JURNAL ABSIS
Jurnal Pendidikan Matematika dan Matematika
Vol. 8 No. 2, August 2025

STUDENTS' ERRORS IN SOLVING PLANE GEOMETRY PROBLEMS: A NEWMAN'S ERROR ANALYSIS APPROACH

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ABSTRACT This study aims to analyze students' errors in solving plane geometry problems using Newman's Error Analysis (NEA), with a focus on identifying specific error patterns that hinder learning. Geometry is a fundamental component of mathematics, yet many students struggle to master concepts involving plane figures and the distance from a point to a line. This research employed a descriptive qualitative design with nine second-semester mathematics education students at Universitas Negeri Medan in the 2024/2025 academic year as subjects. Based on test results, three students with the lowest scores were selected for in-depth analysis. The research instruments consisted of essay- and context-based geometry problems, validated by expert lecturers and piloted for clarity. Data were collected from students' written responses and analyzed using the Miles and Huberman model, which includes data reduction, data display, and conclusion drawing. The findings revealed five categories of errors: reading, comprehension, transformation, process skills, and encoding. Among these, comprehension errors and process skills errors were the most dominant, reflecting students' difficulties in interpreting information and applying accurate solution procedures. This study contributes to the literature by providing detailed insights into students' error patterns in plane geometry and highlighting the value of NEA as a diagnostic tool to inform targeted instructional strategies and improve mathematics learning outcomes.

Keywords: students' errors, plane geometry, Newman's Error Analysis, problem-solving

ABSTRAK Penelitian ini bertujuan untuk menganalisis kesalahan mahasiswa dalam menyelesaikan soal geometri bidang menggunakan Newman's Error Analysis (NEA), dengan fokus pada identifikasi pola kesalahan spesifik yang menghambat pembelajaran. Geometri merupakan komponen fundamental dalam matematika, namun banyak mahasiswa mengalami kesulitan dalam menguasai konsep yang melibatkan bangun datar dan jarak titik ke garis. Penelitian ini menggunakan desain kualitatif deskriptif dengan subjek sembilan mahasiswa pendidikan matematika semester dua di Universitas Negeri Medan pada tahun akademik 2024/2025. Berdasarkan hasil tes, tiga mahasiswa dengan nilai terendah dipilih untuk dianalisis secara mendalam. Instrumen penelitian terdiri atas soal geometri berbasis esai dan konteks, yang divalidasi oleh dosen ahli dan diujicobakan untuk memastikan kejelasan. Data dikumpulkan dari jawaban tertulis mahasiswa dan dianalisis menggunakan model Miles dan Huberman yang mencakup reduksi data, penyajian data, dan penarikan kesimpulan. Hasil penelitian mengungkapkan lima kategori kesalahan, yaitu membaca, pemahaman, transformasi, keterampilan proses, dan pengkodean. Di antara kelima kategori tersebut, kesalahan pemahaman dan keterampilan proses merupakan yang paling dominan, mencerminkan kesulitan mahasiswa dalam menginterpretasikan informasi dan menerapkan prosedur penyelesaian yang akurat. Studi ini memberikan kontribusi terhadap literatur dengan menghadirkan wawasan terperinci mengenai pola kesalahan mahasiswa dalam geometri bidang serta menegaskan pentingnya NEA sebagai alat diagnostik untuk merancang strategi pembelajaran yang lebih terarah dan meningkatkan hasil belajar matematika.

Kata-kata kunci: kesalahan mahasiswa, geometri bidang, Newman's Error Analysis, pemecahan masalah

INTRODUCTION

Mathematics is a branch of science that studies reasoning about mathematical concepts. One of its important branches is geometry, which concerns points, lines, planes, spaces, and their properties, sizes, and interrelationships (Maulana & Pujiastuti, 2020). Mathematics needs to be studied, understood, and mastered by everyone, as it forms the basis of all branches of science and technology. In everyday life, mathematics plays a crucial role in solving problems. Therefore, mathematics must be learned more deeply at every level of education, from the most basic to the highest (Arwadi, Asmaun, & Ruslan, 2024).

Moreover, mathematics is closely related to other fields of science that have contextual connections to daily life, which further underscores its importance. As a science, mathematics deals with abstract objects, is based on axiomatic reasoning, and emphasizes logical truth (Bete, Simarmata, & Naimnule, 2022). The study of mathematics aims to foster systematic logic, as well as critical and creative thinking skills. Broadly, mathematics covers four domains, namely algebra, arithmetic, geometry, and analysis (Arwadi et al., 2024).

At the college level, geometry is one of the compulsory subjects, especially for mathematics majors, and is divided into basic geometry, analytical geometry, and transformation geometry. Basic Geometry is a compulsory course for mathematics education students at the State University of Medan. However, limited mastery of the material often leads to unsatisfactory outcomes in analytical geometry courses. Many students face difficulties in solving geometry problems and frequently make errors. These recurring mistakes highlight the need for analysis to identify their underlying causes.

Error analysis is essential because it allows educators to diagnose types and sources of mistakes. Wahyuni, Rufiana, and Faizah (2024) emphasized that analyzing students' errors helps identify error types and causes, which may include lack of conceptual understanding, difficulties in applying formulas, limited mastery of algebraic operations, and carelessness (Rahmawati, Fatimah, & Sunaryo, 2021).

According to Newman's classification, errors in solving mathematical problems can be grouped into five categories: (1) reading errors, where students misinterpret essential information; (2) comprehension errors, resulting from a lack of conceptual understanding; (3) transformation errors, when students fail to convert problems into appropriate mathematical models; (4) process skill errors, which stem from weaknesses in arithmetic or procedural fluency; and (5) encoding errors, where students draw incorrect conclusions despite obtaining correct intermediate results.

Several previous studies have analyzed students' errors in analytical geometry using Newman's framework. For instance, Bete et al. (2022) and Hajizah & Salsabila (2024) reported that students experienced reading errors marked by difficulty identifying key information, comprehension errors due to incomplete understanding, transformation errors in constructing mathematical models, process skill errors in calculations, and encoding errors when drawing conclusions. Such mistakes indicate the extent of students' mastery of mathematical content. Identifying these errors is crucial as they serve as feedback for improving instructional quality. NEA, with its simple diagnostic procedures, is an effective tool for this purpose (Rahmayanti & Maryati, 2021; Sundayana & Parani, 2023).

In the context of geometry learning, mastery of quadrilateral plane figures is particularly important because it serves as prerequisite knowledge for topics such as solid geometry and similarity. Students who fail to master quadrilaterals often encounter difficulties when studying subsequent materials. For example, errors in solving similarity problems may stem from weak understanding of quadrilateral concepts. Although plane figures are introduced as early as elementary school, errors in solving quadrilateral problems are still common among university students (Ardianzah & Wijayanti, 2020).

Newman's Error Analysis (NEA) provides an effective diagnostic framework to classify errors into five stages: reading, comprehension, transformation, process skills, and encoding. In geometry learning at the college level, the most frequent errors tend to occur at the transformation and process skills stages (Siskawati, 2021). Research by Kania et al. (2022) found that students struggle with geometry problems requiring higher-order thinking skills (HOTS), especially at the transformation and process levels. Similarly, Zamzam (2018) revealed that encoding errors are also prevalent, where students fail to present final answers correctly despite accurate preceding steps.

However, previous studies have not provided a detailed analysis of errors in plane geometry using Newman's Error Analysis, particularly focusing on plane figures and point-to-line distance problems. This research addresses that gap by categorizing errors systematically based on Newman's framework while linking them to students' written responses. Thus, the study not only identifies error types but also provides practical insights for lecturers to design more targeted interventions in geometry instruction. To address these challenges, structured learning approaches emphasizing conceptual understanding are needed. The use of NEA as a diagnostic tool can assist lecturers in identifying common errors and designing remedial strategies, such as exercises focused on transformation and process skills or encouraging students to verbalize their solution steps. Based on this rationale, this study aims to analyze the errors made by mathematics education students at the State University of Medan in solving plane geometry problems using Newman's Error Analysis.

METHODS

This study employed a descriptive qualitative design with the objective of analyzing students' errors in solving geometry problems through Newman's Error Analysis (NEA). The research was conducted with nine second-semester students of the Mathematics Education Program at Medan State University in the 2024/2025 academic year. Participants were selected purposively based on the results of a geometry test, from which three students with the lowest scores were chosen for in-depth error analysis. The primary instrument was the researcher, supported by written tests in the form of open-ended, context-based essay questions. These items were specifically designed to capture errors across the five NEA categories: reading, comprehension, transformation, process skills, and encoding. The study was carried out over a period of one month, focusing particularly on students' difficulties with plane figures and point-to-line distance topics.

To ensure validity, the test instruments underwent expert review by two mathematics education lecturers, followed by revisions to improve clarity and alignment with theoretical indicators. A small-scale trial with students outside the research sample was also conducted to confirm item appropriateness. Data collection was based on students' written responses, which were analyzed using Miles and Huberman's framework consisting of data reduction, data display, and conclusion drawing/verification. Ethical considerations were carefully observed by informing participants about the research objectives, ensuring voluntary participation, maintaining anonymity, and obtaining informed consent. The overall aim was to generate insights into recurring error patterns in geometry and provide practical implications for improving mathematics teaching and learning.

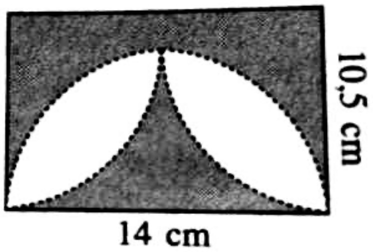
FINDING AND DISCUSSION

The results of this study are presented based on the analysis of students' responses to the geometry test items administered during the research. The purpose of this stage was to identify the types of errors made by students and to classify them according to Newman's Error Analysis framework. A total of nine second-semester students from the Mathematics Education Undergraduate Program who had completed the Geometry of Plane and Space course were involved as participants. These students were given a test consisting of five questions on plane geometry,

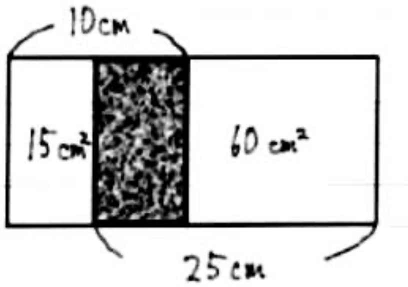
 https://doi.org/10.30606/absis.v8i2.3304

and subsequently, three students with the lowest scores were selected for in-depth error analysis. The five questions administered to the students are presented below.

1. A quadrilateral has diagonal AC measuring 10 cm and diagonal BD measuring 16 cm. If the angle between the two diagonals is 60 degrees, determine the area of the quadrilateral.
2. Find the length of the altitude from point A(3,4) to side BC, given that B(7,2) and C(5,6).'
3. An octagon with 8 equal sides is given. Calculate the area of the polygon if the length of each side is 6 cm.
4. Calculate the area of the shaded region in the following figure.



5. Calculate the area of the shaded region in the following figure.



The scores obtained from nine students who completed five questions related to plane geometry are shown in Table 1. These results provide an overview of the students' overall performance and serve as the basis for selecting subjects for further error analysis.

Table 1. Total scores obtained by students

Subject Name	Question score 1	Question Score 2	Question Score 3	Question Score 4	Question Score 5	Total Score
A1	15	15	15	20	20	85
A2	20	15	15	20	15	85
A3	30	30	15	1	5	81
A4	15	15	20	5	15	70
A5	15	15	15	5	15	65
A6	15	15	15	5	5	55
A7	15	15	15	5	1	51

Subject Name	Question score 1	Question Score 2	Question Score 3	Question Score 4	Question Score 5	Total Score
A8	15	5	5	20	5	50
A9	20	15	15	15	5	70

This descriptive qualitative study analyzed students' errors in solving geometry problems using Newman's Error Analysis. The subjects were nine second-semester mathematics education students at Medan State University in the 2024/2025 academic year. Based on the test results, three students with the lowest total scores were selected: A7 with 55, A8 with 51, and A9 with 50. These students were chosen for in-depth error analysis on plane figures and point-to-line distance problems.

According to the score data in Table 1, A7 obtained the lowest scores on Questions 4 and 5, and these items are discussed in detail in the results section. For A8, the lowest scores were recorded on Questions 2, 3, and 5; however, in addition to Question 5, Question 4 was also analyzed because it contained systematic errors representative of transformation and process skill difficulties, even though the score was not the lowest. This selection was made to provide a more comprehensive description of the types of errors across different problem types. A9's analysis followed the same rationale. Data were collected from written responses and analyzed using Miles and Huberman's model. The following presents the description of subject A7's work on Question 4.

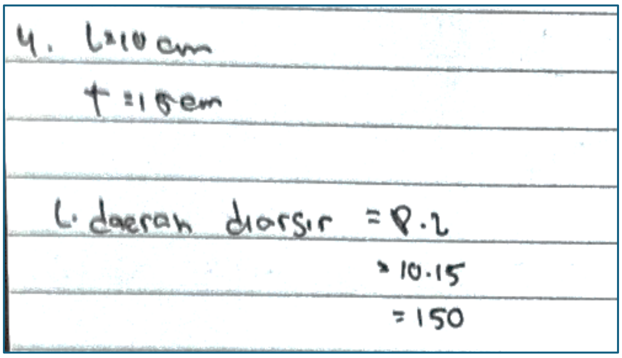


Figure 1. Student A7's answer to Question 4

Based on the analysis of A7's answers, it was found that the student made an error in Question 4, specifically a comprehension error. The student misunderstood the problem, which required first finding the area of the largest rectangle and then subtracting the areas of Rectangle I and Rectangle II to determine the shaded area. Instead, the student directly multiplied the length and width of the largest rectangle. In addition, the student was unable to apply the calculation steps correctly and did not know the appropriate formula to solve the problem (process skill error), which resulted in an incorrect final answer (encoding error).

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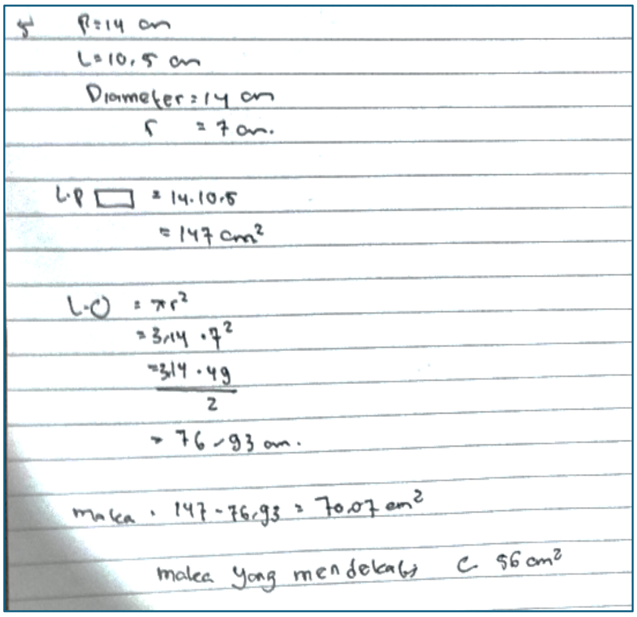

Figure 2. Student A7's answer to Question 5

In Question 5, A7 again made a comprehension error in understanding the question, which required finding the total shaded area. The student misinterpreted the task, which should have involved calculating the shaded area inside the semicircle first. The student also made a process skill error, as shown by the incorrect procedure of subtracting the area of the rectangle from twice the area of the semicircle to find the shaded region. Since the procedure was inaccurate, the final result was also wrong (encoding error). From interviews, it was confirmed that A7 had difficulty understanding the questions, which caused uncertainty in determining the correct solution steps and ultimately led to errors in the final answers.

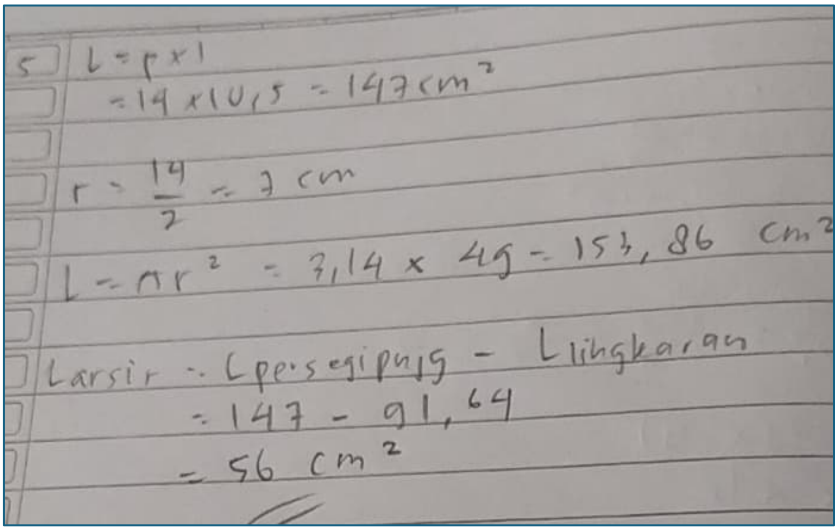

Figure 3. Student A8's answer to Question 4

The analysis of A8's work on Question 4 revealed that the student was unable to understand the problem well (comprehension error). The student should have constructed an equation or mathematical model from the known elements and then determined the height of the largest rectangle, which would later allow the shaded area to be calculated by subtracting the smaller rectangles from the larger one. Instead, the student directly multiplied the height and width of the shaded area without explaining the steps to determine the height of the rectangle. This indicates both a process skill error and a transformation error.

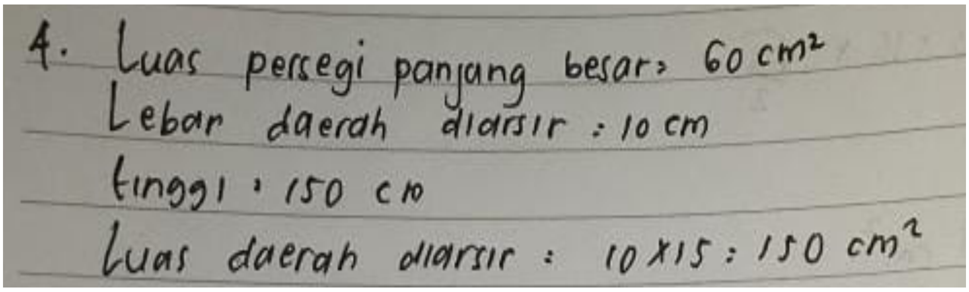

Figure 4. Student A8's answer to Question 5

In Question 5, A8 also made errors. A transformation error was identified as the student was not careful in calculations, particularly in representing the shaded region in the circle. The student also displayed a process skill error by misunderstanding the required steps to obtain the shaded area. Based on interviews, it was revealed that A8 had difficulty understanding the questions, which led to the inability to apply the correct formulas or follow the appropriate steps.

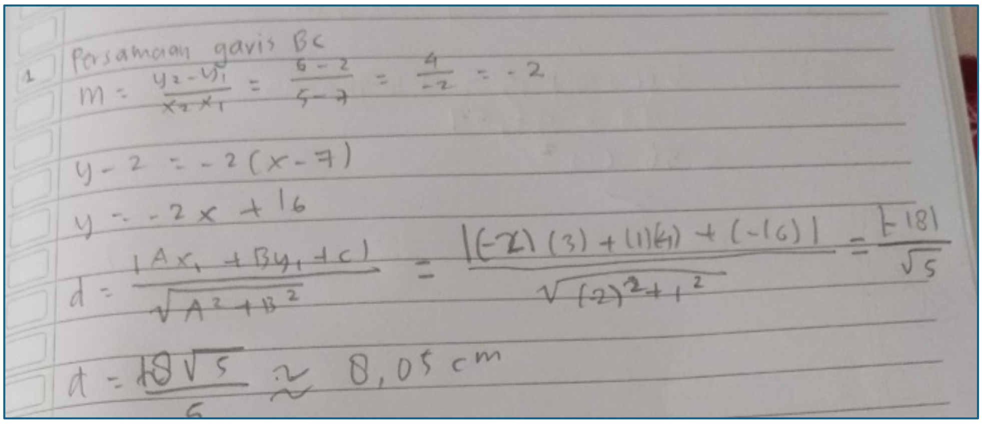

Figure 5. Student A9's answer to Question 1

The analysis of A9's response to Question 1 showed several mistakes. A comprehension error was evident because the student only used the general form of a straight-line equation, while the problem actually asked for the distance from a point to a line, which required rewriting the equation of the line first. A transformation error was also present as the student incorrectly wrote the formula for distance from a point to a line, producing only the general equation of a straight line. These errors reflect a lack of understanding of the material and insufficient problem-solving skills. Furthermore, a process skill error was observed in the incorrect application of the procedure, which led to an inaccurate final answer (encoding error).

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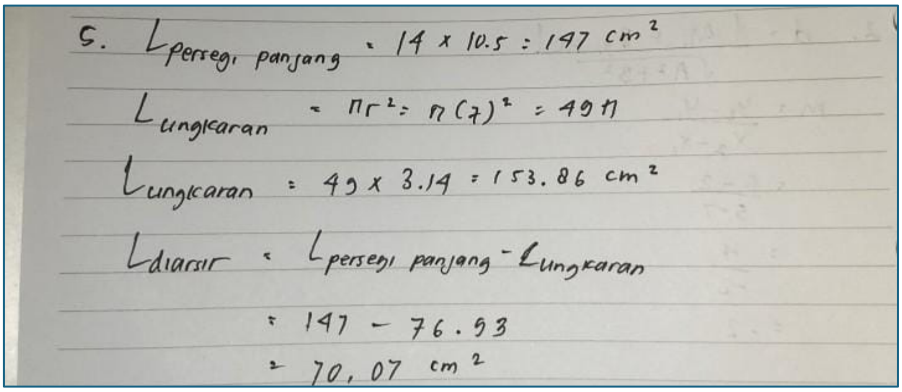

Figure 6. Student A9's answer to Question 5

The analysis of A9's response to Question 5 revealed both reading and comprehension errors. The student simply subtracted the area of the circle from that of the rectangle to determine the shaded region, neglecting the shaded portion inside the semicircle. This mistake was compounded by a process skill error due to the use of an incomplete procedure, and by an encoding error, as the student wrote the formula for the area of a circle incorrectly. These errors indicate a lack of accuracy in calculation and insufficient practice in systematically writing the final conclusion when solving geometry problems.

Based on the research results above, there are errors made by students, including reading errors, comprehension errors, transformation errors, process errors (process skills) and errors in writing the final answer (encoding errors). This is in line with the research of Bete, Simamata, & Naimnule (2022) that the errors that occur when solving math problems are:

Reading error

The types of student errors at this stage are not knowing what is known in the question or not writing down the known elements to make it easier to answer the question or not being able to identify or analyze the question properly. For example, student A9 in question number 5 did not notice that there was an area to be calculated inside the semicircle, so he only subtracted the area of the rectangle from the area of the circle without considering the additional area. This shows that students do not understand all the information presented in the question. Research by Hamid et al. (2020) shows that grade VIII students made 9 reading errors, which indicates a lack of accuracy in understanding the question before starting to solve it.

Misunderstanding of the problem (comprehension)

The types of student errors at this stage are not being able to understand the information contained in the questions or having difficulty determining the problem asked in the questions. The questions asked are about 4 flat shapes and there is 1 question about the distance from a point to a line in a triangle. In the flat shape question of determining the area of the shaded region in a combination of flat

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shapes, most students still have difficulty understanding the question, which causes errors in the solution procedure, calculations, and final answer results. s stage are not being able to understand the information contained in the questions or having difficulty determining the problem asked in the questions. The questions asked are about 4 flat shapes and there is 1 question about the distance from a point to a line in a triangle. In the flat shape question of determining the area of the shaded region in a combination of flat shapes, most students still have difficulty understanding the question, which causes errors in the solution procedure, calculations, and final answer results. For example, student A7 in question number 4 immediately calculated the area of the largest rectangle without subtracting the areas of rectangles I and II, even though he should have found the area of the shaded region in that way. This shows that students do not understand the steps needed to solve the problem correctly. In a study by Yuliyanti and Syam Tonra (2021), junior high school students experienced errors in understanding mathematical concepts in the Pythagorean Theorem material, such as errors in using root symbols and drawing correct right triangles.

Transformation error

The type of student error at this stage is not being able to change the information given in the problem into a mathematical model or a correct mathematical sentence. In this transformation error, students also still have difficulty and make mistakes in transforming known elements with formulas to solve this geometry problem, such as student errors in applying the point-to-line distance formula and students are wrong in using arithmetic operations and wrong in placing the results of the calculation operations that have been obtained in solving the problem. Student A8 in question number 4, for example, did not create a proper mathematical model from the known elements and directly multiplied the height and width of the shaded area without first determining the height of the largest rectangle. Research by Zahra 'Ashri and Noor Aini (2020) shows that grade IX students experience transformation errors in geometric transformation problems, such as errors in writing formulas or incorrect solution steps.

Process error

The type of student error at this stage is an error in applying the procedure or steps of the solution. Students who make this error are also unable to apply the calculation steps correctly, such as errors in applying formulas and steps to solve the area of the shaded region in the combination of rectangular and circular plane shapes and errors in calculations, this occurs due to a lack of accuracy in solving the problem. Student A7 in question number 5, for example, only subtracts the area of the rectangle by twice the area of the circle without considering the shaded area inside the semicircle. This shows that students do not apply the calculation steps correctly. In a study by Febriyanti et al. (2022), high school students made mistakes in planning and

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implementing geometry problem solving, which was caused by a lack of understanding of the material and the ability to associate various concepts.

Error in writing the answer (encoding)

The types of student errors at this stage are due to errors and inaccuracies in calculations, resulting in errors in determining the final answer and errors in making conclusions occur because students write conclusions that do not match the answers obtained or the correct answers. Student A9 in question number 5, for example, wrote the area of a circle as πr^2 but wrote it as πr, indicating inaccuracy in writing the final answer. Research by Hamidah et al. (2020) showed that grade VIII students made errors in writing the final answer 43 times, indicating a lack of accuracy in writing the final result after performing calculations.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the error analysis of students in solving geometry problems on plane figures and line equations using Newman's framework, five categories of errors were identified. Reading errors occurred when students had difficulty identifying what was known and what was being asked, particularly in problems involving the area of shaded regions. Comprehension errors arose when students were unable to understand the information provided in the problem. Transformation errors were found when students failed to translate the given information into a correct mathematical model or equation and were unable to select and apply the appropriate formula. Process skill errors appeared when students could not carry out calculation steps accurately or lacked carefulness in following the solution procedures. Finally, encoding errors were identified when students wrote incorrect final answers, either due to inaccuracy in calculation or because they were not accustomed to systematically concluding their solutions.

This study suggests that students need more practice in solving geometry problems and regular opportunities to evaluate their problem-solving abilities. Such practice should not only focus on plane geometry but also extend to other areas of geometry to strengthen their conceptual understanding and procedural fluency.

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