Jurnal Iqra'
Kajian Ilmu Pendidikan

OPEN ACCESS

Volume 10, Number 2, August 2025

An Analysis of Students' Understanding of Multiplication and Division Concepts Using HOTS Questions in Terms of APOS Theory

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ARTICLE INFO

Article history:

Received
February 12, 2025

Revised
July 31, 2025

Accepted
September 02, 2025

ABSTRACT

Understanding concepts in mathematics is a very important ability. Because almost all activities in everyday life are related to mathematics. This study aims to explore fourth grade elementary students' understanding of the concepts of multiplication and division using HOTS questions in terms of APOS theory. This type of research is qualitative using an explorative descriptive approach. The research subjects were 6 students who had been selected based on the criteria of high, medium and low scores. Data collection techniques in the study used interviews, tests and documentation. From the results of the study it was found that students' understanding of concepts related to multiplication and division using HOTS questions in terms of APOS theory experienced significant differences. Students with high concept understanding criteria are able to reach the schema stage. Students with moderate concept understanding, still find it difficult at the process stage to the scheme. This is because these students have not been able to identify the type of problem included in the multiplication or division problem. Meanwhile, students in the low category have not been able to reach the action stage. Students who fall into this low category find it difficult when distinguishing which ones include multiplication problems and which ones include division problems, so that at the action stage they are unable to write what is known, asked until the answer. This is a serious concern for all of us to continue to pay attention to the continuity of learning, especially mathematics on multiplication and division material. For educators, this study highlights the importance of explicitly teaching problem structures, operation identification, and meaning-making in context. For curriculum developers, integrating APOS-informed tasks into learning materials and assessments could enhance conceptual understanding from early grade.

Keywords: APOS Theory, HOTS Problems, Mulitiplication, Higher Order Thinking Skill

Published by Institut Agama Islam Ma'arif NU (IAIMNU) Metro Lampung
Website https://journal.iaimnumetrolampung.ac.id/index.php/ji/index
E-ISSN 2548-7892

INTRODUCTION

Mathematics is one of the important subjects in education. This is in line with his opinion Silvia et al. (2023), which states that math lessons are very important to be taught at the elementary school level. This is because almost all human activities in everyday life are always closely related to mathematics. With the existence of mathematics in every level of education, it is able to facilitate all human activities in everyday life such as measuring distances, dividing equal parts, buying and selling transactions and many more. In line with that Rismayanis et al. (2022) states that mathematics facilitates all human activities in everyday life such as exchanging money, calculating speed, and so on through its understanding. Mathematics is a compulsory subject at every level of education in Indonesia. In mathematics education it is

important to teach reasoning in order to shape students' personalities (Lenterawati et al., 2018). Reasoning can occur when students carry out the thinking process that occurs in the brain (Faizah et al., 2022; Sa'adah et al., 2023). The importance of mathematics at every level of education, especially in elementary school, requires that students be able to think and understand every concept taught.

Understanding is defined as an ability possessed by someone to understand and understand what he knows. According to Elsani (2021), understanding is a student's skill in thinking, acting and making decisions in solving a problem that feels right. From the understanding ability possessed by students, it can be connected to mathematical concepts (Lestari & Surya, 2017). Concept understanding is defined as an ability that must be possessed by students so that other abilities can be formed by itself such as problem solving, communication and mathematical presentation skills (Surya et al., 2017). Concept understanding is expected to be instilled as early as possible to train students' critical thinking. This is in line with the opinion of research (Khofifah et al., 2021; Ningsih et al., 2020; Tata & Haerudin, 2022; Pramesti & Mampouw, 2020).

Students must understand math concepts early on so that they can solve problems and learn a lot. Thinking in mathematics learning provides positive encouragement to students to be confident in understanding concepts or solving mathematical problems (Faizah & Sudirman, 2022). Thus it can be concluded that with this concept understanding, students are able to process known information, then think about what processes are designed to solve problems, and what steps are used in solving these problems. In this case, understanding the concept plays an important role in creating the teaching and learning process in order to achieve maximum learning outcomes. Good concept understanding can encourage students to be able to think critically, creatively, and innovatively.

However, in reality there are still many students in elementary schools who are classified as low in the ability to understand mathematical concepts. This can be seen from the results of research showing that in PISA 2018, Indonesia's mathematics score was 379, lower than the international average of 489 so it can be said that Indonesian students still lack understanding of mathematical concepts (Damayanti & Rufiana, 2021; Setyaningsih & Firmansyah, 2022; Putri & Adiputra, 2022; Septian et al., 2020). This shortcoming is certainly a concern for all education stakeholders to pay more serious attention to the education system, especially in mathematics subjects. Low understanding of student concepts, especially in multiplication and division material. In line with that, according to research conducted by Fajaryna et al. (2023), mentioned that most students with low concept understanding due to having difficulty in calculating multiplication and division operations.

Students' low understanding of concepts related to multiplication and division operations can be analyzed by giving Higher Order Thinking Skill (HOTS) questions in mathematics. In line with that right, according to research conducted by Tasrif (2022) explains that giving HOTS questions to grade IV elementary school students can bring out higher order thinking skills which include critical, logical, creative, and analytical thinking abilities. Students' inability to solve HOTS problems is caused by their lack of ability to understand mathematical concepts. This opinion is also supported by research conducted by Yuliandini et al. (2019) which states that students are at least introduced and given HOTS-based multiplication and division problems even though the intensity is not too frequent. Thus, it is hoped that HOTS-based multiplication and division problems can analyze the extent of students' concept understanding related to multiplication and division operations.

Various theories are used to describe the extent of students' understanding of mathematical concepts. In this study, the APOS (Action, Process, Object, Scheme) theory developed by Jean Piaget was used. According to Gusman et al. (2017), APOS theory is the right theory to describe the extent of students' understanding of mathematical concepts because the characteristics of APOS theory refer to explanations of how mathematical concepts can be learned, how a person can build mental structures to understand concepts from what they see and know, so that they can build knowledge to solve more complex problems.

Action in APOS theory refers to the ability of students when writing down what information is known in the problem. Process refers to the student's ability to determine the solution steps such as students will use multiplication or division in solving math problems. Object refers to the student's ability to organize and apply the predetermined solution steps. Schema refers to the student's ability to conclude the answers that have been obtained from all previous APOS stages. So, the problem formulations in this study are:

1. How do students understand the concepts of multiplication and division based on APOS theory?
2. How do students solve HOTS-based problems in terms of APOS theory?

METHOD

This research was carried out in grade IV of the Laboratory Elementary School, State University of Malang (UM). This research is used in the second semester of mathematics subjects in the 2024/2025 academic year. This type of research is qualitative with a descriptive approach. Descriptive qualitative research is research conducted to research an object or a phenomenon that is in accordance with real conditions in the field (Sugiyono, 2015).

The subjects of this study are students in class IVC of UM Laboratory Elementary School with a total of 20 students. While the object of the research is the understanding of concepts using tests, interviews, and documentation. This study uses 3 questions to understand the concept of multiplication and division using HOTS questions. Content validity is the ability of the assessment tool to measure the content it should be, so that the test instruments in this study are not tested. This means that the test must have the ability to explain the meaning of the idea or variable to be measured (Nana, 2017). The following are the test and interview data collection instruments used in this study:

Table 1. Concept Comprehension Test

Question Number	Question Indicator	APOS Stage on Indicators	Learning Outcomes	Indicator of understanding the Concept
1	HOTS question was given related to the distribution, namely 20 numbers of Pak Santo's chickens which then the chickens would be placed in the cage. Each cage is filled with 4 chickens. If Pak Santo has had 2 cages before. Students are expected to be able to analyze how many cages are still needed by Pak Santo and how many total cages Pak Santo has.	**A (Action)** Students can write down what they know and ask questions about the questions. **P (Process)** Students can determine the steps of the division work **O (Object)** Students can operate the steps of the division process until they get the right results **S (Scheme)** Students make conclusions from the steps of the work and the results obtained in the questions	Students can perform multiplication and division operations of counted numbers up to 100 using concrete Objects, pictures and mathematical symbols.	Summarize sentences that present information Interpreting information from one form to another Deducing a concept or finding a pattern from a

			series of facts
2	Given a HOTS question related to multiplication and division, Dino bought as many as 8 packs of ballpoint pens which were divided among 2 of his friends as much. When in 1 pack of ballpoint pens there are 4 pieces. So students are expected to be able to analyze the number of ballpoint pens received by each Dino friend and if Dino's friend buys another 4 pieces, then what is the total ballpoint pen of Dino's friend	**A (Action)** Students can write down what they know and ask questions about the questions. **P (Process)** Students can determine the steps of the division work **O (Object)** Students can operate the steps of multiplication and/or division until they get the right results **S (Schema)** Students make conclusions from the steps of the work and the results obtained in the questions	
3	Given a HOTS question related to multiplication and division, namely Mother bought 3 kg of eggs for Rp. 36,000.00. If each 1 kg contains 12 eggs, then students are expected to be able to analyze how much eggs cost each milligram and how many total eggs mothers buy.	**A (Action)** Students can write down what they know and ask questions about the questions. **P (Process)** Students can determine the steps of the division work **O (Object)** Students can operate the steps of multiplication and/or division until they get the right results **S (Schema)** Students make conclusions from the steps of the work and the results obtained in the questions	

Table 2. Rubric for Assessment Questions for Concept Comprehension Test

Concept Understanding Indicators	APOS Stages Based on Indicators	Score	Assessment Criteria
Summarize sentences that present information on multiplication and	**Action** Students can write down what they know	4	Students can describe what is known and asked questions in the question very precisely.

Concept Understanding Indicators	APOS Stages Based on Indicators	Score	Assessment Criteria
division problems	and ask questions about the questions	3	Students are quite precise in describing what is known and asked in the questionsdiketahui dan ditanyakan pada soal.
		2	Students can only describe one of the things that are known and asked in the question precisely
		1	Students are not right in describing what is known and asked in the question
Interpret information from sentences into the form of multiplication and division steps	**Process** Students can determine the steps to work on the questions **Object** Students can operate the steps on the questions until they get the right answers	4	Students can determine and operate the steps on the questions until they get the right answers very well.
		3	Students can determine and operate the steps on the problem, but get incorrect answers
		2	Students can only determine the steps of working on the questions and cannot operate the steps until they get the right answer.
		1	Students cannot determine the steps of working on the questions and operate the steps until they get the right answers
Make conclusions from the steps and answers to the problem of multiplication and division of numbers	**Schema** Students can make conclusions from the steps and results obtained in the questions	4	Students can draw conclusions from the steps and the results obtained very well
		3	Students can make conclusions from the steps and the results obtained quite well
		2	Students are incomplete in making conclusions from the steps and the results obtained
		1	Students do not make conclusions from the steps of the work and the results obtained

A 12-point lead for 1 game, then

Student final grades = $\frac{Scores\ earned\ by\ students}{Maximum\ Score} \times 100$

Maximum Score = 36

Table 3. Criteria for Student Comprehension Level through Tests

Value Interval	Category
100-76	High
75-51	Medium
≤50	Low

Table 4. Guidelines for Interviews with Teachers

No	Teacher Interview Question Grid
1.	Number of students in grade IV
2.	Students' enthusiasm to learn multiplication and division operations
3.	Students' understanding of multiplication and division of numbers
4.	Students' understanding of concepts of multiplication and division of integer operations

Table 5. Guidelines for Interviews with Students

No	Student Interview Question Grid
1.	The initial activities carried out after digesting the questions
2.	Checking the steps of the work
3.	Check the overall answer

The data analysis technique is used in solving each problem of understanding the concept of multiplication material and the division of HOTS questions then analyzed based on 3 indicators of concept understanding, namely summarizing sentences that present information, interpreting information from one form to another, and deducing a concept or finding a pattern from a series of facts. Furthermore, 6 students were selected based on the category of high, medium and low test results (2 students in each category) which were reviewed based on the APOS theory. A total of six students who have been selected are then interviewed to get answers that have not been listed or have not had time to write on the test question sheet.

RESULT AND DISCUSSION

The results of the study show that as many as six students who have been selected based on the high, medium and low score categories (2 students in each category) can be seen based on the following table:

Table 6. The results of prospective teacher GPA scores

Number	Student	Result	Categori
1	LS	97	High
2	AN	83	High
3	ZS	75	Medium
4	MK	52	Medium
5	AO	25	Low
6	AZ	8	Low

Based on the table above, the ability to understand the concept of fourth grade students of the UM Laboratory Elementary School material of multiplication and division using HOTS questions reviewed from the APOS theory can be described as follows:

Understanding the Concept of Multiplication and Division Using HOTS Problems Reviewed from APOS Theory in LS Subjects

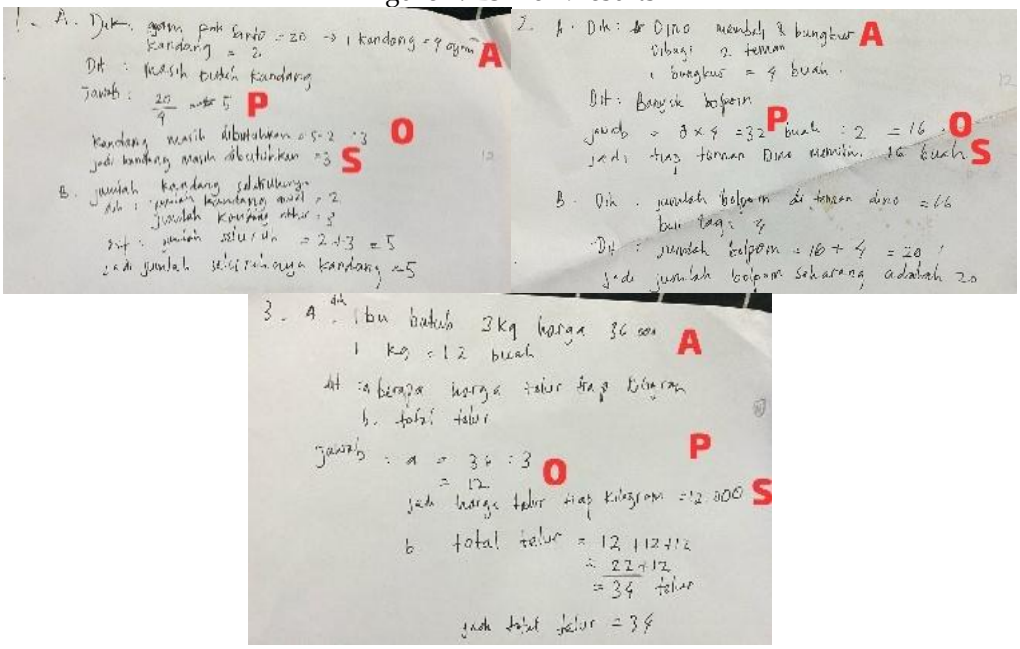
In the Action stage, from the overall question LS has been able to write down what is known, asked and answered in the question so that LS has been able to achieve the indicator of concept understanding in the action stage, namely summarizing sentences that present information. The following are the results of the LS subject work in the Action stage:

At the Process stage, from the overall LS problem, it is able to determine what solution will be done by determining what operation will be used, LS is able to determine using multiplication and or division operations in the problem. So that LS has been able to achieve the indicator of concept understanding at the process stage, namely interpreting information from one form to another.

At the Object stage, from the overall LS problem, it has been able to operate the steps of the operation that have been determined in the previous stage, namely the process. LS at this stage has been able to operate stacked multiplication and division using porogapit. Even in one of the questions, namely question number 3, it can be seen that LS operates (12x3) by means of repeated summation, namely 12 + 12 + 12. But it's just that the final result obtained is not right. This was during an interview with LS, explaining that LS subjects were not careful in arithmetic. LS has been able to achieve indicators of concept understanding at the object stage, namely interpreting information from one to another.

At the Schema stage, all the questions worked on by LS have shown that LS is able to achieve indicators of concept understanding at the schema stage, namely concluding a concept or finding a pattern from a series of facts. This can be seen from the results of LS's work by writing the conclusion on each question as evidenced by writing "so...." The following is a documentation of the results of LS work on all questions analyzed based on APOS theory:

Figure 1. LS work results



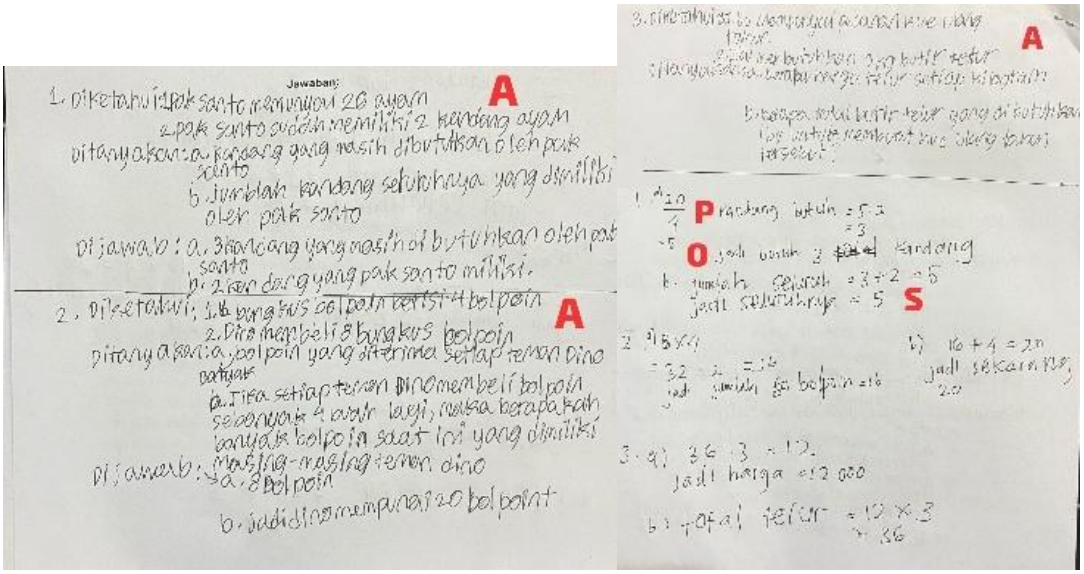
Understanding the Concept of Multiplication and Division Using HOTS Problems based on APOS Theory in AN Subjects

In the Action stage, from all the questions that have been done, the AN subjects are seen to have written down what they know, asked, and answered the questions carefully. However, there are some questions that AN is incomplete in writing the action stage. However, AN during an interview admitted that he forgot to write the information from the "known" part at

the action stage. So that the AN subject is still able to achieve the indicator of concept understanding at the action stage shown by AN being able to summarize sentences that present information. In the Process Stage, AN has been able to determine several steps that will be used to solve the problem, both multiplication and division. Thus, AN is able to achieve indicators of understanding the concept of the process stage, namely interpreting information from one to another.

At the Object Level, AN is already very good at operating multiplication and division. It can be seen that in the AN subject uses multiplication and division well and gets the right answer. In the Schema stage, AN seems to have written the conclusion of all the questions that have been worked on. It can be seen from the results of the work, AN wrote the word "So...". So AN has been able to meet the indicators of understanding the concept at the schema stage, namely concluding a concept or finding a pattern from a series of facts. The following is a documentation of the results of AN's work on all questions analyzed based on APOS theory:

Figure 2. AN work results



Understanding the Concept of Multiplication and Division Using HOTS Problems based on APOS Theory in ZS Subjects

In the Action Stage, ZS has been able to show what writing is known, asked and answered. Although ZS is seen in some questions, it is still incomplete and perfectly written from the action stage. However, this condition ZS has been able to achieve an indicator of understanding the concept of the action stage, which is shown by ZS being able to summarize sentences that process information.

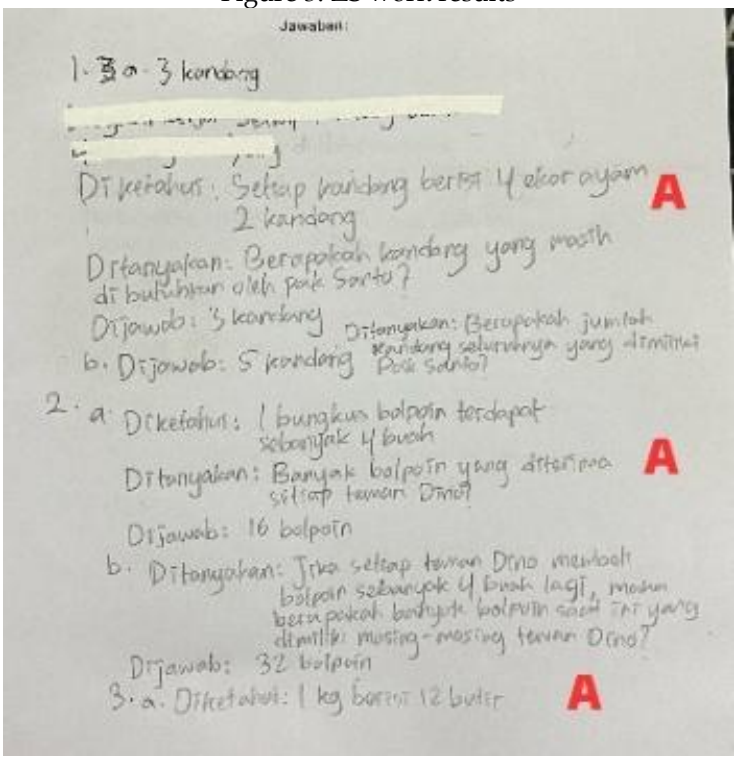
Process Stage, ZS does not write down what will be done next or in other words ZS cannot determine what operations are used in the problem, whether it is multiplication or division. This result is supported by the interview process with ZS which stated that ZS does not understand multiplication and division, the type of problem used whether it includes multiplication or division, so ZS finds it difficult to distinguish between the types of multiplication and or division problems. So with ZS, it has not been able to achieve the indicator of understanding the concept of the process stage, namely interpreting information from one form to another.

Object stage, because ZS finds it difficult to determine what operation will be used in solving the problem, then ZS is automatically unable to work on the process stage. When interviewed, ZS was asked about multiplication and division by the researcher. ZS is already able to do stacked multiplication correctly. It's just that ZS is not able to distinguish between

types of multiplication and or division story problems, but when operating multiplication ZS is already able to. Thus, ZS has not been able to achieve the indicator of understanding the concept of the process stage, namely interpreting information from one form to another.

Schema stage, ZS does not continue at the process stage until the schema. With this, ZS has not been able to achieve the indicator of understanding the concept of the schema stage, namely concluding a concept or finding a pattern from a series of facts. The following is a documentation of the results of ZS's work on all questions analyzed based on the APOS theory:

Figure 3. ZS work results



Understanding the Concept of Multiplication and Division Using HOTS Problems based on APOS Theory in MK Subjects

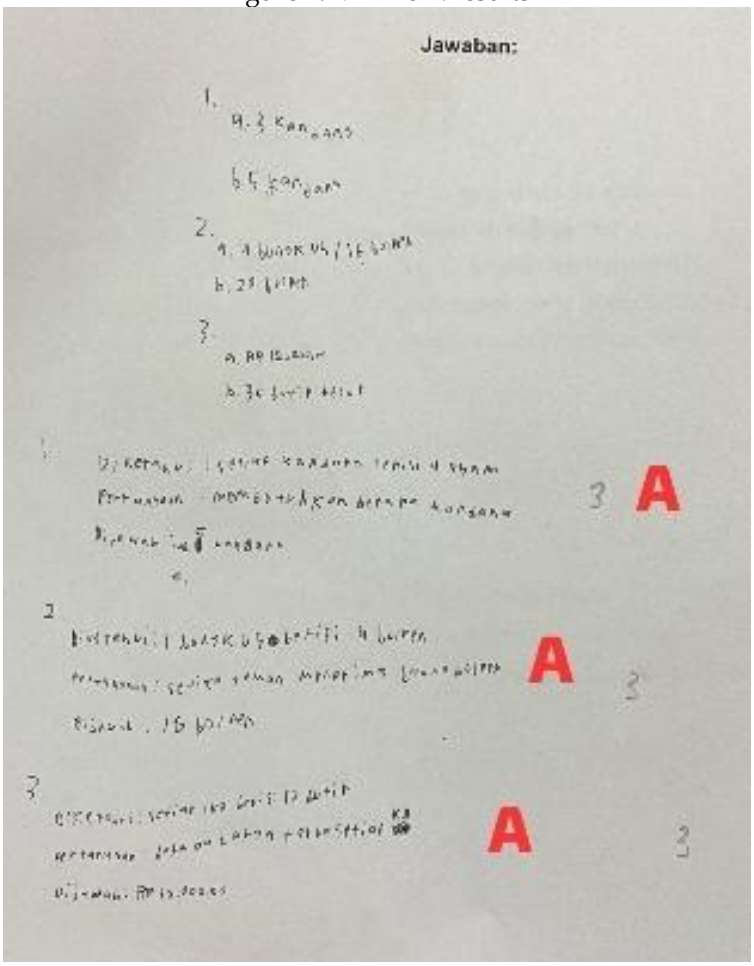
In the Action Stage, the Constitutional Court tries to write down what is known, asked and answered on the questions. However, all the questions that are done are still incomplete in stating the information from the questions. When interviewed, the Constitutional Court explained according to what was known in the question. This means that the Constitutional Court still does not fully understand what information is known, asked and answered at the action stage. So that the Constitutional Court has not been able to achieve an indicator of understanding the concept of the action stage, which is shown by AN being able to summarize sentences that present information.

At the Process Stage, the Constitutional Court has not been able to determine what steps to use on the question, it can be seen from the results of the Constitutional Court's work that does not write down the steps to solve the problem. When interviewed, the Constitutional Court was unable to answer the questions given by the researcher. Even when asked about multiplication, the Constitutional Court has not been able to answer. Thus, the Constitutional Court has not been able to achieve the indicator of understanding the concept of the process stage, namely interpreting information from one form to another.

At the Object stage, the Constitutional Court found it difficult because it did not understand multiplication and division in a fundamental way. MK only memorizes up to 3 times. For further multiplication, even up to layered multiplication, the Constitutional Court has not been able to do it. At the Schema stage, due to the inability to work on the previous

stage, the Constitutional Court has not been able to determine the conclusion of the problems that have been worked on. So that the Constitutional Court has not been able to achieve the indicator of understanding the concept of the schema stage, namely concluding a concept or finding a pattern from a series of facts. The following is a documentation of the results of the Constitutional Court's work on all questions analyzed based on APOS theory:

Figure 4. MK work results

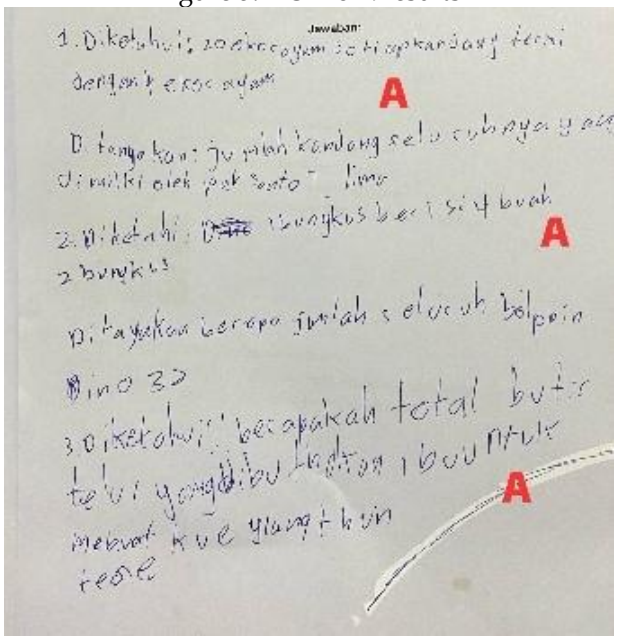


Understanding the Concept of Multiplication and Division Using HOTS Problems based on APOS Theory in AO Subjects

The Action Stage, the AO tries to write down what is known, asked and answered. Of all the questions that were done, AO was only able to reach the Action stage. Although some of the AO questions are still incomplete in writing the Action stage, the AO has been able to achieve the indicator of concept understanding, namely summarizing sentences that present information.

The Process Stage, Object and Schema AO are not written on the answer sheet. When interviewed, the AO explained that the AO was not able to work on multiplication and/or division, so the next stage of APOS (process, object, and scheme) could not be continued. AO when interviewed by the researcher admitted that under AO he was only able to answer up to multiply 2. Thus, the AO has not been able to achieve the indicators of concept understanding at the process, object and schema stages. The following is a documentation of the results of the AO's work on all questions analyzed based on the APOS theory:

Figure 5. AO work results

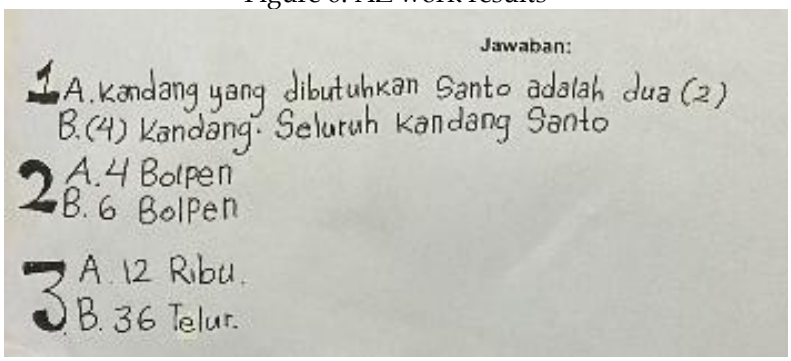


Understanding the Concept of Multiplication and Division Using HOTS Problems based on APOS Theory in AZ Subjects

In the Action Stage, AZ does not write down what is known, asked and answered. AZ only immediately wrote the answer to each question given. When interviewed, AZ was unable to determine what was known, asked and answered when the researcher asked the question. AZ explained that the difficulty in interpreting the question is included in the story of multiplication and or division. So that AZ has not been able to achieve the indicator of understanding the concept of the action stage, which is shown by AZ not being able to summarize sentences that present information.

Process, Object and Schema stage, AZ has not been able to determine what will be done because AZ does not understand the Action stage so that to proceed to the next APOS stage is not yet able to. The following is a documentation of the results of AZ's work on all questions analyzed based on APOS theory:

Figure 6. AZ work results



Based on the exploration of each research subject, it was found that not all students in grade 4 of elementary school were able to understand the concept of multiplication and division. This is shown from the results of tests and interviews with subjects ZS, MK, AO, and AZ who still had difficulty understanding multiplication and division problems. The difficulties experienced by the research subjects are in line with Umam & Susandi (2022) who stated that conceptualization errors made by students are the inability of students to answer questions. The APOS theory discusses what happens in students' minds when learning mathematical concepts, as well as the successes and failures they face when completing math assignments. The

existence of student errors in calculating multiplication and fractions shows that students are careless in understanding multiplication and division problems, even though on the other hand the material is the basic material in mathematics (Alghazo & Alghazo, 2017; Özcan et al., 2017; Septiany et al, 2015; Umam et al., 2017).

DISCUSSION

The findings align with and extend previous studies that underscore difficulties among elementary students in distinguishing operations or constructing conceptual understanding in mathematics. For instance, Alghazo & Alghazo (2017) highlighted persistent misconceptions in basic arithmetic operations. Similarly, Özcan et al. (2017) found that students struggle with non-routine problem solving, echoing this study's observation of students' difficulties with HOTS problems. Faizah et al. (2022) and Sa'adah et al. (2023) demonstrated how students' thinking processes develop in stages, which supports the APOS framework used here. Lestari & Surya (2017) and Khofifah et al. (2021) emphasized that conceptual understanding is a prerequisite for higher-level skills like reasoning and problem-solving. Contrastingly, this study delves deeper by using APOS theory as an analytical lens, providing a micro-level diagnosis of students' conceptual construction stages. While Pramesti & Mampouw (2020) and Umam et al. (2017) used APOS in algebra or linear problems, this research focuses on basic operations, revealing similar deficiencies even at foundational levels. Damayanti & Rufiana (2021) and Fajaryna et al. (2023) noted limited multiplication/division abilities among elementary students, but without integrating APOS theory. Hence, this study contributes by mapping specific cognitive hurdles across APOS stages and suggesting differentiated interventions based on students' positioning in those stages.

The findings offer valuable insights for curriculum designers, educational policymakers, and elementary educators. First, instructional strategies should be tailored to scaffold students through APOS stages by emphasizing transitions between actions, processes, and abstract concepts. Second, problem-solving tasks must consistently involve HOTS elements to challenge students' reasoning. The clear stratification among students' comprehension levels indicates the necessity for more personalized learning interventions in mathematics. Furthermore, training for teachers on identifying and supporting learners at different cognitive stages becomes crucial.

Despite its contributions, this study is limited by its small sample size and the qualitative design, which may restrict the generalizability of findings. Another limitation is the exclusive reliance on APOS theory without triangulating with other cognitive learning models. Additionally, the study context—a single laboratory school in Malang—might not reflect the diversity of elementary learning environments across Indonesia or globally. Future studies should expand the sample to include a wider range of schools and demographics. Mixed-method or longitudinal designs could uncover how conceptual understanding evolves over time. Researchers are encouraged to combine APOS with frameworks such as SOLO taxonomy or Bloom's revised taxonomy to enrich analysis. Moreover, developing and validating intervention models based on the APOS framework may further support students in progressing through stages of conceptual understanding. Finally, future investigations could explore the role of digital learning environments in fostering HOTS through APOS-based instruction.

CONCLUSION

Based on research that has been conducted on grade IV students of UM Laboratory Elementary School, it is concluded that students' understanding of concepts related to multiplication and division using HOTS problems reviewed by APOS theory has experienced significant differences. Students with an understanding of the concept of high grade criteria are already able to reach the scheme stage. Students with moderate understanding of concepts, still

feel difficulties at the process stage up to the scheme. This is because the student has not been able to identify the type of question that includes multiplication or division. Meanwhile, students with an understanding of the concept of low category have not been able to reach the action stage. Students in this low category understanding find it difficult to distinguish which is a matter of multiplication and which is a matter of division, so that at the action stage they are not able to write down what is known, asked and even answered. This is a serious concern for all of us to continue to pay attention to the continuity of learning, especially mathematics in multiplication and division materials.

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