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ANALOGICAL REASONING IN SOLVING ALGEBRA PROBLEMS VIEWED FROM STUDENTS' MATHEMATICAL ABILITIES

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Abstract

The issue in this study is to examine whether there are differences in the revenue from tourist attraction levies at Mount Kelud and the revenue from the regional original income through financial report analysis, which will use data from the tourism sector levies, specifically the Mount Kelud tourist attraction and the regional original income of Kediri Regency, over a period of 5 years before and 3 years after the occurrence of Covid-19. The population of this study is all annual financial reports issued by the DISPARBUD (Department of Tourism and Culture) of Kediri Regency. The financial reports of Mount Kelud tourism levies and the regional original income over 8 periods are divided into 5 periods before Covid-19 and 3 periods after Covid-19, from the years 2015/2018 to 2022/2023. The analytical technique used in this study is a comparative quantitative method through the Paired Sample t-test analysis approach. The results of this study show that the tourism levies before the occurrence of Covid-19 differ significantly from the tourism levies after the occurrence of Covid-19. It is evident that the t-value is 2.251 with a probability value of 0.039, which is less than the 0.05 threshold. The regional original income of Kediri Regency before the occurrence of Covid-19 also differs significantly from the regional original income after the occurrence of Covid-19. It is evident that the t-value is 2.955 with a probability value of 0.042, which is less than the 0.05 threshold.

Kata Kunci:
Analogi, Aljabar, Kemampuan Matematis

Abstrak

Penelitian ini bertujuan untuk mendeskripsikan penalaran analogi dalam menyelesaikan masalah aljabar ditinjau dari kemampuan matematis siswa. Penelitian dilakukan di kelas VIII MTsN Aryojeding Rejotangan Tulungagung. Subjek penelitian yaitu 3 siswa yang terdiri dari 1 siswa berkemampuan matematis tinggi, 1 siswa berkemampuan matematis sedang dan 1 siswa berkemampuan matematis rendah. Jenis penelitian ini adalah deskriptif eksploratif. Hasil penelitian ini mendeskripsikan bahwa penalaran analogi pada subjek kemampuan matematis tinggi yaitu S_1 dalam menyelesaikan penalaran analogi yaitu *encoding, inferring, mapping, applying* dengan baik. Penalaran analogi pada subjek kemampuan sedang yaitu S_2 dalam menyelesaikan masalah mampu melakukan proses *inferring, mapping* dan *applying* dengan baik, akan tetapi pada tahap *encoding* masih belum tepat. Penalaran analogi subjek kemampuan matematis rendah yaitu S_3 dalam menyelesaikan masalah mampu melakukan proses *encoding* dan *mapping*, sedangkan pada proses *inferring* dan *applying* masih merasa kesulitan karena kurangnya pemahaman terhadap materi aljabar

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INTRODUCTION

The ability to reason in mathematics is a crucial aspect that significantly influences logical, analytical, and critical thinking patterns in students. According to the national education goals of Indonesia outlined in Permendiknas No 22 of 2006 concerning content standards, particularly in mathematics education, students are expected to use reasoning in patterns, properties, performing mathematical manipulations to make generalizations, construct proofs, or explain mathematical ideas and statements. Sumarmo (2010) agrees that reasoning is an essential element in mathematical understanding, exploring ideas, estimating solutions, and applying relevant mathematical expressions, as well as understanding that mathematics is meaningful and logical.

Reasoning can be described as a thought process in drawing a conclusion that results in knowledge. Reasoning ability means the ability to draw appropriate conclusions from existing evidence and according to specific rules. According to Syofni (1989), students' reasoning ability is highly necessary in the mathematics learning process in the classroom because it affects students' learning achievements. Baroody (1993) also believes that reasoning can directly improve students' learning outcomes if students are given the opportunity to use their reasoning skills to make estimations based on their own experiences, making it easier for them to understand concepts.

In reality, few teachers prepare lessons well and facilitate students to reason. This is supported by Puji Iriyanti's (2010) research on the portrait of eighth-grade mathematics teaching in Indonesia as follows: (1) only a little time is used by teachers to discuss or address mathematical problems that arise in the learning process, (2) 57% of learning time is used to discuss low-complexity problems, and 3% of the time is used to discuss high-complexity problems, (3) teachers do not ask students to find alternative solutions to the discussed problems, (4) 52% of mathematics learning time uses conventional teaching strategies, (5) teachers tend to dominate classroom learning. These characteristics indicate that teachers only directly transfer their knowledge to students. Teachers rarely provide opportunities for students to reason about a concept or material being studied. Teachers only give routine practice problems without connecting the material studied to problems often encountered by students in daily life. This results in students' reasoning abilities being low.

This is also supported by initial observations in eighth grade at MTsN Aryojeding Rejotangan Tulungagung, showing that students' responses to the following problems were as follows: What is the value of x, and what is the relationship between the problems $6x - 2x = 8$ and $8x = 10 + 3x$? For such problems, out of 30 students in the class, only 15 students answered 2, while 11 students answered 4.8, and 4 students did not answer. In response to the students' answers, the researcher asked what the relationship between the two problems was; some students answered that the values were the same, but some did not know that the two problems had the same value. Additionally, many students were confused in explaining the process they used to obtain the results. This was evidenced by 11 students who got the answer 4.8 and 4 students who could not understand the problem, while only 15 students could correctly explain and obtain the result 2. Therefore, these initial observations indicate that many students still struggle with reasoning analogically about problems and lack understanding of algebraic material.

Therefore, efforts are needed to improve students' analogical reasoning to ensure they can process learning in mathematics effectively. Novick (English, 1999) states that analogical reasoning is a thought process aimed at obtaining a conclusion or new knowledge by comparing analogous objects with existing knowledge. Alwyn & Dindyal (2009) also argue that analogical reasoning requires students to find relationships between source problems and target problems and relate them to relevant mathematical concepts. Therefore, students must have a strong conceptual understanding and the ability to connect old knowledge with new knowledge (May: 2006). Sternberg (English, 2004) states that there are four indicators used to measure analogical reasoning, namely: Encoding, Inferring, Mapping, Applying. Mofidi (2012) believes that if students can perform all stages of

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analogical reasoning, they can study mathematics more deeply, and mathematical concepts can be stored in long-term memory by emphasizing analogical reasoning in mathematics learning.

Thus, mathematics learning will greatly benefit from using analogical reasoning as a teaching tool in the classroom. According to Sasanti's (2005) research on junior high school students, analogical reasoning can improve students' ability to solve mathematical problems. Based on the aforementioned points, the researcher is interested in conducting research on analogical reasoning to help students solve mathematical problems, particularly in algebra, in the form of "Analogical Reasoning in Solving Algebraic Problems Viewed from Students' Mathematical Abilities."

RESEARCH METHOD

This type of research can be categorized as descriptive exploratory research, which describes the results of the exploration of the analogical reasoning process in solving algebraic problems from the perspective of students' mathematical abilities. It is called descriptive exploratory research because the data generated in the study is in the form of verbal descriptions and aims to describe the reasoning interaction process that occurs during the learning process.

The subjects of this research are eighth-grade students at MTsN Aryojeding Rejotangan Tulungagung. The study focuses on 3 students with different abilities: 1 student with high mathematical ability, 1 student with moderate mathematical ability, and 1 student with low mathematical ability. The selection was made by considering the students' mathematical ability test scores, which were compiled and validated by the researcher. Additionally, the researcher also sought input from the mathematics teacher to ensure that the selected students could communicate their ideas well, thus facilitating the data collection process.

RESULT AND DISCUSSION

Description of Analogical Reasoning of High Ability Students on S1

After S1 completed the analogical reasoning test questions, their thought processes for each question were examined. It was evident from the thought processes that S1 was able to perform all stages of analogical reasoning, including encoding, inferring, mapping, and applying. The researcher then interviewed S1 to describe the analogical reasoning they had performed. The thought process developed by the researcher from S1's work on the questions indicated that S1 could use all stages of analogical reasoning effectively. The stimulus provided by the researcher in giving hints during the problem-solving process significantly helped S1 understand the source problem and the target problem. To describe how S1's analogical reasoning was carried out, the researcher first ensured that S1 had understood the given problem. An excerpt from the interview regarding S1's understanding of the question is shown in Dialogue 1.

Dialogue 1:

R: Have you understood the given problem?

S1: Yes... (while thinking and recalling their work)... I have, sir.

Dialogue 1 shows that S1 understood the problem being addressed in the question. S1 recognized that the given question aimed to find the applicable rule from the source problem and then apply that rule to the target problem. In solving the given problem, S1 first performed the encoding process on the source problem. This can be seen from the interview excerpt shown in Dialogue 2.

Dialogue 2:

R: From the problem you have read, what is known?

S1: The length and perimeter of the rectangle, sir...

R: What are the length and perimeter of the rectangle?

S1: The length is twenty-five centimeters more than the width, and the perimeter is eighty-two centimeters.

In solving the given problem, S1 was a diligent and meticulous student. First, S1 performed the encoding process by writing down the known elements of the source problem. Based on the results of their work and the interview, S1 mentioned that the known elements were the perimeter of the rectangle (82 cm) and the length (25 cm more than the width, symbolized as 25 + w), while the width was still unknown. S1 then performed the encoding process on the target problem. This was done to facilitate S1 in solving the target problem. Based on the results of their work and the interview, S1 mentioned that the known elements in the target problem were the perimeter of the right-angled triangle (40 cm), the length of the hypotenuse (17 cm), and the height (7 cm more than the base, symbolized as b + 7), while the base was still unknown. S1 then observed the relationship between the known elements in the source problem and the target problem. From the source problem, S1 began to suspect that 264 was the area of the rectangle. Since the given information included the perimeter (82 cm) but not the length and width, S1 inferred this relationship. The interview excerpt is shown in Dialogue 3.

Dialogue 3:

R: Then what does two hundred sixty-four represent?

S1: It represents the area of the rectangle, sir...

R: How did you know that two hundred sixty-four is the area of the rectangle?

S1: Because the problem gives the perimeter and length, sir...

From the interview explanation in Dialogue 3, S1 strongly suspected that the relationship in the source problem was between the rectangle and its area. To find the rectangle's area, S1 first determined the formula for the perimeter: k=2p+2wk = 2p + 2wk=2p+2w. By substituting the given perimeter (82 cm) and the length (w + 25), they found the width to be 8 cm. Since the length is 25 cm more than the width, adding 25 cm to 8 cm results in a length of 33 cm. With both the length and width known, S1 used the formula L=p×wL = p \times wL=p×w to find the area, resulting in 264 cm². Thus, S1 correctly inferred that 264 cm² was the area of the rectangle.

Next, S1 mapped the applicable rule from the source problem to the target problem (mapping). S1 concluded that in the source problem, the relationship was between the rectangle and its area, while in the target problem, the relationship was between the right-angled triangle and its area. The interview excerpt shown in Dialogue 4 illustrates how S1 mapped the rule.

Dialogue 4:

R: How did you find the area of the rectangle?

S1: The area of the rectangle is length times width, sir. Since the length is thirty-three and the width is eight, the area is thirty-three times eight, resulting in two hundred sixty-four square centimeters.

R: If you already know that two hundred sixty-four is the area of the rectangle (source problem), how do you solve the asked problem (target problem)?

S1: By finding the area, too, sir... that is, finding the area of the right-angled triangle.

After gathering sufficient information from the problem, S1 proceeded with the applying process by finding the area of the right-angled triangle. Since the given information in the target problem included the perimeter and the length of the hypotenuse, S1 first determined the lengths of the base and height using the perimeter formula for a right-angled triangle: k=a+b+ck = a + b + ck=a+b+c. Given the perimeter (40 cm), where aaa is the base, bbb is the height (a + 7), and ccc is the hypotenuse (17 cm), they substituted these values into the perimeter formula, resulting in a base length of 8 cm and a height of 15 cm. With the base and height known, S1 used the formula L=12×a×tL = \frac{1}{2} \times a \times tL=21×a×t to find the area, resulting in 60 cm². S1 successfully solved the target problem, adhering to the predetermined indicators of analogical reasoning: encoding, inferring, mapping, and applying. By identifying the relationship in the source problem, S1 also applied it to the target problem, arriving at the correct answer. English (2004) argues that the steps in solving the source problem are subsequently applied to the target problem. Additionally, the stimuli provided by the researcher significantly influenced S1's process in solving the problem. Thus, it can be concluded that S1 was able to perform analogical reasoning in algebraic material perfectly according to their mathematical ability.

Description of Analogical Reasoning of Moderate Ability Students on S2

In this section, we will describe the analogical reasoning of students with moderate abilities. After completing the analogical reasoning test, S2 could not yet be categorized as a student capable of performing analogical reasoning well in solving problems. From S2's thought process, it was evident that they had difficulty completing the problem according to the stages of analogical reasoning, which include encoding, inferring, mapping, and applying, particularly in the encoding and applying stages. The researcher then interviewed S2 to describe the problem-solving process they had undertaken. After understanding S2's thought process, the researcher conducted a detailed interview to gather more information about their thought process in solving the source and target problems. Before delving deeper into S2's analogical reasoning process, the researcher asked if S2 understood the given problem to ensure they could perform analogical reasoning. An excerpt from the interview is shown in Dialogue 5.

Dialogue 5:

R: Do you understand and comprehend the problem in this question?

S2: Not really, sir... (while smiling)

The dialogue indicates that S2 did not fully understand the meaning of the question. When answering the researcher's question, S2 responded hesitantly about their work. The interview continued to understand how S2 performed analogical reasoning based on the stages of encoding, inferring, mapping, and applying. The encoding process performed by S2 in this study is demonstrated by their ability to identify the known elements in the source problem and the target problem. The researcher then interviewed S2 to understand their encoding process for the source problem. An excerpt from the interview, showing that S2 had not yet identified all elements in the source problem, is presented in Dialogue 6.

Dialogue 6:

R: What do you know from the problem you have worked on?

S2: What, sir...?

R: Try to observe based on your work. What do you know from the question?

S2: The length and perimeter of the rectangle, with the length being twenty-five centimeters more than the width, and the perimeter being eighty-two centimeters.

S2 then performed the encoding process for the target problem. This was done to help S2 solve the target problem. Based on their work and the interview, S2 mentioned that the known elements in the target problem were the perimeter of the right-angled triangle (40 cm), the length of the hypotenuse (17 cm), and the height (7 cm more than the base). However, S2 symbolized the height as 7a, which did not match the given information, while the base was still unknown. Thus, S2's encoding for the target problem was inaccurate. S2 analyzed the relationship between the elements in the source problem. This stage required the ability to connect existing knowledge to draw conclusions. S2 processed the information obtained from the given problem to find a solution for the source problem. S2 concluded that the relationship in the source problem was between the rectangle and its area. An excerpt from the interview is shown in Dialogue 7.

Dialogue 7:

R: Then what does two hundred sixty-four represent?

S2: The area of the rectangle.

R: How do you know that two hundred sixty-four is the area of the rectangle?

S2: Because the length and perimeter are given, and the width is still being found.

Next, S2 mapped the applicable rule from the source problem to the target problem (mapping). S2 concluded that the source problem involved the relationship between the rectangle and its area, while the target problem involved the relationship between the right-angled triangle and its area. An excerpt from the interview illustrating S2's mapping process is shown in Dialogue 8.

Dialogue 8:

R: Then what is the asked problem about?

S2: The area of the right-angled triangle.

R: How do you know that the asked problem is the area of the right-angled triangle?

S2: Because the perimeter, the length of the hypotenuse, and the height are given.

Once sufficient information was obtained from the question, S2 then performed the applying process by finding the area of the right-angled triangle. Since the known elements in the target problem were the perimeter and the length of the hypotenuse, S2 first determined the base and height of the right-angled triangle using the perimeter formula for a right-angled triangle: k=a+b+ck = a + b + ck=a+b+c. By substituting the known elements into the formula, they found the base length to be 8 cm and the height to be 15 cm. Using the area formula for a right-angled triangle: L=12×a×tL = \frac{1}{2} \times a \times tL=21×a×t, S2 found the area to be 60 cm². At this stage, S2 performed the inferring, mapping, and applying processes well, but their encoding process was inaccurate. English (2014) stated that at the most basic level, mathematical reasoning requires students to understand how symbols represent abstract concepts. Thus, it is concluded that S2 has not yet fully mastered the analogical reasoning process in solving algebra problems according to their mathematical ability.

Description of Analogical Reasoning of Low Ability Students on S3

In this section, we will describe the analogical reasoning of students with low abilities. After completing the analogical reasoning test, S3 could not yet be categorized as a student capable of performing analogical reasoning in algebra. From S3's thought process, it was evident that they could not solve the problem well according to the predetermined indicators of analogical reasoning.

After understanding S3's thought process, the researcher then interviewed S3 to gather detailed information about their thought process in solving problems. Before delving deeper into S3's analogical reasoning process, the researcher asked if S3 understood the meaning of the given problem to ensure they could perform analogical reasoning. An excerpt from the interview is shown in Dialogue 9.

Dialogue 9:

R: Do you understand this question?

S3: No, sir.

The dialogue indicates that S3 did not understand the question. The interview continued to understand how S3 performed analogical reasoning based on the stages of encoding, inferring, mapping, and applying. The encoding process performed by S3 in this study is demonstrated by their ability to identify the known elements in the source problem and the target problem. The researcher then interviewed S3 to understand their encoding process for the source problem. An excerpt from the interview, showing that S3 could identify all elements in the source problem, is presented in Dialogue 10.

Dialogue 10:

R: What do you know from the question?

S3: The length is twenty-five centimeters more than the width, and the perimeter is eighty-two centimeters.

S3 then performed the encoding process for the target problem. This was done to help S3 solve the target problem. Based on S3's work, they mentioned that the known elements in the target problem were the perimeter of the right-angled triangle (40 cm), the length of the hypotenuse (17 cm), and the height (7 cm more than the base) symbolized as a+7a + 7a+7, while the base was still unknown. At this stage, S3 analyzed the relationship between the elements in the source problem. This stage required the ability to connect existing knowledge to draw conclusions. S3 processed the information obtained from the given problem to find a solution for the source problem. In this process, S3 made an error in multiplying the length and width when finding the area of the rectangle. S3 concluded that the relationship in the source problem was between the rectangle and its area. An excerpt from the interview is shown in Dialogue 11.

Dialogue 11:

R: Then what does two hundred sixty-four represent?

S3: Its area,... because the perimeter is already known.

Next, S3 mapped the applicable rule from the source problem to the target problem (mapping). S3 concluded that the source problem involved the relationship between the rectangle and its area, while the target problem involved the relationship between the right-angled triangle and its area. An excerpt from the interview illustrating S3's mapping process is shown in Dialogue 12.

Dialogue 12:

R: Then to solve the asked problem, what does it represent?

S3: Its area,... the area of the right-angled triangle.

R: How do you know that the asked problem is the area of the right-angled triangle?

S3: Like this, sir (Referring to the previous problem).

Once sufficient information was obtained from the question, S3 then performed the applying process by finding the area of the right-angled triangle. Since the known elements in the target problem were the perimeter and the length of the hypotenuse, S3 first determined the base and height of the right-angled triangle using the perimeter formula for a right-angled triangle: k=a+b+ck = a + b + ck=a+b+c, resulting in a base length of 8 cm. However, S3 could not continue their work due to a lack of understanding of algebra. At this stage, S3 performed the encoding and mapping processes well, but they struggled with the inferring and applying processes due to their limited understanding of algebra. Skemp (1987) explained that if the understanding of a concept is imperfect, other related concepts will be in a hazardous state. Thus, it is concluded that S3 has not yet mastered the analogical reasoning process in solving algebra problems.

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CONCLUSSION

Analogical reasoning in students with high mathematical ability (S1) appears very strong based on their work and interviews. S1 was able to solve problems through all stages of analogical reasoning, which includes encoding, inferring, mapping, and applying, accurately. This success is due to S1's understanding of the given problem and recognition that the target problem can be solved similarly to the source problem. Thus, it is concluded that S1 is capable of performing analogical reasoning in solving algebra problems. Analogical reasoning in students with moderate ability (S2) is less effective, primarily because S2's encoding stage is not applied correctly. However, S2 performed well in the inferring, mapping, and applying stages. The difficulty at the encoding stage stems from S2's lack of proficiency in encoding the known elements of the source problem. Therefore, it is concluded that S2 has not yet fully mastered the process of analogical reasoning in solving algebra problems. Analogical reasoning in students with low mathematical ability (S3) cannot yet be considered adequate. S3 experienced difficulties in the inferring and applying stages while managing the encoding and mapping stages. At the applying stage, S3 could not solve the problem accurately due to a lack of understanding of algebraic concepts. Therefore, it is concluded that S3 is not yet capable of performing analogical reasoning in algebra. In summary, analogical reasoning in solving algebra problems varies significantly with students' mathematical abilities, highlighting areas of strength and needed improvement in each ability group.

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