ANALYSIS OF STUDENTS' MISTAKES IN SOLVING CONTEXTUAL MATHEMATICS PROBLEMS IN TRIGONOMETRY MATERIALS BASED ON CASTOLINE THEORY

Zahran Khalda Treifa[1], Munadi[2], M. Shaefur Rokhman[3]

1,2,3Indonesia

zahrankhalda@gmail.com

The purpose of this study is to describe the mistakes made by students in class X.7 in solving contextual mathematics problems of trigonometric material based on the stages of Kastolan, and to describe the factors that cause mistakes made by students of class X.7 in solving contextual mathematics problems of trigonometric material based on the stages of Kastolan. The method used is qualitative descriptive. The research was conducted at SMA Negeri 2 Slawi by taking research subjects using *the cluster sampling method.* The data analysis techniques used are data reduction, data presentation, and conclusion drawn. Data collection techniques are tests, interviews, and documentation. Based on the results of the study, it can be concluded that the mistakes made by students include: (a) Conceptual errors, inability to determine the appropriate trigonometric formula, not understanding the basic concepts of trigonometry, and connecting the solution with formulas that are actually not necessary, (b) Procedural errors, incompleteness in the completion step, not writing down the information known and questioned, unsystematic completion steps, and not writing down final conclusion, (c) Technical errors, errors in calculation operations, errors in determining trigonometric comparative values, and not conducting a review of the answers. Then the factors that cause mistakes made by students are: (a) Students do not understand the concept of trigonometry, (b) Students are not thorough in calculating, (c) Students are confused at certain stages and forget, (d) Students are in a hurry when working on the problem, (e) Students do not understand the purpose of the problem.

Keywords: Fault analysis; the Castle theory; Trigonometry; Contextual math.

1 INTRODUCTION

Mathematics education has an important role in training students to think critically, logically, and systematically, because one of the functions of mathematics is as a means of forming students' reasoning (Soedjadi in Purwasih et al., 2018). Mathematics has its own uniqueness because the material is essentially abstract (Agnesti & Amelia, 2020), so that there are still many students who have difficulty when working on problems, especially contextual math problems which tend to be more difficult than problems that only contain numbers (Susanti in Rahmawati & Permata, 2018).

Trigonometry is one of the materials whose concepts are widely used in daily life (Ayu & Zanthy, 2020), especially in the trigonometric comparison subchapter which discusses the relationship of sides and angles in a right triangle (Hidayat & Aripin, 2020). Because trigonometry is only obtained by students in class X, students need to understand the concept in depth through practice questions, both simple and contextual, although students' difficulties are more dominant in contextual questions or story questions (H. Palayukan, 2018). These difficulties can cause errors, namely forms of deviation from the rules or procedures that have been set (Rosyidi in Ulpa et al., 2021), which ultimately shows students' low critical thinking skills in solving contextual problems (Rindiyana et al., in Prihatini & Setiawan, 2020).

Various theories can be used to analyze student errors, including Newman, Polya, Watson, Nolting, and Kastolan theories. This study uses the Kastolan theory because this theory makes it easier to group students' errors in solving mathematical problems involving abstract concepts such as trigonometry (Sahriah in Afdila et al., 2018). The Kastolan stage divides errors into three types, namely conceptual errors that occur when students misinterpret the problem or misuse formulas, procedural errors caused by improper completion steps, and technical errors that occur due to lack of precision in calculations (Sahriah in Afdila et al., 2018). The use of this theory is also supported by the findings of the Uttar Pradesh et al. (2024) and Princess et al. (2025) which states that Kastolan's theory excels in identifying students' mistakes systematically and gradually, so that it can be known at which stage mistakes occur, whether in concept understanding, step preparation, or calculation.

Previous research by Ulfa & Kartini (2021) In the logarithmic material, it was found that 33.3% of students made conceptual errors, 38.1% made procedural errors, and 23.8% made technical errors. Research Ayuningsih et al. (2020) In the linear program material, 83% of students made conceptual errors, 56% made procedural errors, and 17% made technical errors. The results of the initial observation on January 15, 2025 through an interview with a mathematics teacher of SMA Negeri 2 Slawi also showed that students still experienced confusion in determining the initial steps of completion, made inappropriate work steps, and made mistakes when changing the problem to a mathematical model in the trigonometric comparison material.

Based on this description, this study aims to (1) describe the types of mistakes made by students based on the stages of Kastolan in solving contextual mathematics problems in trigonometry material, and (2) describe the factors that cause these errors to occur. The results of the research are expected to be evaluation materials for teachers in improving the delivery of material and choosing more appropriate trigonometry learning methods.

2 METHODOLOGY

This research uses a qualitative approach that is descriptive with a case study design, because it is focused on an in-depth exploration of students' mistakes in certain contexts (Creswell in Sugiyono, 2023:5). The research was carried out at SMA Negeri 2 Slawi, Tegal Regency. The research procedure consists of four stages, namely the preparation stage, implementation, data analysis, and drawing conclusions (Stuart et al., 2017).

The research instrument was in the form of eight contextual description questions of trigonometric comparative material that had been validated by three validators (two lecturers and one mathematics teacher), then tested on 36 students of class X.9 as an instrument test class. The results of the trial were analyzed through validity tests using the Product Moment correlation formula, reliability tests using Cronbach's Alpha formula, and analysis of difficulty and differentiating power. All eight questions were declared valid (r count > 0.339) and reliable ($\alpha = 0.920 > 0.6$). Based on the results of the analysis of the level of difficulty and differentiation, four question items, namely numbers 1, 3, 4, and 5, were selected as research instruments in class X.7 which amounted to 36 students, with 29 students participating in the test.

Sampling and selection of research subjects using *cluster sampling* Because the object of the research is widespread, so the determination of the sample is carried out based on a specific group (Sugiyono in Putra & Prihatsanti, 2016). The selection of research subjects was based on the Mid-Semester Summative Assessment (ASTS) scores, which were grouped into high, medium, and low ability categories using the *extreme groups approach*, i.e. taking 27% of students in the highest and lowest groups respectively (Preacher in Arghita et al., 2021). The grouping of students is made in descending order, students in the top 27% of the sample size are selected as the highest group, students in the bottom 27% of the sample size are selected as the lowest group, and students in the middle are in the middle group (Zhu & Wu, 2023). From each category, two subjects were selected, so that six research subjects were obtained, namely two high-ability students (ST-8 and ST-35), two medium-capable students (SS-31 and SS-2), and two low-ability students (SR-18 and SR-26).

The data collection techniques used included written tests, semi-structured interviews, and documentation. Data was analyzed using Miles and Huberman's interactive model, including data reduction, data presentation, and conclusion drawing (Sugiyono, 2023:321). The validity of the data was tested through technical triangulation and source triangulation, namely by comparing test results, student interviews, and interviews with mathematics teachers as comparative sources.

3 RESULTS

The text included in a section or subsection should begin one line after the section or subsection's title. Don't use hard tabs and limit the use of hard reverts to a single revert at the end of a paragraph.

3.1 Description of Research Implementation Results

The research was carried out in class X.7 of SMA Negeri 2 Slawi which amounted to 36 students, but at the time of the test only 29 students were present. After the answer sheets are collected, the students' answers are analyzed based on the stages of Kastolan errors in each question item. A recapitulation of the percentage of student errors is presented in Table 1.

Table 1. *Recapitulation of Student Error Percentage Based on Castel Stages*

Question Number	Conceptual Errors	Procedural Errors	Technical Fault
Number 1	27,5%	96,5%	89,6%
Number 2	27,5%	96,5%	34,5%
Number 3	27,5%	100%	41,4%
Number 4	31%	100%	82,7%

Based on Table 1, procedural errors are the most common mistakes made by students in all question items (96.5%-100%), followed by technical errors, while conceptual errors have the lowest percentage (27.5%-31%). The high percentage of procedural errors is mainly due to the fact that most students do not write down the information that is known, asked, or the final conclusion of the answer.

3.2 Error Analysis Results Based on Ability Categories

An in-depth analysis of the six research subjects showed a different pattern of error in each ability category, as summarized in Table 2.

Table 2. *Characteristics of Errors Based on Student Ability Categories*

Ability Categories	Error Conceptual	Error Procedural	Error Technical
Height	Not found	Incomplete steps (root shape, conclusion)	Lack of thoroughness in root counting operations
Medium	Misplaced triangle sides	Information & steps are not systematic	Incorrect substitution & root shape
Low	Not yet understanding the basic formula & values	Unsystematic steps, without conclusions	Misuse of Comparison Values & Calculation Operations

3.2.1 High-Ability Students

The two highly capable subjects, ST-8 and ST-35, were not found to have made conceptual errors in all of the question items. Both subjects were able to determine the correct trigonometric formula and explain the reason for choosing the formula when interviewed, which shows that the understanding of the concept is not just memorizing. Triangulation with the math teacher corroborated this finding, as the teacher stated that both students had a good understanding of the concept and were quite active in asking questions. However, both subjects still made procedural errors in the form of not completing the process of rationalizing the root form and not writing the final conclusion, as well as technical errors in the form of inaccuracy in the root form calculation operation. Based on the interview results, the mistake was more caused by a hasty attitude and lack of habit of double-checking answers, not because of a lack of understanding of concepts.

3.2.2 Moderately Capable Students

The two moderately capable subjects, SS-31 and SS-2, showed mixed results. The SS-2 subjects consistently did not make conceptual errors on all of the question items, whereas the SS-31 experienced repeated conceptual errors, especially in determining the position of the front and oblique sides to the elevation angle. For example, in the kite issue, the SS-31 places the thread length as the front side, when it should be the oblique side, because it mistakenly determines the position of the observer in the triangle image. The results of the interview show that the SS-31 itself admitted that it was still confused about determining the location of the sides of the triangle. In the procedural aspect, both subjects still show less systematic completion steps and often do not write down known and questioned information, while in the technical aspect, errors often occur at the stage of value substitution and determination of root form due to lack of precision

3.2.3 Low-Ability Students

The two low-ability subjects, SR-18 and SR-26, showed the highest error rate among the three categories. In the conceptual aspect, SR-18 has consistently not been able to determine the right trigonometry formula and admitted in interviews that he lacks understanding of sine, cosine, and tangent formulas, and focuses more on studying Pythagorean material than trigonometry. SR-26 is able to determine the correct formula in some questions, but triangulation with the teacher shows that the conceptual understanding is generally low, so the correct answer does not always reflect a complete understanding of the concept. In the procedural aspect, the two subjects did not write down the known information and the final conclusion, and the written settlement steps did not collapse. On the technical aspect, errors include ignorance of trigonometric comparative values at special angles (e.g. tan value 45°), calculation operations errors, and non-review of answers

3.3 Discussion

The findings of this study are in line with Kastolan's theory, which states that conceptual errors occur when students are not able to understand or apply mathematical concepts correctly, procedural errors occur when students do not complete and complete the completion steps, while technical errors are related to errors in calculation operations and lack of habit of reviewing the results of the work. The higher the student's mathematical ability, the fewer conceptual errors are made, while procedural and technical errors are still found in all skill categories, albeit with different characteristics.

The factors that cause conceptual errors in moderate- and low-ability students are in line with the opinion Lara & Sjakhyakirti (2025) that students do not understand concepts and materials and are not serious in learning and rarely repeat the material at home. These factors are also in line with the opinion Night Owl et al. (2024) that conceptual errors are caused because students do not know the formula of the problem. Procedural errors across all categories were dominated by the habit of not writing down known-asked information, which was in line with the findings Lara & Sjakhyakirti (2025) that this is also influenced by the tendency of teachers not to emphasize writing such information during learning. Meanwhile, technical errors in all categories were mostly caused by the lack of precision and haste of students in working on the questions, in line with the opinion Lara & Sjakhyakirti (2025).

These results also reinforce the findings Uttar Pradesh et al. (2024) which states that students' mistakes in contextual trigonometry material can be minimized by getting students used to writing solutions in a systematic and structured manner. Thus, understanding of concepts is an aspect that needs to be strengthened from the beginning of learning, followed by the habit of compiling complete completion procedures and re-examining the calculation results, so that errors at the procedural and technical levels can be minimized in all categories of students' abilities.

4 CONCLUSION

Based on the results of the research, it can be concluded that students at each level of ability still make conceptual, procedural, and technical mistakes with different characteristics in solving contextual mathematics problems in trigonometry comparison materials. High-ability students do not make conceptual mistakes, but still make procedural errors in the form of incompleteness of completion steps and technical errors in root form calculation operations. Capable students are making all three types of mistakes with varying intensity, especially in determining the position of the sides of the triangle and writing steps that are less systematic. Low-ability students are the group that makes the most mistakes at

all stages, mainly because they do not understand the basic concepts and values of trigonometry comparisons.

THANKS

The author would like to thank Supervisors I and II for the guidance provided during the research process, to SMA Negeri 2 Slawi for providing permission and assistance during data collection, and to all parties who have helped the implementation of this research.

REFERENCES

[1] Afdila, N. F., Roza, Y., & Maimunnah. (2018). *Analysis of Students' Mistakes in Solving Contextual Problems of Building Flat Side Space Materials Based on Castle Stages*. *5*(1), 65–72. (Article)

[2] Agnesti, Y., & Amelia, R. (2020). *Analysis of Mistakes of Grade VIII Junior High School Students in Solving Story Problems in Comparative Materials reviewed from Gender*. *pp. 4*(01), 151–162. (Article)

[3] Arghita, V. A., Siaputra, I. B., & Natalya, L. (2021). *Indonesian Journal of Guidance and Counseling: Theory and Application of the Role of Personality in the Relationship between Procrastination and Academic Motivation: Not as a Moderator but a Predictor*. *10*(1), 1–14. (Article)

[4] Ayu, L. S., & Zanthy, L. S. (2020). *ANALYSIS OF MISTAKES OF GRADE XI VOCATIONAL SCHOOL STUDENTS IN SOLVING TRIGONOMETRY PROBLEMS*. *4*(1), 1–16. (Article)

[5] Ayuningsih, R., Setyowati, R. D., & Utami, R. E. (2020). *Analysis of Student Errors in Solving Linear Program Problems Based on Castolian Error Theory*. *2*(6), 510–518. (Article)

[6] H. Palayukan, L. P. (2018). *ANALYSIS OF STUDENTS' ERRORS IN SOLVING TRIGONOMETRIC COMPARISON PROBLEMS ON RIGHT TRIANGLES BASED ON WATSON'S CRITERIA IN CLASS X OF RANTEPAO CATHOLIC HIGH SCHOOL*. *Sec. 4*. (Article)

[7] Hidayat, W., & Aripin, U. (2020). *Identify student answer errors in trigonometry courses based on Krathwohl's knowledge dimension*. *4*(1), 142–153. (Article)

[8] Kawengian, S. T., Monoarfa, J. F., & Manurung, O. (2024). *Analysis of students' mistakes in solving triangle story problems according to the stages of caste*. *3*(5), 5276–5289. (Article)

[9] Lara, D., & Sjakhyakirti, U. (2025). *ANALYSIS OF DIFFICULTIES IN SOLVING PISA-TYPE MATH STORY PROBLEMS BASED ON CASTE ERRORS*. 29–39. (Article)

[10] Prihatini, D., & Setiawan, W. (2020). *Analysis of the mistakes of junior high school students in grade ix in solving problems on the subject matter of building a flat side room*. *7*(1), 63–69. (Article)

[11] Purwasih, R., Aripin, U., Fitrianna, A. Y., Study, P., & Mathematics, P. (2018). *Implementation of ICT-Based Worksheet Learning to Improve High Order Mathematical Thinking (HOMT) Ability of Junior High School Students*. *7*(1), 57–65. (Article)

[12] Putra, M. T. P., & Prihatsanti, U. (2016). *THE RELATIONSHIP BETWEEN WORKLOAD AND TURNOVER INTENTION IN EMPLOYEES AT PT . "X."* *5*(April), 303–307.

[13] Putri, S., Hasanah, A., & Herman, T. (2025). *Analysis of Junior High School Students' Mistakes in Solving Ratio Material Story Problems Based on Kastolan Theory*. *09*(December 2024), 890–905. (Article)

[14] Rahmawati, D., & Permata, L. D. (2018). *ANALYSIS OF STUDENTS' MISTAKES IN SOLVING LINEAR PROGRAM STORY PROBLEMS WITH THE NEWMAN PROCEDURE*. *5*(2), 173–185. (Article)

[15] Ulfa, D., & Kartini, K. (2021). *Analysis of Student Errors in Solving Logarithmic Problems Using the Stages of Castoline Errors*. *pp. 5(*01), 542–550. (Article)

[16] Ulpa, F., Maharani, S. A., Marifah, S., & Ratnaningsih, N. (2021). *Analysis of Students' Mistakes in Solving Contextual Problems in Flat Side Space Building Materials Reviewed from Nolting Theory Analysis of Student Mistakes in Solving Contextual Problems in Solving Flat Side Space Building Materials Based on Castoline Stages. The results of the study revealed that*. *3*(2), 67–80. (Article)

[17] Utari, N. P. R., Wibawa, K. A., & Wena, I. M. (2024). *Error Analysis Based on Castoline Stages in Solving Contextual Problems in Trigonometry Problems*. *Sec. 4*, 161–173. (Article)

[18] Yudhanegara, M. R., Priyanto, B. H., & Lestari, K. E. (2017). *APPLICATION OF CONDITIONING-REINFORCEMENT- SCAFFOLDING THEORY ASSISTED BY MASTERY LEARNING TEACHING MATERIALS IN THEORY COURSES*. *3*(2), 111–124. (Article)

[19] Zhu, C., & Wu, X. (2023). *A Study on Differential Effects of Mathematics Reading Ability on Students' Value-Added Mathematics Achievements*. (Article)