subject can simplify the algebraic form from the results of solving the arithmetic operation problem of algebraic form. This shows that the understanding of concepts at the object stage (O1) related to linking the properties of the arithmetic operations of addition, subtraction and multiplication of algebraic forms is understood by introverted subject. In addition, the understanding of concepts at the object stage (O2) related to simplifying an algebraic form is understood by introverted subject.

When SI was asked about the relationship with the nature of arithmetic operations of algebraic forms in questions numbers 1a and 1b, SI explained that *"Question 1a is*

associative, because in the second row (while pointing to the answer) I grouped similar terms with the same variable -r with -2r then +13p with -3p and then operated, question 1b is distributive because I multiplied each term and then spread it one by one". Based on the results of the written test in figure 5 and the interview excerpts, SI has met the indicators of understanding the concept of APOS theory at the object stage, namely being able to relate the properties of arithmetic operations of algebraic forms to solve problems of arithmetic operations of addition, subtraction and multiplication of algebraic forms, and can simplify algebraic forms. SI concept understanding reached the object stage of APOS theory. If it is associated with the mental mechanism of APOS theory, SI experiences encapsulation because the understanding at the process stage of arithmetic operations of algebraic forms is used to build his understanding at the object stage. SI uses the concept understanding at the process stage to relate the properties of algebraic form calculation operations. SI simplifies the algebraic form by linking the understanding of concepts in the process stage.

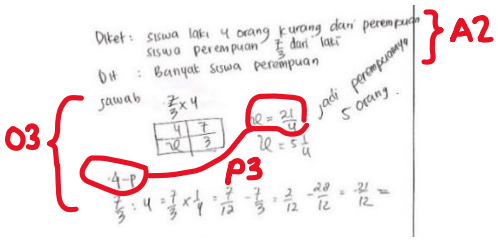

Figure 6. Introverted Subject Answer to Question Number 2 at the Object Stage

In figure 6, introverted subject cannot solve algebraic form problems from modeling algebraic forms because the permissions written down are incorrect. introverted subject only simplify fractional forms. This shows that understanding the concept at the object stage (O3) related to solving algebraic form problems from modeling algebraic forms to simple forms has not been understood by introverted subject.

When asked about the results of solving the problem of algebraic form SI explained "5 women, because after I calculated it found $x=5\frac{1}{4}$ *so rounded up 5 people (while showing the answer)"*. Based on the written test in figure 6 and the interview excerpt, SI did not fulfill the object stage indicator referring to APOS theory because he made the wrong equation and wrote the wrong solution to the problem correctly.

3) Scheme Stage

The results of the written test of understanding the concept of algebraic form using APOS theory at the schema stage of introverted subject as follows.

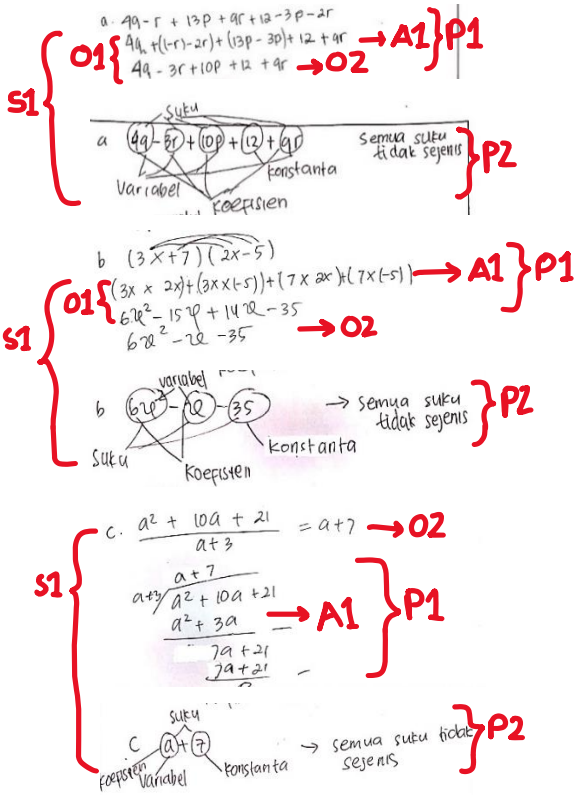

Figure 7. Introverted Subject Answers Question Number 1 at the Scheme Stage

In figure 7, introverted subject can complete the arithmetic operations of algebraic form (addition, subtraction, multiplication and division) Introverted subject can identify the elements of algebraic form in each result of arithmetic operations of algebraic form. Introverted subject can relate the properties of the arithmetic operations of addition, subtraction, and multiplication of algebraic forms and can simplify the algebraic form of the solution to the problem of arithmetic operations of algebraic forms. This shows that the understanding of concepts at the scheme stage (S1) related to solving the arithmetic operations of addition and subtraction of algebraic forms is understood by introverted subject. understanding of concepts at the scheme stage (S1) related to solving the arithmetic operations of multiplication of algebraic forms is

understood by introverted subject. understanding of concepts at the scheme stage (S1) related to solving the arithmetic operations of division of algebraic forms is understood by introverted subject. so it can be said that the understanding of concepts at the scheme stage (S1) related to solving arithmetic operations of algebraic forms ranging from addition, subtraction, multiplication to division is understood by introverted subject.

When asked about the results of solving the arithmetic operations of algebraic forms, SI explained that the answers written were sure to be correct and explained *"Because it is in accordance with how to add, subtract, multiply, and divide algebraic forms, sis"*. Based on the results of the written test in figure 7 and the interview excerpts, SI has fulfilled the scheme indicators referring to APOS theory because he can solve the arithmetic operations of addition, subtraction, multiplication and division of algebraic forms correctly, can identify elements, can relate the properties of arithmetic operations of algebraic forms and write answers in the simplest algebraic form.

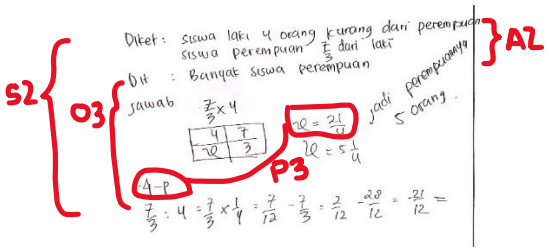

Figure 8. Introverted Subject Answer Question Number 2 at the Scheme Stage

In figure 8, introverted subject cannot solve contextual problems related to algebraic forms. The introverted subject is wrong in making the permissiveness of the problem so that the final solution written down is incorrect and in the form of fractions. This shows that understanding of concepts at the scheme stage (S2) related to solving contextual problems related to algebraic forms has not been understood by introverted subject.

When asked about the results written from solving contextual problems related to algebraic forms, SI explained *"Because after I calculated it, I found* $x=5\frac{1}{4}$ *so I rounded it to 5 people (while showing the answer)"*. Then SI explained that he was not sure about the answer because it was in the form of fractions.

Based on the results of the written test figure 8 and interview excerpts, SI did not meet the indicators of understanding the concept of APOS theory at the scheme stage, namely not being able to model a problem into an algebraic form and use it to solve the problem. SI's concept understanding did not reach the scheme stage of APOS theory. If it is associated with the mental mechanism of APOS theory, SI does not experience thematization because it does not meet the indicators of concept understanding at the scheme stage.

Based on the previous explanation, it can be explained that students with introverted personalities fulfill all indicators of understanding the concept of algebraic form referring to APOS theory, namely the action, process, object and scheme stages related to the concept of completing arithmetic operations of algebraic forms. This is in line with Nisa, (2020) which found that understanding the concept of quadrilateral material for students with introverted personalities fulfills the action, process, object, and scheme stages referring to APOS theory. In addition, students with introverted personalities experience mental mechanisms of interiorization at the process stage, encapsulation at the object stage referring to APOS theory. This is in line with Asiala dkk (1996) which states that the action is interiorized to form a process which is then packaged to form an object, the process is encapsulated into a cognitive object.

However, students with introverted personalities do not fulfill all indicators of understanding the concept of algebraic form referring to APOS theory for problems of algebraic form in problem number 3, students with introverted personalities only fulfill indicators at the action stage. Students with introverted personalities do not have an understanding of the concept in modeling the mathematics of an algebraic form problem because the permissiveness written is not correct. This is in line with the research of Faridhatijannah et al., (2022) who found introverted students' errors in making mathematical models of a mathematical problem.

b. Results and analysis of concept understanding of algebraic form material using APOS theory on extroverted personality subject.

1) Action Stage

The results of the written test of understanding the concept of algebraic form

using APOS theory at the action stage of extroverted subject as follows.

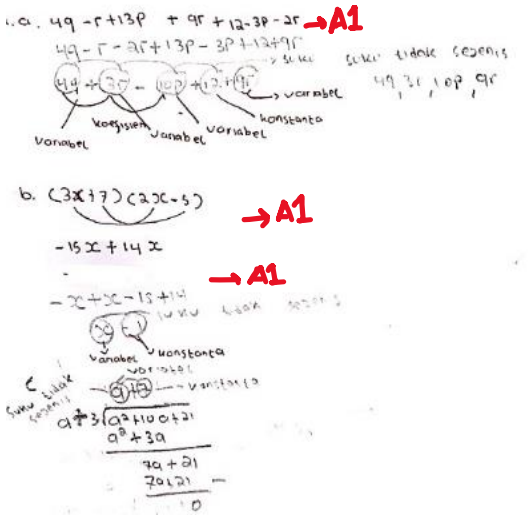

Figure 9. Extroverted Subject Answers Question Number 1 at the Action Stage

In figure 9, extroverted subject can recall the concept of similar terms and variables when operating the addition of algebraic forms by grouping similar terms, namely the same variable then given parentheses. Extroverted subject can recall the concept of multiplying algebraic forms by multiplying each of their terms then similar terms are operated on. Extroverted subject can recall the concept of division of fractions by means of porogapit, namely multiplying the divisor of an algebraic form by another algebraic form and then similar terms are operated. This shows that the understanding of concepts at the action stage (A1) related to the concept of algebraic forms (terms, similar terms, and variables) is understood by extroverted subject.

When SE was asked about how to calculate algebraic forms, SE explained *"Question 1a by adding and subtracting similar terms, the same variables, constants with constants, question 1b cross-multiply the terms in each algebraic form then operate the results, question 1c with porogapit, using this line sign, the divider in the area that is divided is in then operated stacking down until the remainder is zero for the result is above this (while pointing to the form written in the solution of problem 1c). (with pointing to the form written in the solution to problem 1c)".* Based on the written answers in figure 9 and the interview excerpts, SE has fulfilled the indicators of understanding the concept of APOS theory at the action stage because she can explain the concepts of variables, terms, similar terms, and constants.

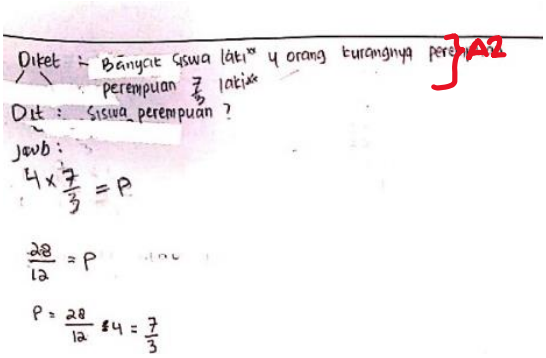

Figure 10. Extroverted Subject Answers Question Number 2 at the Action Stage

In figure 10, extroverted subject can determine the known and questionable information in algebraic form problems. Extroverted subject wrote down the known information from the problem, namely male students 4 less than female students and female students $\frac{7}{3}$ of men. Extroverted subject wrote down the information asked about the problem, namely asked many female students. This shows that the understanding of concepts at the action stage (A2) related to determining the known and questionable information in the problem of algebraic form is understood by extroverted subject.

When SE was asked again regarding the information known and asked about contextual problems related to algebraic forms, SE explained again the results that had been written down. based on the written test answers in figure 10 and interviews with extroverted subject, it can be seen that SE can understand problem number 2 by mentioning the information known and asked. So that SE has fulfilled the indicator of understanding the concept at the action stage for problem number 2 because it can determine the information known and asked about the problem of algebraic form.

2) Process Stage

The results of the written test of understanding the concept of algebraic form using APOS theory at the process stage of extroverted subject as follows.

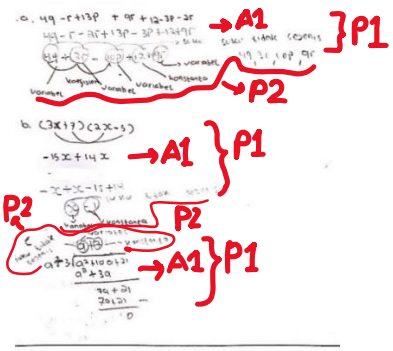

Figure 11. Extroverted Subject Answers Question Number 1 at the Process Stage

In figure 11, extroverted subject can determine the method and completion of addition, subtraction and division operations of algebraic forms. Extroverted subject are less precise in writing the operation signs in addition and subtraction which should be $-3r \; and \; +10p$. Extroverted subjects write the solution by multiplying the front term by the back term and then operating and writing the final result $x-1$ is not correct Extroverted subject can identify the elements of algebraic form from the results of solving the arithmetic operation problem of algebraic form, where the element is identified incompletely, namely the coefficient qr. This shows that understanding of concepts at the process stage (P1) related to determining the method and completion of arithmetic operations of algebraic forms has not been understood by extroverted subjects. In addition, understanding of concepts at the process stage (P2) related to identifying and determining elements in an algebraic form is understood by extroverted subject.

When SE was asked about what method was used to complete the arithmetic operation of algebraic forms in problem number 1, SE explained that *"Problem 1a, I moved the same terms, then added the terms with the same variables -r and -2r then 13p and -3p then operated to get the final result 4q + 3r-10p +12 +qr (while pointing to the solution), problem 1b, 3x multiplied by -5 plus 2x multiplied by +7 the result is -15x + 14x to find the final result x-1, problem 1c, a² +10a +21 divided by a +3, I wrote it in this porogapit (while pointing to the answer) then for the inside the first step eliminates a² inside the outside multiplied by a written the result inside a² +3a then subtracts the inside to find the remainder 7a + 21, then eliminates 7a +21 with the outside multiplied by 7 the result is 7a +21 which is operated again minus the final result a +7 ".* then SE was asked to recheck the results of his work, SE realized his mistake and *explained "Ooo yes sis it's wrong, it should be -3r and +10p". (While showing the answer)".* Based on the written results in figure 11 and interview excerpts SE does not fulfill all indicators of APOS theory concept understanding indicators at the process stage. SE can solve addition, subtraction, and division calculation operation problems but cannot solve multiplication calculation operation problems of algebraic forms correctly. SE can identify and determine the elements in algebraic form. SE's concept understanding at the process stage of APOS theory has not been fulfilled because there are indicators that have not been met. If it is associated with the mental mechanism of APOS theory at the process stage, SE experiences interiorization because she is aware of the conceptual understanding of the elements of algebraic form at the action stage. SE uses the conceptual understanding at the action stage to solve the arithmetic operations of addition, subtraction and division of algebraic forms. In addition, SE determines and identifies the elements of algebraic form in the solution result by linking the understanding of concepts in the action stage.

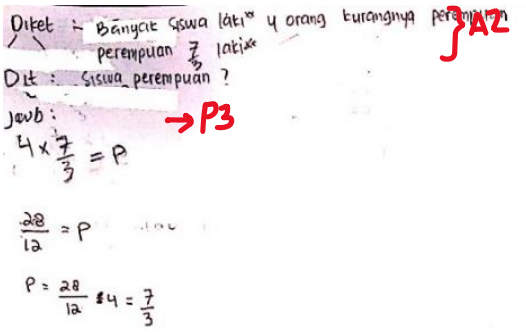

Figure 12. Extroverted Subject Answers Question Number 2 at the Process Stage

In figure 12, extroverted subject cannot model the problem into algebraic form. Extroverted subject is wrong in writing the permissiveness of female students. This shows that understanding the concept at the process stage (P3) related to modeling contextual problems into algebraic form has not been understood by extroverted subject.

When asked about arithmetic operations and permissiveness made from algebraic form problem solving, SE explained using multiplication and division operations of algebraic forms, and using variable p for

female. Based on the written answers in figure 12 and interview excerpts, SE conceptual understanding has not reached the process stage for problem number 2 because SE is wrong in making problems and completing the calculation operations on algebraic form problems.

3) Object Stage

The results of the written test of understanding the concept of algebraic form using APOS theory at the object stage of extroverted subject as follows.

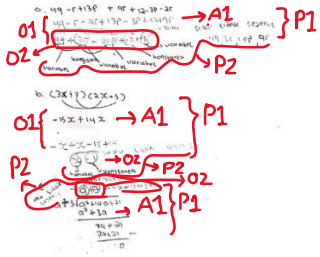

Figure 13. Extroverted Subject Answer to Question Number 1 at the Object Stage

In figure 13, extroverted subject can relate the properties of arithmetic operations of addition and subtraction of algebraic forms. Extroverted subject write the solution by grouping similar terms without brackets, where the answers written are included in the associative properties, namely grouping. Seen from the picture, extroverted subject cannot relate the properties of the arithmetic operation of multiplying algebraic forms. Extroverted subject can simplify the algebraic form of the solution to the problem of calculating the algebraic form. This shows that understanding the concept at the object stage (O1) related to linking the properties of arithmetic operations of algebraic forms has not been understood by extroverted subject. In addition, understanding the concept at the object stage (O2) related to simplifying an algebraic form is understood by extroverted subject.

When SE was asked about the relationship with the nature of arithmetic operations of algebraic forms in questions numbers 1a and 1b, SE explained that *"Problem 1a, commutative, because in the second row (while pointing to the answer) I swapped similar terms with the same variable r with 2r then 13p with 3p and then operated on it. Problem 1b, Distributive because I multiplied the leading term with the trailing term and vice versa and then distributed them one by one"*. Based on the written results in figure 13 and the interview excerpts, SE does not fulfill all indicators of understanding the concept of APOS theory at the object stage. SE only fulfills the indicator of simplifying algebraic form. SE is less precise in giving reasons when linking the properties of multiplication operations, this is because at the process stage SE is wrong in solving the problem of multiplication operations of two algebraic forms. If it is associated with the mental mechanism of APOS theory at the object stage, SE has not experienced encapsulation completely because it is still wrong in the operation of calculating the multiplication of algebraic forms.

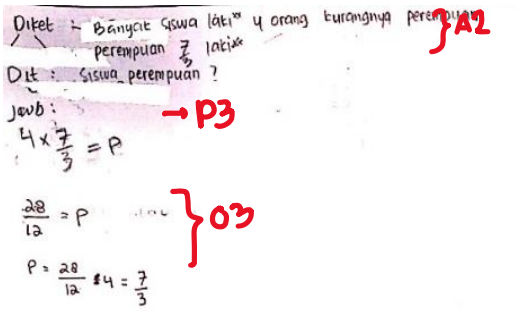

Figure 14. Extroverted Subject Answer to Question Number 2 at the Object Stage

In figure 14, extroverted subject cannot solve algebraic form problems from modeling algebraic forms because the permissions written down are incorrect. extroverted subject only simplify fractional forms. This shows that understanding the concept at the object stage (O3) related to solving algebraic form problems from modeling algebraic forms to simple forms has not been understood by extroverted subject.

When asked about the results of solving the problem of algebraic form SE explained *"28 women, after I calculated it I found* $p=\frac{28}{12}$ *when divided by 4 the result is* $\frac{7}{3}$ *so 28 people"* (while showing the results of his answer). Based on written in figure 14 and interview excerpts SE did not fulfill the object stage indicators referring to APOS theory because it was wrong to make the permissiveness and wrong to write the solution to the problem correctly.

4) Scheme Stage

The results of the written test of understanding the concept of algebraic form

using APOS theory at the schema stage of extroverted subject as follows.

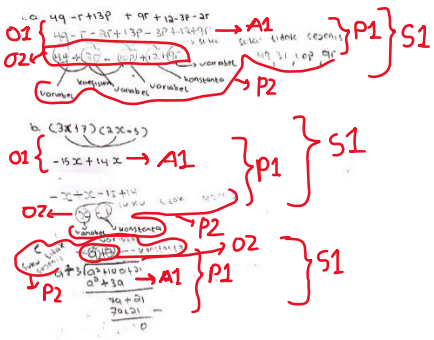

Figure 15. Extroverted Subject Answers Problem Number 1 at the Scheme Stage

In figure 15, extroverted subject can complete the arithmetic operations of algebraic forms (addition, subtraction and division), but cannot complete the arithmetic operation of multiplying algebraic forms. Extroverted subject can identify the elements of algebraic form in each result of arithmetic operations of algebraic form. Extroverted subject cannot relate the properties of the arithmetic operations of addition, subtraction, and multiplication of algebraic forms but can simplify the algebraic form of the solution results on the problem of arithmetic operations of algebraic forms. This shows that the understanding of concepts at the schema stage (S1) related to solving the arithmetic operations of addition and subtraction of algebraic forms is understood by extroverted subjects. Understanding of concepts at the schema stage (S1) related to completing the multiplication calculation operation of algebraic forms is not understood by extroverted subject. understanding of concepts at the schema stage (S1) related to completing the division calculation operation of algebraic forms is understood by extroverted subjects. So it can be said that the understanding of concepts at the schema stage (S1) related to solving arithmetic operations of algebraic forms only addition, subtraction and division is understood by extroverted subject.

When SE was asked to recheck her solution, SE realized her mistake and explained the correct answer *"Yes kak I was not careful, the final result should be 4q-3r+10p +12 +qr"*. Then the researcher asked again related to the results of solving the multiplication operation problem, SE explained the final result was -1, the result was not correct. Based on the written results in figure 15 and the interview excerpts, SE did not fulfill the scheme indicator referring to APOS theory because she could not solve the arithmetic operation problem of multiplying algebraic forms correctly, and could not relate the properties of arithmetic operations of algebraic forms even though SE could identify the elements and write the answer in the simplest algebraic form.

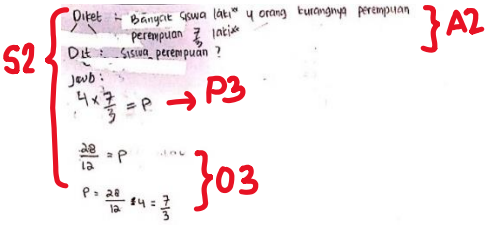

Figure 16. Extroverted Subject Answers Question Number 2 at the Schema Stage

In figure 16, extroverted subject answer regarding the problem of algebraic form. Seen from the picture, extroverted subject cannot solve contextual problems related to algebraic forms. Extroverted subject is wrong in making permissiveness of the problem so that the final solution written is incorrect and in the form of fractions. This shows that understanding of concepts at the scheme stage (S2) related to solving contextual problems related to algebraic forms has not been understood by extroverted subject.

When asked about the results written from solving contextual problems related to algebraic forms SE explained "Because after I calculated it, I found $p=\frac{28}{12}$ *so I rounded it up to 28 people (while showing the answer)"*. Then SE explained that she was not sure about the answer because it was in the form of a fraction.

Based on the written results in figure 16 and the interview excerpts, SE did not meet the indicators of understanding the concepts of APOS theory at the scheme stage, namely not being able to model a problem into an algebraic form and use it to solve the problem. SE concept understanding did not reach the scheme stage of APOS theory. If it is associated with the mental mechanism of APOS theory SE does not experience thematization because it does not meet the indicators of concept understanding at the scheme stage.

Based on the previous explanation, it can be explained that students with extroverted

personalities do not fulfill all indicators of understanding the concept of algebraic form referring to APOS theory. Students with extroverted personalities only fulfill the action stage indicators. In line with Agustina & Nyimas Aisyah (2018) students are in the understanding of the action stage concept refering to APOS theory only procedural activities. This is in line with Bahrudin (2019) which found differences in understanding the concept of flat shapes using APOS theory between introverted and extroverted students, where extroverted personality students only reach the action stage. In addition, students with introverted personalities experience interiorization mental mechanisms at the process stage referring to APOS theory. This is in line with Asiala et al., (1996) which states that actions are interiorized to form processes. In addition, the incomplete understanding of the concept of students with extroverted personalities is supported by the results of research that shows carelessness in solving problems by students with extroverted personalities. This is also in line with Atika Sari & Kurniasari (2022) who state that extroverted students tend to have the characteristics of being fast in solving problems even though they are not perfect and sometimes careless.

4. Conclusion

Understanding the concept of algebraic form material using APOS theory in junior high school students with introverted personalities is at the action, process, object and scheme stages related to the concept of calculating algebraic forms, and is at the action stage related to the concept of solving contextual problems related to algebraic forms. While extroverted junior high school students are only at the action stage referring to APOS theory related to the concept of arithmetic operations of algebraic forms, and the concept of solving contextual problems related to algebraic forms. At the action stage, introverted and extroverted subjects understand the concept of algebraic forms such as variables, terms and similar terms for the problem of calculating algebraic forms, the subject understands the information known and asked about the problem of algebraic forms. At the process stage, introverted subject understanding the concept of arithmetic operations (addition, subtraction, multiplication and division) of algebraic forms while extroverted subject only understand the concepts of addition, subtraction and division of algebraic forms. Introverted and extroverted subjects understand concepts related to how to identify the elements of an algebraic form. Introverted and extroverted subjects experience an interiorization mental mechanism at the process stage because they associate understanding at the action stage for concept understanding at the process stage. At the process stage, introverted and extroverted subjects do not yet understand the concept related to how to make permissiveness or mathematical models in solving arithmetic operations on algebra.

At the object stage, introverted subject understanding the concept of the properties of arithmetic operations, while extroverted subject does not understand the concept of the properties of arithmetic operations of algebraic forms. Introverted and extroverted subjects understand concepts related to how to simplify algebraic forms. Introverted subject experience encapsulation mental mechanisms at the object stage because the understanding of concepts at the process stage is packaged into the object stage, while extroverted subject does not experience. However, introverted and extroverted subjects do not understand the concept of simplifying algebraic forms because from the beginning the permissions made by introverted and extroverted subjects are wrong so that the final result of solving algebraic form problems is also wrong.

At the scheme stage, introverted subject understand the concept of algebraic forms such as variables, terms, and similar terms, understand how to operate (addition, subtraction multiplication and division) algebraic forms, understand in identifying elements of algebraic forms, understand the properties of arithmetic operations (addition, subtraction and multiplication) algebraic forms, understand how to simplify algebraic forms, to have an understanding of the concept in solving arithmetic operations of algebraic forms. Whereas extroverted subject understand the concept of the concept of algebraic forms such as variables, terms, and similar terms, understand how to operate (addition, subtraction and division) of algebraic forms, but does not understand concepts related to how to calculate the multiplication of algebraic forms, understand in identifying the elements of algebraic forms, does not understand the properties of arithmetic operations (addition, subtraction and multiplication) of algebraic forms, understand how to simplify algebraic forms, and does not understand the concept in solving arithmetic operations of algebraic forms. However, in the problem of algebraic form problems, introverted and extroverted subjects only understand the information known and asked in the problem, do not understand the concept of making a model or mathematical model of an algebraic form problem,

and do not understand concepts related to how to solve algebraic form problems.

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