

MATHEMATICAL CREATIVE THINKING SKILLS: USING APOS THEORY TO IDENTIFY STUDENT ERRORS IN SOLVING CONTEXTUAL PROBLEMS

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ABSTRACT

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Individuals with strong creative thinking abilities are particularly adept at effectively addressing mathematical contextual problems. However, students often need more vital creative thinking skills in the classroom, frequently due to errors they make themselves. This study aims to identify students' specific errors when solving contextual problems related to integer operations. This research adopts a qualitative approach, using an exploratory and descriptive technique, focusing on sixth-grade elementary school students. Participants were selected based on the teacher's recommendations, specifically targeting students with strong communication skills to comprehensively examine their errors in dealing with contextual problems and their creative thinking skills. The research utilized tests and interviews as instruments for data collection, incorporating methodologies such as testing, interviewing, and triangulation. The results indicate a significant deficiency in students' innovative thinking skills, rendering them unable to solve problems effectively, which leads to an inability to meet the four criteria of creative thinking. Based on the Action-Process-Objects-Scheme (APOS) theory, the identified errors in students' approaches to contextual mathematical problems can be categorized into four types: (1) interpretive errors, (2) errors in conceptual understanding, (3) procedural errors, and (4) computational or technical errors. The insight gained from this study can inform the design of integer learning activities, helping minimize contextual problem-solving mistakes that require creative thinking skills. Consequently, further research is essential to develop a mathematical learning model that can enhance students' mathematical creative thinking abilities.

Keywords: Contextual problems; mathematical creative thinking skills; error identification

1. INTRODUCTION

Creative thinking is essential in the twenty-first century, particularly in the field of education (Cooper, 2021; Smith, 2022; Rahayuningsih et al., 2021). As one of the objectives of mathematics education, creative thinking can assist students in understanding their surroundings (Puspitasari et al., 2019; Yayuk et al., 2020). Furthermore, creative thinking plays a role in achieving meaningful learning (Ammaralikit & Chattiwat, 2020; Junaedi et al., 2021). As a result, teachers must foster creative thinking in classroom learning activities. Thinking creatively in mathematics is a key component for students in addressing mathematical difficulties, as it allows them to consider new facts and ideas while solving mathematical problems (Ndiung et al., 2021; Puspitasari et al., 2019). The ability to think creatively in mathematics can also be described as a cognitive function that refers to the capacity to develop mathematical ideas and concepts (Nwoke, 2021; Yayuk et al., 2020). Furthermore, the ability to think creatively in mathematics is one of the features of higher-order thinking, allowing students to generate new ideas from difficult problems (Ali et al., 2021; Junaedi et al., 2021). As a result, students must be able to think creatively in mathematics.

Many experts have presented indicators of creative thinking skills. A person with strong creative thinking abilities must meet four criteria: fluency, flexibility, originality, and elaboration (Jumadi et al., 2020; Rahayuningsih et al., 2021). Fluency is the ability to generate many types of ideas to solve problems. Flexibility refers to the capacity to provide multiple solutions to a situation. Originality is the ability to articulate original thoughts that have not previously been considered. Elaboration refers to the ability to develop ideas or thoughts and explain problems in detail. Therefore, these are the indicators of creative thinking ability in this study, according to this explanation.

Contextual problem-solving in mathematics can provide students with various ideas based on real-life experiences (Hawa et al., 2019; Nugroho et al., 2020). In addition, students will be able to solve contextual mathematical problems by correctly applying mathematical procedures or processes (Fonteles Furtado et al., 2019; Hunukumbure et al., 2021). On the other hand, students continue to make errors when dealing with contextual challenges related to creative thinking questions (Haghverdi & Wiest, 2016; Soneira, 2022). As a result, teachers should investigate student errors in order to incorporate appropriate classroom learning strategies.

Errors are a significant component of conceptual knowledge and are necessary in mathematics teaching (Barkai, 2021; Hu et al., 2022; Jones et al., 2020). As a result, teachers need to be able to identify student errors through effective error analysis (Faizah et al., 2022; Peltier & Peltier, 2020). Therefore, students are encouraged to complete the activities assigned by the teacher (Kenney et al., 2020; Santia et al., 2019). Students commonly make interpretive errors, conceptual errors, procedural errors, and computational errors (calculations) (Haghverdi & Wiest, 2016; Kenney et al., 2020; Khalid & Embong, 2019; Peltier & Peltier, 2020). For example, when students turn variables into numbers, they make interpretation errors when translating or concluding a problem statement (Kshetree et al., 2021). This is usually tied to the number object (40). The conceptual error indicates a student's failure to comprehend a concept in the problem at hand and a failure to assess the connection in a situation (Ammaralikit & Chattiwat, 2020; Köğce, 2022). Procedural errors occur when students fail to modify an algorithm despite understanding the principles (Ammaralikit & Chattiwat, 2020; Lien et al., 2021). Finally, computational errors are connected to calculation mistakes made by students (Al-Jarf, 2022; Emara et al., 2021). These errors were caused by a variety of factors, including students' low disposition toward mathematics, a poor teaching framework, insufficient teaching ability, students' perception of complex mathematics material, students' limited understanding of mathematics, and a lack of understanding in students' higher-order thinking capacity (Kshetree et al., 2021; Prayitno et al., 2022). As a result, assessing students' mental processes when solving mathematical assignments is vital.

The Action-Process-Object-Schema (APOS) theory can be used to investigate students' mental processes when answering contextual challenges related to creative thinking questions. The APOS theory is divided into four stages: action, process, object, and schema (Arnawa et al., 2021). In APOS theory, the action phase is carried out by an individual employing mathematical concepts in conjunction with a specific algorithm, directed by external stimuli during the action phase (Arnawa et al., 2021; Bintoro et al., 2021; Moon, 2019). The process phase of APOS theory includes repetitive actions and reflection, which help shift from relying on external signals to relying on internal cues (Arnawa et al., 2021; Boz-Yaman & Yiğit Koyunkaya, 2019; Tatira, 2021). The object phase of APOS theory focuses on recognizing that specific processes and transformations of action are regarded as a single entity, allowing for explicit shifts (Van Melle & Ferreira, 2022). Finally, the schema phase is a collection of predetermined ideas about actions, processes, objects, and schemas that are combined to build a mathematical structure for solving mathematical problems (Arnawa et al., 2021; Moru, 2020). APOS theory investigates what occurs in a person's mind when learning a mathematical concept and the successes and failures encountered during mathematical activities.

APOS theory provides a structured cognitive development pathway that supports creative thinking skills in mathematics. For creative thinking to be effective, students often need to develop high-level schemas (the final APOS stage). Incomplete progression through the APOS stages can limit creative thinking to less flexible or shallow approaches, potentially leading to errors. Creative thinking in mathematics can lead to errors when students generate novel solutions without a complete conceptual understanding. Creative ideas in mathematics need to be based on well-formed schemas; otherwise, students may design flawed approaches due to over-reliance on intuition or incomplete processing. Errors often highlight gaps in APOS development, especially when students fail to transition smoothly between stages (e.g., from process to object). This framework can explain why some errors occur even in students who are adept at generating creative solutions but lack schema understanding.

Numerous studies have been conducted on error analysis. Research by Didiş Kabar and Erbaş (2021) shows that students make mistakes in the four presented model problems. According to Polya, research by Sukoriyanto et al. (2016) reveals that students continue to make errors when tackling permutation and combination problems. Sari et al. (2018) state that the most common inaccuracy in representational abilities is problem-solving using arithmetic symbols. Research by Khalid and Embong (2019) indicates that errors arising when completing common problems involving integer operations are misconceptions. Ozrecberoglu et al. (2022) found that student performance in answering non-routine math tasks is low due to the frequent occurrence of errors. Finally, Jones et al. (2020) found that students had difficulties solving problems involving fractions.

According to previous research findings, academics have yet to examine the types of errors students make when answering contextual problems related to mathematical creative thinking using APOS theory. This gap in the literature encouraged the researchers to conduct a study to uncover and identify errors made by elementary school students when solving contextual problems that require creative thinking skills, utilizing APOS theory. By applying APOS theory, this study aims to identify students' errors in solving contextual problems related to creative thinking topics. The researchers chose the APOS theory because it can describe students' mental processes in constructing mathematical concepts. Furthermore, this initial identification is critical for shaping students' creative thinking skills, allowing for the development of relevant learning models based on the study's findings.

2. METHODS

2.1 Research design

The exploratory descriptive approach is used in this study's qualitative investigation. This approach aims to collect verbal data from students' responses when they complete a written test on contextual mathematical problems. In addition, open-ended questions were used in interviews to confirm the research subjects' responses. The issues addressed in this study include students' difficulties in answering contextual mathematical problems related to creative thinking skills using the APOS theory (Action-Process-Object-Schema).

2.2 Research subject

The participants in this study were all sixth-grade students from a state elementary school in Cirebon Regency. Since not all students were selected as participants, a purposive sampling technique was used to choose the research subjects. Fifty students had studied integer material. Within the allotted time, students were required to solve four contextual mathematical problems that assessed their creative thinking skills. Based on the indicators of creative thinking, all response papers were collected and analyzed. Students who performed exceptionally well were not selected as subjects. On the other hand, students who made errors while solving contextual problems, including those involving numerical material, were considered research subjects. The research subjects were chosen based on the teacher's recommendation, specifically targeting students with good communication skills to facilitate the examination and identification of errors in handling contextual problems related to creative thinking skills. Two students were selected for interviews based on the teacher's recommendation.

2.3 Research instrument

The test and interviews used as research instruments have been construct-validated by two mathematics education experts. The primary purpose of these tests is to identify various errors made by students. The test comprises four contextual questions, specifically designed based on indicators of students' creative thinking abilities. These indicators are based on the four characteristics of creative thinking according to Kshetree et al. (2021): fluency, flexibility, originality, and elaboration. Interviews are conducted to gather additional information from students' written response sheets. These interviews are unstructured, meaning that the researchers do not prepare specific questions in advance for the research subjects. Instead, students

are expected to explain their responses during the interview. Interview questions are based on students' answers on the test sheets. Finally, the researchers confirm the test answers with the interviewed students.

2.4 Data collection

Data were collected from 40 students who completed a test consisting of four essay-style questions addressing contextual challenges related to mathematical creative thinking skills. Each student was given 40 minutes to complete the test and submit their answer sheet. The researchers reviewed the responses, focusing on identifying common errors made by students. The researchers then collaborated with the class teacher to select six students with strong communication skills for interviews. After selecting the research subjects, interviews were conducted to further corroborate the students' written responses. Interviews lasted 45 to 60 minutes, and all of them were recorded. The APOS theory was used to conduct interviews for this study to gain a deeper understanding of the error students made when tackling challenges involving mathematical creativity in context. The researchers then independently assessed the outcomes of the student interviews. After selecting the research subjects, the researchers conducted interviews to further explore and clarify the students' written responses. Each interview, lasting between 45 and 60 minutes, was fully recorded. Using the APOS theory as a framework, the interviews aimed to gain deeper insights into the specific error students made when approaching contextual challenges in mathematical creativity. The researchers then independently reviewed and analyzed the interview results. The next step involved data triangulation, achieved by comparing the results of the written test on contextual mathematical problems related to creative thinking skills with the interview insights gathered from both the researchers and students. Based on these triangulated results, the researchers derived their final findings.

2.5 Data analysis

Data analysis began with validated transcripts of interviews, student work results, and field notes, using triangulation to ensure accuracy. An open, inductive thematic approach was employed for coding, mapping transcripts into categories based on the APOS framework. Initial codes were arranged alongside the text to facilitate analysis and were continuously refined to accurately represent participants' voices. Qualitative data coding requires diverse strategies depending on the intended analysis. After reviewing the research questions, further analytical coding was conducted, addressing the research questions through APOS framework themes in a comparative and contrasting manner to obtain multi-perspective analytical dimensions. The coded transcripts were carefully reviewed to ensure that statements and quotes accurately represented the analysis. All final coding decisions were guided by the research questions and the researchers' understanding of the data at hand.

3. RESULTS AND DISCUSSION

According to the Fluency indicator, Figure 1 shows the findings from the contextual problem-solving test of students' critical thinking skills. Figure 1(a) depicts students' responses in Indonesian, and Figure 1(b) depicts students' responses in English. The test results demonstrated that students could not meet the Fluency indicator when answering contextual mathematical problems, as they could not provide various solutions. This occurred because students did not comprehend how to solve the problems, leading to mistakes. It was likely due to students' inability to understand the questions posed in these tasks. As a result, interviews were conducted to identify students' errors in solving contextual problems related to the Fluency indicator using the APOS theory.

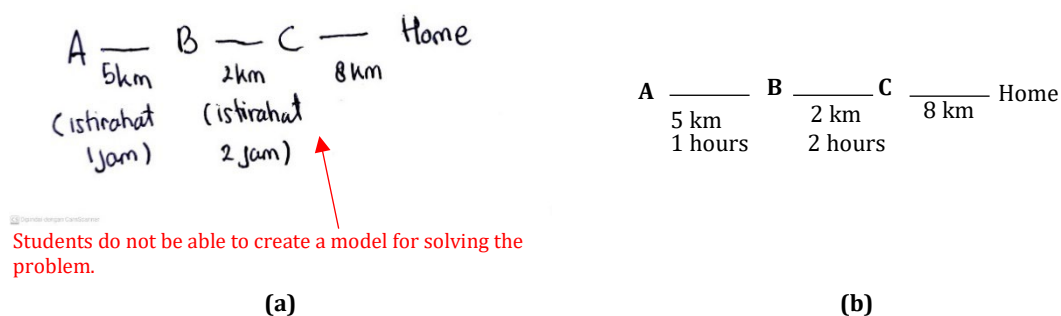


Figure 1: Students' answers on the Fluency indicator in Indonesian (a) and in English (b)

The results of the interviews revealed that students made an interpretive error. It was shown that students did not write down what they knew or what was requested in the response. Furthermore, students drew incorrect route diagrams based on the problems in the questions. Although students could convert daily language into mathematical language, they did not understand the meaning of the questions.

Figure 2 shows the results of the contextual problem-solving test of students' creative thinking skills, measured by the Flexibility indicator. Figure 2(a) depicts students' responses in Indonesian, while Figure 2(b) depicts students' responses in English. The test findings demonstrate that students did not meet the Flexibility indicator for solving contextual mathematical problems, as they were unable to propose various solutions or approaches to the topic at hand. Furthermore, they could not present more than one approach or procedure for working on questions. This was likely due to students' inability to understand the questions raised in answering these issues, causing them to make mistakes. As a result, interviews were conducted to identify student errors in solving contextual problems using the APOS theory.

Cara 1

Benar = $4 \times 30 = 120 - 15$
 $= 105$ ga dijawab: $5 \times 1 = 5$

Salah = $5 \times 2 = 10$

Students do not be able to perform the procedure to solve the problem

(a)

Rule 1

True = $4 \times 30 = 120 - 15 = 105$

Wrong = $5 \times 2 = 10$

Not Answer = $5 \times 1 = 5$

(b)

Figure 2: Students' answers on the Flexibility indicators in Indonesian (a) and in English (b)

The interviews revealed that students made an interpretive error. It was shown that students did not write down what they knew or what was requested in the response. They could convert daily language into mathematical language, but they did not understand the significance of the questions. Students also made conceptual errors, as evidenced by a student applying the incorrect operating formula for integers. Furthermore, students made incorrect choices for the numbers to be operated on in the problem. Students also made procedural errors because they could not fully explain their answers, as well as computational errors. All of these errors were demonstrated in their responses to the problem.

Figure 3 illustrates the outcomes of the contextual problem-solving test of students' creative thinking skills, as measured by the Originality indicator. Figure 3(a) depicts students' responses in Indonesian, whereas Figure 3(b) depicts students' responses in English. The test findings demonstrate that students were unable to meet the Originality indicator when solving contextual mathematical problems because they could not convey fresh concepts that had not been previously considered. This was due to students' inability to propose original ideas and their failure to understand the questions when attempting to solve these problems. Using the APOS theory, interviews were conducted to identify student errors in solving contextual problems related to questions on the Originality indicator.

25

Danang = $75 : \frac{1}{3}$

Sisa makanan = $75 - 25$
 $= 50 : 2$
 $= 25$

Blimbing yang diharis gito dan irma adalah 25 buah

Students do not be able to understand the question properly

(a)

Danang = $75 : 1/3$

Food left = $75 - 25$
 $= 50 : 2$
 $= 25$

Startfruits given to Gito and Irma are 25.

(b)

Figure 3: Students' answers on the Originality indicator in Indonesian (a) and in English (b)

The results of the interviews revealed that students made errors in their understanding. They did not write down what they knew or what was requested in the response. Students could convert language into mathematical language, but they did not understand the meaning of the questions. Students also misunderstood the concepts. This was demonstrated by their incorrect use of formulas for fractional and integer arithmetic operations. Furthermore, students made incorrect choices for the numbers to be operated on in the problem. They also made procedural errors, as they could not fully explain the answers they obtained, and computational errors as well. Finally, it was shown that students provided incorrect final answers.

Figure 4 shows the results of the contextual problem-solving exam on students' creative thinking skills, as measured by the Elaboration indicator. Figure 4(a) presents students' responses in Indonesian, while Figure 4(b) shows their responses in English. The exam results indicated that students did not meet the Elaboration indicator when answering contextual mathematical problems because they were unable to develop ideas or explain the problems they had solved in detail. This was due to students' failure to describe their answers in detail, which led to mistakes. As a result, interviews need to be conducted using the APOS theory to identify student errors in solving contextual problems related to the Elaboration indicator.

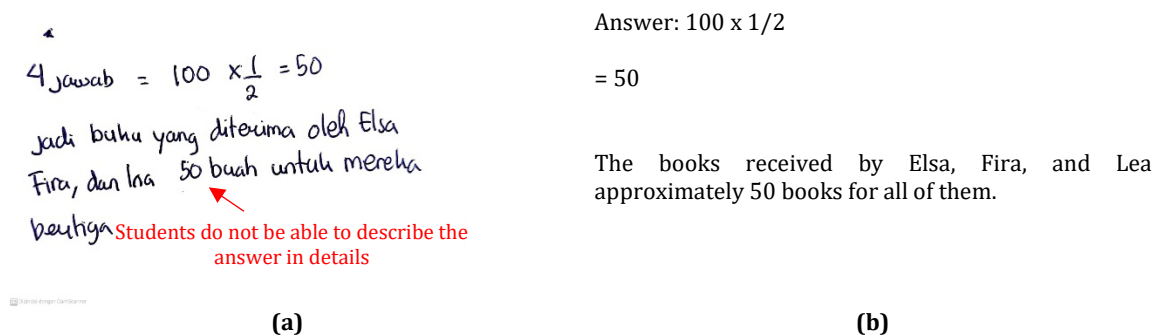


Figure 4: Students' answers on the Elaboration indicator in Indonesian (a) and in English (b)

The interviews revealed that students made errors in their understanding. It was evident that students did not write down what they knew or what was requested in the response. Although students could convert everyday language into mathematical language, they did not fully grasp the significance of the questions. Students also made conceptual errors, as evidenced by their incorrect application of the operating formula for integers. Furthermore, students made incorrect choices for the numbers to be operated on in the problem. Additionally, students made procedural errors because they could not fully explain the answers they obtained, and they also made computational errors.

Students with low mathematical creative thinking abilities were chosen as research subjects. This is because the students could not answer the four questions presented in contextual situations using the four indicators of creative thinking abilities. Students' inability to attain indicators of creative thinking skills in contextual mathematical problems was driven by a lack of familiarity with these types of questions (Ilhan & Akin, 2022; Kolar & Hodnik, 2021). In addition, students were accustomed to challenges that did not necessitate the use of creative thinking skills. As a result, students must become acquainted with contextual difficulties that necessitate applying creative thinking skills (Rafiee & Abbasian-Naghneh, 2020; Yustina et al., 2022).

To handle contextual difficulties, students' creative thinking skills need to be developed. One approach is to employ a learning model that requires students to actively participate in their learning in class. Material delivery must also focus on outcomes, and problems must provide students with challenges related to contextual problems. This is consistent with research by Balakrishnan (2022), which suggests that one strategy to promote creative thinking skills in elementary school students is to use teaching strategies that require students to be active in classroom learning and familiarize them with addressing complex challenges connected to learning. Furthermore, teachers must provide immediate supportive feedback to students, allowing them to actively find their answers so that students do not struggle to solve contextual problems (Kim et al., 2022).

In sixth-grade elementary school, two students with low creative thinking skills made mistakes when answering contextual mathematical problems. Students' common errors in solving contextual problems requiring creative thinking abilities can be divided into four categories: interpretation errors, conceptual errors, procedural errors, and computational/technical errors. Students' interpretation errors occur when they fail to understand the topic or problem in the given context. They are unable to grasp the significance of the questions posed to them. Based on the four questions provided, students could not write down what was known and what was asked in the question, leading them to misinterpret the meaning.

In question one, the student incorrectly described the sketch of the route image based on the difficulty of the problem. The student created a route using only straight lines, although the question stated that the path should return to the starting position because Budi returns to the origin. The student was also incorrect in their findings in response to the inquiry. They made errors in responding correctly to the presented contextual difficulties based on the four questions. Additionally, the students did not fully comprehend the questions presented. This was due to their inability to define or comprehend sketch drawings in a specific topic (Özdemir & Dede, 2022).

Students made conceptual errors, such as incorrectly applying the formula for arithmetic operations with mixed integers. In question two, the students performed arithmetic operations on integers without considering which operation takes precedence between addition, subtraction, multiplication, and division, which led to incorrect results. The students also misunderstood the division process of numbers in question two. In response to question two, the students answered $75 \div \frac{1}{3}$. In this question, the students crossed out the numbers 75 and 3, showing that they had a wrong understanding of division and multiplication operations. The correct concept is $75 \div \frac{1}{3} = 75 \times 3$. Additionally, students chose the incorrect number to operate on in the problem. This was because they did not fully comprehend what was being asked in the problem, causing numbers that did not need to be operated on to become operational (Joung & Kim, 2022).

Based on the four questions, students experienced errors in choosing the numbers to operate on. This was due to their failure to read the questions carefully, which led to misunderstandings of what the questions actually signified. Students' understanding of mathematical concepts remains low. The result is supported by Karakuş et al. (2022), who indicate that students' conceptual comprehension is poor when answering specific mathematical problems. As a result, students make conceptual errors. The finding is supported by a study by Tooher and Johnson (2020), which found that students struggle to grasp particular mathematical topics if they do not understand the concepts relevant to the studied issues. Students will make mistakes when answering problems, particularly contextual ones. Conceptual errors can also develop as a result of prior knowledge. This is consistent with the findings of a study by Jarrah et al. (2022), which found that students' conceptual errors are also caused by prior mathematical learning. For example, students are unable to comprehend integer concepts because they merely memorize integer formulas without understanding the concept or how to apply them. As a result, students struggle to gain a correct and comprehensive understanding of the concept (Barbieri & Booth, 2020).

Students made procedural errors, including failing to explain the steps on the answer sheet adequately. In question one, students only mentioned the outcome and were unable to explain the methods used to obtain the answer. Then, in questions two and three, students could explain the steps involved, but only partially, as their final answers were incorrect. The students could not clarify their answers to question four because they misinterpreted the significance of the question. Furthermore, students were incorrect in concluding the results of the given problem. This was demonstrated in question five, where students assumed that the books delivered to Elsa, Fira, and Ina were all the same, totaling 50 books. The problem fails to indicate that the book distribution among Elsa, Fira, and Ina was the same. As a result, students did not understand the significance of the problem, and their conclusions were incorrect. Students were also incorrect in executing integer operations when solving problems, even though they had reached the correct conclusions. Therefore, students need to apply all the principles required to answer the problem to avoid errors in determining the outcome (Hu et al., 2022). Students must be able to present valid mathematical reasoning, draw conclusions, and develop generalizations in order to solve specific mathematical problems (Köğçe, 2022).

Students' technical or computational errors occurred during the calculation procedure. For example, this can be observed in the process of multiplying integers in problem number two. The student carried out the operation $6 \times (-1) = -5$. The conclusions of these calculations were incorrect, resulting in incorrect final answers to the problems. This finding aligns with the study by Khalid and Embong (2019), which found that most students had broad misconceptions regarding integer operations, such as the multiplication of positive and negative integers. Errors in dividing integers by fractions occurred because students were less attentive while performing operations. As a result, a technical error occurred. For example, in question three, students completed the operation $75 \div \frac{1}{3} = 25$. The outcomes of these calculations were inaccurate, causing students to conclude the final answer to the presented questions incorrectly. According to the study, the most common mistakes students make in the operation of dividing integers are those who are negligent in using the methods provided in the problems (Üzel, 2018). As a result, students must have strong fundamental mathematical problem-solving abilities to solve contextual mathematical problems (Sternberg et al., 2021). This is essential to ensure that students' mistakes do not reoccur.

According to the findings, sixth-grade students were still in the action stage of the APOS theory. This occurs because students lack an APOS conceptual structure, which causes them to make errors when faced with contextual mathematical problems. For example, students have trouble implementing integer operations due to a lack of conceptual structure related to the process, object, and schema stages (Kshetree et al., 2021). This demonstrates that students cannot manage the application of theorems and formulas required for specific mathematical problems. Based on the APOS theory analysis, students have difficulties understanding the concept of operations on numbers. This is because, at the previous level, students could not understand the concept of operations on integers, which caused them to make errors in solving the problems presented. Students only memorize formulas, so they struggle when learning about the concept of operations on integers.

In addition, students lack experience understanding integer operations, do not fully understand the concept of integer operations, and have minimal prior knowledge of integer operations from the previous level. As a result, teachers must have an effective strategy to identify student errors. One technique for reducing student errors in handling contextual problems is to hold open discussions that focus on efforts to overcome student errors during the learning process (Ilhan & Akin, 2022).

Assessing and analyzing students' errors in completing contextual problems on creative thinking skills is considered an essential tool for learning (Rahayuningsih et al., 2021). Furthermore, it is indicated that to overcome cognitive obstacles in solving difficulties presented in mathematics learning, students must have a positive mindset and engage in optimal thinking activities that activate prior knowledge and experience in solving specific problems. Since students in different courses differ in their capacities for creative thought, the understanding of individual students should be considered while designing a teacher's thinking activity (Jumadi et al., 2020).

These findings suggest that teachers should appropriately prepare students on both the procedural and conceptual aspects of mathematics. Both features are critical in comprehending mathematical material (Barbieri & Booth, 2020). Identifying students' errors in addressing contextual mathematical problems and their ability to think creatively about integer operations has helped teachers recognize students' shortcomings. This will assist teachers in preparing classroom activities and addressing errors that occur. Students' errors are caused by a lack of creative thinking skills when tackling contextual mathematical problems. According to Tooher and Johnson (2020), a student with low skills in creative thinking will make mistakes in solving the problem.

Therefore, students' ability to think creatively needs to be developed so that similar errors do not occur again. After improving their creative thinking skills, students will be able to develop their own formulas or principles for solving mathematical problems. According to the research, strengthening mathematical creative thinking skills would allow students to pay attention to all components required to solve mathematical problems, enabling them to discover formulas or rules on their own (Foster, 2021).

4. CONCLUSION

It can be concluded that the students selected for the study did not meet the four creative thinking indicators of fluency, flexibility, originality, and elaboration. This incapacity was caused by errors made by students when tackling contextual problem-solving tasks that required creative thinking skills. According to the APOS theory, student errors include: (1) Misinterpretation errors: incorrectly converting the questions into mathematical language/symbols and misinterpreting the given questions; (2) Conceptual errors: students misused formulas when working with fractions and integers. Furthermore, students made incorrect choices for the numbers that were operated on in the problem; (3) Procedural errors: students improperly concluded the question. This occurred because students failed to pay attention to what was asked in the question and were incorrect in carrying out the processes needed to solve the problem, as they were unable to explain the solutions they had received; (4) Technical/computational errors: students made mistakes in computations involving integer operations, and their final answers to the questions they worked on were incorrect.

Future studies should focus on the development of new learning models capable of improving mathematical creative thinking skills. This is significant because research shows that students with strong creative thinking skills adapt quickly to new problems. On the other hand, students who lack creative thinking skills will struggle to solve problems. Future research should explore how students think while tackling contextual problems in mathematics. Identifying students' cognitive processes will help them gain a better understanding, as they approach problem-solving in specific ways. When teachers understand their students' thought processes, they can quickly identify students' problems solving skills. As a result, the teacher can adjust the learning approach for future lessons.

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