

## Analysis of Students' Error Patterns in Trigonometry Diagnostic Tests Using the GetMath Platform in Senior High Schools in Banda Aceh

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### ABSTRACT

Understanding trigonometric concepts remains a significant challenge for senior high school students, as reflected in the high frequency of conceptual and procedural errors when solving trigonometry problems. These difficulties are often insufficiently detected through conventional assessments, underscoring the need for diagnostic instruments that can more precisely identify students' error patterns. This study aimed to examine the characteristics of trigonometry diagnostic test items and analyze students' answer error patterns in senior high schools in Banda Aceh using the GetMath platform. A descriptive quantitative approach was employed, involving 200 students from three public senior high schools—SMAN 3, SMAN 5, and SMAN 10 Fajar Harapan—selected through purposive sampling. The instrument consisted of 13 multiple-choice items with option levels (D0–D4), developed based on the Cognitive Diagnostic Assessment framework. Data were collected digitally and analyzed descriptively to determine the distribution of errors across option levels. Results showed varying error patterns among schools, with the highest correct response rate at SMAN 5 (49%), followed by SMAN 10 (41%) and SMAN 3 (27%). Dominant errors were categorized as most severe and minor errors, indicating limited conceptual and procedural understanding. These findings highlight the importance of follow-up remedial and enrichment programs to improve students' mastery of trigonometry.

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## **INTRODUCTION**

Understanding trigonometric concepts remains a major challenge for secondary school students across various countries. Numerous studies have reported that students experience misconceptions and procedural errors in understanding trigonometric ratios, identities, and their applications in real-life contexts (Hamzah, Maat, & Ikhsan, 2021). In line with these findings, Dhungana (2023) emphasized that students frequently encounter difficulties in comprehending the abstract nature of trigonometric concepts, where errors arise not only in conceptual and procedural aspects but also in the relationships between them. Therefore, assessment approaches capable of deeply identifying students' difficulties in each concept are required, one of which is through diagnostic mathematics tests.

Diagnostic tests aim to identify students' levels of understanding of various mathematical concepts, thereby enabling more individualized feedback to help students recognize their strengths and weaknesses (Alfageh et al., 2024). Diagnostic tests are developed based on analyses of sources of errors or learning difficulties, utilizing supply-response items (such as essay or short-answer questions) or selected-response items (multiple-choice questions accompanied by reasoning), and are complemented by follow-up plans to address identified difficulties (Rahma & Khabibah, 2022). In this study, the diagnostic test is designed to obtain information regarding students' answer error patterns according to option levels developed based on the Cognitive Diagnostic Assessment (CDA) framework.

This study aims to analyze students' answer error patterns according to option levels in solving e-learning-based diagnostic mathematics tests through the GetMath platform, developed by the Research and Development Center for Indonesian Realistic Mathematics Education (PRP-PMRI), Universitas Syiah Kuala (USK). Numerous studies have examined students' errors in solving mathematical problems. Research by Deringöl (2019) and Hajerina, Suciati, and Mailili (2022) indicates that the most common errors made by students are conceptual errors, principle errors, and procedural errors.

Other studies have reported that students' errors in solving mathematical problems include reading errors, comprehension errors, transformation errors, process skill errors, and errors in writing final answers (Ainin, Hartono, & Aripin, 2020; Ketterlin-Geller & Yovanoff, 2019; Nurdiawan & Zanthly, 2019; Rahma & Khabibah, 2022). Furthermore, the study conducted by Makhubele (2021) revealed that the primary sources of students' errors in solving mathematical problems are a lack of understanding of basic concepts, insufficient prior knowledge, misconceptions, and incorrect application of rules. These findings indicate that extensive research has been conducted to analyze students' errors in solving mathematical problems. However, analyses of students' answer error patterns according to option levels in diagnostic mathematics tests, particularly those utilizing the GetMath platform, remain limited.

GetMath provides real-time diagnostic data that enables teachers to analyze individual student performance as well as overall class performance, thereby facilitating the identification of areas requiring further attention. GetMath has

received positive feedback from educators, highlighting improvements in students' motivation and academic achievement. Students are more motivated to achieve high scores during practice sessions, which enhances their self-confidence and further encourages those whose performance has not yet reached optimal levels. Overall, GetMath offers a structured approach to mathematics learning with a focus on long-term retention and mastery of skills. With features that support personalization and real-time diagnostics, this platform can serve as a valuable tool for both teachers and students in the mathematics learning process. The findings of this study are expected to contribute to the development of more effective technology-based diagnostic assessments in the context of secondary school mathematics education

## LITERATURE REVIEW

### 1. Trigonometry Diagnostic Test

Trigonometry Diagnostic Test is an assessment instrument systematically designed to identify students' levels of understanding, misconceptions, and conceptual as well as procedural errors in trigonometric topics, including trigonometric ratios, identities, and their applications. This test does not merely focus on the final answers but also examines students' problem-solving processes, thereby revealing underlying learning difficulties and providing a basis for planning appropriate instructional follow-up (Novika, 2024)

### 2. Students' Error Patterns

Students' Error Patterns refer to systematic and recurring tendencies in the types and forms of errors made by students when solving learning tasks or problems, reflecting limitations in conceptual understanding, procedural weaknesses, or specific misconceptions. These patterns are analyzed based on the characteristics of students' responses and can be used to identify sources of learning difficulties as well as to design more appropriate instructional or assessment follow-up strategies (Rahamdani, 2025).

In the mathematics learning process, students' errors are not merely errors in arriving at the final answer, but rather reflect their way of thinking and level of understanding of the concepts being studied. Therefore, analyzing student error patterns is crucial for uncovering the sources of learning difficulties and the characteristics of students' conceptual and procedural understanding. Various theories and approaches have been developed to explain student error patterns in solving mathematics problems, which can serve as the basis for designing more effective assessments and learning strategies (Aljura et al, 2025).

#### a. Newman's Error Analysis (NEA) Theory

According to Newman, student errors occur in stages and can be classified into five types: errors in reading, problem comprehension, transformation, process skills, and writing the final answer. Student error patterns emerge when one or more of these stages is not properly completed, thus helping to identify specific points of learning difficulty.

b. Conceptual and Procedural Error Theory

This theory differentiates student errors into conceptual errors (inaccuracies in understanding mathematical concepts or principles) and procedural errors (inaccuracies in steps or algorithms for solving problems). Student error patterns are analyzed based on the dominance and interrelationship between the two types of errors.

c. Misconception Theory

In this theory, student error patterns are viewed as the result of erroneous but stable knowledge structures. Errors do not occur randomly, but consistently because students construct understandings that deviate from scientific concepts, thus influencing how they interpret and solve problems.

4. Cognitive Diagnostic Assessment (CDA) Theory

CDA views student error patterns as a representation of their mastery or lack of mastery of specific cognitive attributes. Each student's answer choice or response reflects a specific cognitive state, allowing error patterns to be analyzed in greater detail based on the level of attributes or options that have been designed.

5. Constructivism Theory

From a constructivist perspective, student error patterns are considered part of the knowledge construction process. Errors indicate the developmental stage of student understanding and serve as important indicators for designing learning interventions that align with previous learning experiences (Azizah et al, 2025).

## **METHODOLOGY**

This study used a descriptive quantitative approach. The descriptive research was designed to identify patterns of student error responses when completing a mathematics diagnostic test using the GetMath platform. The test is expected to detect error patterns based on the option level. The study subjects consisted of students from three public high schools in Banda Aceh City: SMAN 3, SMAN 5, and SMAN 10 Fajar Harapan. The total number of respondents was 200 students, with relatively homogeneous characteristics based on grade level and curriculum background. School selection was conducted purposively, considering the availability of digital facilities and student readiness to use the GetMath platform.

The instrument used was a trigonometry diagnostic test consisting of 13 multiple-choice questions. For multiple-choice questions, the option levels were assigned as developed by Suryawati et al. (2023) based on the CDA framework in the research report as follows: (i) Option (D0) is the option with the most errors; (ii) Option (D1) is the option with the most errors; (iii) Option (D2) is the option with moderate errors; (iv) Option (D3) is the option with a minor error; (v) Option (D4) is the answer key. Each question is designed to measure students' conceptual understanding and procedural skills in key trigonometry topics, such as trigonometric ratios, identities, and applications in geometric contexts. The

questions are structured based on the core competency framework of the Independent Curriculum and have undergone content validation by a mathematics education lecturer and two experienced teachers.

Data is collected through the GetMath digital platform, which serves as a medium for presenting questions and automatically storing student responses. Each student completes the test within 45 minutes using a mobile device or school computer under teacher supervision.

## RESEARCH RESULT

The results of this study are student learning outcomes in a diagnostic test using the GetMath website developed by PRP-PMRI. The questions were developed based on the stages of the test development model, which consists of self-evaluation, expert review, one-to-one, small group, and field testing. The paper-based diagnostic test questions were developed in the one-to-one phase with six grade 12 science students, while the small group phase was piloted on 22 grade 12 science students at SMAN 5 Banda Aceh. In the field phase, the diagnostic test questions were e-learning-based and piloted on 69 grade 12 students at SMAN 5 Banda Aceh.

The following are the student learning outcomes of the three schools: SMAN 5 Banda Aceh, SMAN 3 Banda Aceh, and SMAN 10 Fajar Harapan Banda Aceh, presented in Table 1 and Diagram 1.

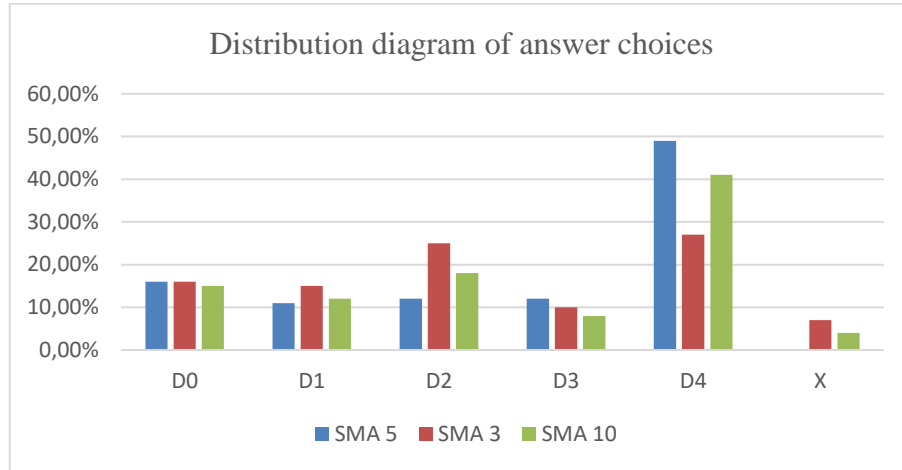
Table 1 Percentage of Student Answer Selections from the Three Schools

<i>Answers</i>	<i>SMA 5</i>	<i>SMA 3</i>	<i>SMA</i> <i>10</i>
<i>D0</i>	16,00%	16,00%	15,00%
<i>D1</i>	11,00%	15,00%	12,00%
<i>D2</i>	12,00%	25,00%	18,00%
<i>D3</i>	12,00%	10,00%	8,00%
<i>D4</i>	49,00%	27,00%	41,00%
<i>X</i>	0,00%	7,00%	4,00%

### Notes

- D0: Most severe error
- D1: Severe error
- D2: Minor error
- D3: Least severe error
- D4: Correct answer

**Diagram 1 Distribution of Student Answer Choices in the Three Schools**



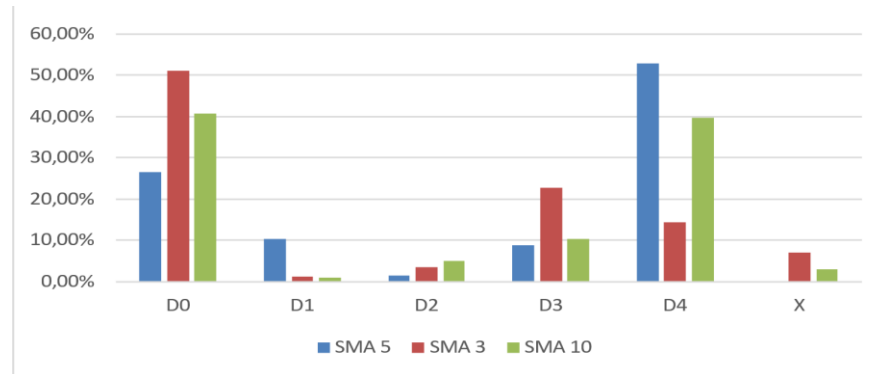
Based on the students' learning outcome data, the best performance was dominated by students from SMAN 5 Banda Aceh, followed by SMAN 10 Fajar Harapan and SMAN 3 Banda Aceh. Of the 13 trigonometry questions administered through the GetMath platform, 49% of the responses provided by SMAN 5 students were correct. The distribution of errors consisted of 16% most severe errors, 11% severe errors, 12% minor errors, and 12% least severe errors. Furthermore, 41% of the responses provided by students from SMAN 10 Fajar Harapan were correct, with an error distribution of 15% most severe errors, 12% severe errors, 18% minor errors, 8% least severe errors, and 4% unanswered responses. Meanwhile, only 27% of the responses provided by students from SMAN 3 were correct, with error distributions of 16% most severe errors, 15% severe errors, 25% minor errors, 10% least severe errors, and 7% unanswered responses.

These results are influenced by various factors, including the situation and conditions during test administration (Suharsimi, 2006). In addition, environmental factors and test locations also affect performance, as do the timing and scheduling of the test. During the test, many students did not complete the assessment seriously due to the test being conducted after the semester examination period, which caused students to feel fatigued and lose focus. Classes that were closely supervised by teachers appeared more focused and serious during the test.

Currently, student admission to public senior high schools in Banda Aceh is based on a zoning system, which tends to reduce visible academic competition among students and may result in less optimal learning outcomes, even though the schools have excellent accreditation status. However, the findings of this study show a different pattern based on the author's observations. The level of participation, perseverance, and seriousness in completing the test was very high among students from SMAN 10 Fajar Harapan compared to the other two schools; nevertheless, the results obtained did not reflect the observed classroom conditions. The test results indicated that students from SMAN 5 Banda Aceh achieved the highest scores.

In relation to the test results, data showed that students from SMAN 5 answered all of the questions provided. This contrasts with students from SMAN

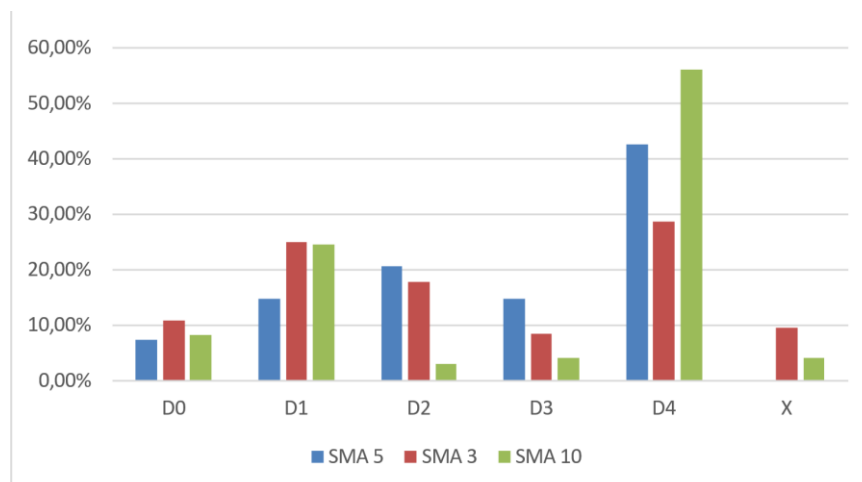
3 and SMAN 10 Fajar Harapan, who completed the test without answering all questions. This finding indicates that students from SMAN 5 made greater efforts to attempt all test items, even though some of their responses were classified as D0 (most severe errors). Questions with D0-level responses were found in Question 5, which is consistent with the distribution shown in Figure 2.



**Figure 2. Distribution of Answer Errors for Question 5**

Based on Figure 2, the analysis of Question 5, which involved operations of trigonometric functions, shows that the majority of students selected D0-level answers. This indicates that students experienced difficulties in recalling trigonometric identity formulas and in understanding the material comprehensively. Several students selected other incorrect options, including D3-level answers, indicating a lack of careful attention to the problem; D1-level answers, indicating difficulties in connecting trigonometric concepts; and D2-level answers, indicating challenges in recalling trigonometric identity formulas and overall conceptual understanding.

In contrast to Question 5, the distribution of student responses for Question 6 was concentrated at the D4 level, indicating correct answers. This can be observed in Figure 3.



**Figure 3. Distribution of Answer Errors for Question 6**

Based on Figure 3, the analysis of Question 6, which also involved operations of trigonometric functions, shows that the majority of students selected D4-level answers. However, despite most students providing correct responses, some students still made errors ranging from the least severe to the most severe levels. Question 6 also recorded the highest number of omitted responses (students who did not answer) compared to the other 13 questions.

Following the analysis of students' responses, follow-up actions can be implemented to improve students' abilities and understanding. These follow-up measures can be aligned with various features available on the GetMath platform, including the provision of learning modules in the form of videos or interactive materials designed to explain mathematical concepts in a simple and structured manner, in accordance with the curriculum and students' educational levels.

Furthermore, practice exercises can be provided to strengthen students' understanding and application of concepts, supported by a question bank covering various levels of difficulty, from basic to advanced. In addition, the GetMath platform offers automated evaluation and feedback systems that provide instant feedback on students' responses. The assessment process is also accompanied by explanations for incorrect answers. Students' practice results can be presented in the form of progress reports that allow teachers to monitor students' development over time, indicating that progress tracking is one of the key strengths of the GetMath application.

## **CONCLUSIONS AND RECOMMENDATIONS**

Based on the results and discussion, the author concludes several things: the distribution of SMAN 5 students' answer errors: 16% made the most serious error, 11% made the most serious error, 12% made the least serious error, 12% made the least serious error, and 0% made no answer. The percentage of correct answers for SMAN 5 students was 49%. The distribution of SMAN 3 students' answer errors: 16% made the most serious error, 15% made the most serious error, 25% made the least serious error, 10% made the least serious error, and 7% made no answer. The percentage of correct answers for SMAN 3 students was 27%. The distribution of SMAN 10 Fajar Harapan students' answer errors: 15% made the most serious error, 12% made the most serious error, 18% made the least serious error, 8% made no answer, and 4% made no answer. The percentage of correct answers for SMAN 5 students was 41%.

Based on the discussion and conclusions, the author proposes several suggestions: The importance of diagnostic tests for follow-up in the form of remedial and enrichment programs should be raised during the implementation of diagnostic tests. Furthermore, students need to be supported while answering questions, and their motivation and participation need to be increased. Furthermore, the test schedule and conditions must be considered so that students can answer questions according to their actual abilities.

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