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The Analysis of Students' Conceptual Comprehension Ability on Trigonometry Material at SMA Negeri 1 Raya Kahean

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ABSTRACT

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This research aims to describe the mathematical concept comprehension abilities of 10th-grade students in Class X-3 at SMA Negeri 1 Raya Kahean, focusing on trigonometry. The study adopts a descriptive approach with a qualitative methodology, and subject selection is carried out through purposive sampling, involving 35 students. The research instruments include field observations and essay-based tests. The findings reveal that the mathematical concept comprehension abilities of Class X-3 students in trigonometry are categorized as high at 11.42%, moderate at 48.57%, and low at 40%.

A. INTRODUCTION

Education is one of the basic needs for humans. Education is not acquired instantly, but requires a learning process to achieve results or effects that correspond to the process undergone. According to Nanang (2014: 27), education is a conscious effort made by individuals or specific groups through teaching and/or training activities, extending throughout life in various learning environments to prepare humans to play their roles appropriately. When discussing education, two meanings are consistently emphasized by experts. First, education aims to humanize individuals, and second, education involves the transfer of culture. Viewed from the perspective of education as a tool to humanize individuals, the fundamental aim is to develop human potential as much as possible so that, at some point, individuals grow to their fullest extent (Daulay and Pasa: 2014). From this definition, it can be concluded that education is very important and needed by humans in their life journey to develop the potential within them. Additionally, the growth and progress of a nation are significantly influenced by the quality and competence of the education established by that country.

Mathematics education is a process that assists individuals in acquiring the ability or skills to organize numbers or symbols in a structured manner based on clearly defined rules and theories, enabling the attainment of accurate results applicable to their lives. The beauty of mathematics lies in the complexity of puzzles that may arise in mathematical problems. Satisfaction arises when these puzzles can be solved effectively. Mathematics is a discipline that involves objects such as facts, concepts, operations, and principles. Therefore, mathematics is crucial to be learned. All mathematical objects must be understood correctly by students because certain mathematical topics can serve as prerequisites for mastering other mathematical subjects, as well as for other subjects such as physics, finance, and more.

According to Abdurrahaman (2009), the reasons why students need to learn mathematics are: (1) It is consistently applied in aspects of life. (2) All fields of study require relevant mathematical skills. (3) It serves as a powerful, concise, and clear means of communication. (4) It can be used to present information in various ways. (5) It enhances logical thinking, precision, and spatial awareness. (6) It provides satisfaction in the effort to solve challenging problems. Hudojo (2005) also states that the subject of mathematical study is not merely

quantity but is more focused on relationships, patterns, forms, and structures because, in reality, quantitative goals hold little meaning in mathematics. Therefore, it can be said that mathematics deals with structured ideas whose relationships are logically organized.

This implies that mathematics is highly abstract, involving conceptual abstractions and deductive reasoning. Consequently, the process of learning mathematics entails acquiring knowledge about the concepts and structures inherent in the subject and establishing connections between these elements. Susanto's statement (2013) supports this notion, outlining the objectives of mathematics education in schools, which encompass: (1) Grasping mathematical concepts, elucidating the interconnections between these concepts, and applying them or employing algorithms. (2) Employing reasoning in analyzing patterns and properties, manipulating mathematical ideas through generalization, constructing proofs, or explaining mathematical concepts and statements. (3) Addressing problem-solving skills, involving the ability to comprehend problems, devise mathematical models, solve these models, and interpret the solutions obtained. (4) Conveying ideas through symbols, tables, diagrams, or other means to elucidate situations or problems. (5) Cultivating an appreciation for the application of mathematics in everyday life. From the aforementioned explanations, it is evident that mastering conceptual understanding is the foremost requirement for students. Enhancing the ability to comprehend mathematical concepts is crucial, as it closely correlates with reasoning, communication, and problem-solving skills. A proficient understanding of concepts facilitates students in successfully attaining their learning objectives.

Grasping the concepts of the material serves as the fundamental basis for problem-solving (NCTM, 2000). The objective of teaching and learning mathematics in secondary school is to achieve an understanding of mathematical concepts, articulate the connections between these concepts, and adeptly apply concepts or algorithms in problem-solving situations (MoE, 2015). An individual's proficiency in comprehensively and functionally understanding mathematical ideas is denoted as conceptual understanding (Kilpatrick, Jane, & Findell, 2005). Notably, according to the Trends In International Mathematics And Science Study (TIMSS) results in 2015, Indonesia ranked 44th out of 49 countries, with an average score of 397, compared to the international average score of 500 (Hadi & Novaliyosi, 2019; Minarni, Napitupulu, & Husein, 2016).

However, the significance of the previously explained understanding does not correspond with the current level of mathematical comprehension attained by students, as indicated by various earlier research findings. According to the analysis of mathematical ability test results focusing on the comprehension of mathematical concepts in Sari's study (2014), the average score for the comprehension ability of Grade XI IPS 2 is 34.49, falling into the inadequate category. This observation is further supported by Damayanti's research (2017), which identified types of errors made by students in solving fraction operation problems, specifically errors related to the understanding of fraction arithmetic operations. This research leads to the conclusion that the insufficient understanding of mathematical concepts among students results in errors when solving mathematical problems, consequently influencing the academic achievements of students.

Understanding concepts is the cornerstone and a crucial step in the continuum of learning mathematics. To facilitate students' grasp of mathematical concepts, math instruction should offer opportunities for students to construct these ideas. This approach ensures that students are not overwhelmed with abstract mathematical content, which could impede their understanding. A strong grasp of conceptual understanding during math instruction aids students in comprehending and applying mathematical concepts in practical situations. By comprehending each presented concept, students can more easily navigate problem-solving and link the concepts to their existing knowledge. Conversely, when a student lacks understanding of a specific concept, they encounter difficulties in applying it to solve problems.

Based on the observations, it is commonly found that the implementation of teaching is still lacking in variety, the learning process tends to rely on certain (conventional) methods, and there is little attention to the students' understanding of the conveyed information. Students are less active in the learning process, often listening and writing, causing the lesson content to be memorized without a true understanding of the concepts. The teaching methods also lack incorporating discussions, and students are not taught to construct their own understanding of mathematical concepts; typically, the focus is on routine problems, which provides limited opportunities for students to develop their understanding of mathematical concepts. Therefore, this research aims to assess the conceptual understanding abilities of Class X-3 students at SMA Negeri 1 Raya Kahean.

B. RESEARCH METHODS

This research is a descriptive study utilizing a qualitative approach. The selection of research subjects was carried out using purposive sampling, a technique for sampling data sources based on specific considerations (Sugiyono, 2013). The chosen subjects are from Class X-3 at SMA NEGERI 1 RAYA KAHEAN for the

academic year 2020/2021, comprising 35 students, who demonstrated a higher passing percentage compared to other classes. The objective is to evaluate the students' proficiency in understanding mathematical concepts. The research employs field observations and test results as instruments, with the test designed to assess the students' comprehension of mathematical concepts. The test questions are presented in essay format.

The methodology used for data analysis involved examining students' responses to the provided test, which included questions aimed at evaluating their understanding of mathematical concepts. The analysis was carried out utilizing a scoring rubric designed for assessing students' proficiency in mathematical conceptual understanding. According to this rubric, a score of 0 indicates unsatisfactory performance, a score of 1 reflects less than satisfactory performance, a score of 2 indicates satisfactory performance, and a score of 3 signifies superior performance (Iryanti, 2004).

As per the scoring rubric for mathematical conceptual understanding, the analysis of research data involves the following steps:

1. Identifying the scale of students' responses for each test item.
2. Computing the score achieved by each student for each test item using the formula:
   Score = Scale × Weight
3. Summing these scores to derive the total score for each student.
4. Calculating the final score for each student with the formula:
   Final Score = (Total Score)/(Maximum Score) × 100
5. Assigning the category based on the students' proficiency level.

Table 1. The students' proficiency level

Score	Categories
$66{,}66 < P \leq 100$	High
$33{,}3 < P \leq 66{,}66$	Moderate
$0 < P \leq 33{,}3$	Low

Source: Nazir (2005)

The data analysis in this research was conducted using the process and components of qualitative data analysis as outlined by Miles and Huberman (Sugiyono, 2018), which explains four stages: (1) data collection. This study collected data using an essay test instrument. (2) Data condensation. Data condensation is the process of selecting, focusing, simplifying, and making abstracts of action data from field notes, interviews, transcripts, various documents, and field notes. Using data condensation makes the data more solid/robust. The conclusion of this process is obtained by the researcher after several steps, such as classifying and describing the acquired data. (3) Data display. The researcher presents data to facilitate a better understanding of research-related issues. Data presentation helps the researcher understand the research context because it involves in-depth analysis in the form of narrative text and data presentation in the form of graphs, matrices, networks, and charts. And (4) conclusion drawing/verification. The final step involves drawing conclusions based on the research findings.

C. RESULT AND DISCUSSION

The results of this study are the scores obtained by students in the test assessing their ability to comprehend mathematical concepts in solving problems related to trigonometry. The following are the obtained results:

Table 2. Level of Students' Conceptual Understanding

Categories	Average Scores	Number of Students	Percentage
High	77,5	4	11,42%
Moderate	50,58	17	48,57%
Low	19,21	14	40%

Based on the information in Table 3, it is observed that students' understanding of trigonometry-related problems falls into the following categories: the high category represents 11.42%, with 4 students achieving an average score of 77.5. The moderate category constitutes 48.57%, including 17 students with an average score of 50.58. In contrast, the low category makes up 40%, with 14 students obtaining an average score of 19.21. The most significant percentage lies in the moderate category, at 48.57%, encompassing 17 students with an average score of 50.58. Considering these results, the analysis of students' responses for each high, moderate, and low category across all indicators of mathematical conceptual understanding abilities is detailed as follows:

1. High Category on Students' Mathematical Conceptual Understanding Ability

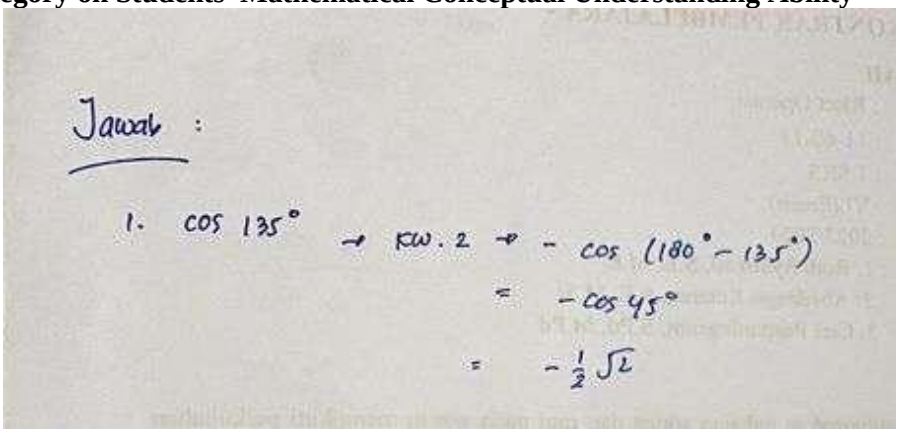

Figure 1. Results of Student A's Exercise Question Number 1

Based on the provided response, student A demonstrates proficiency in all aspects of mathematical conceptual understanding because: (1) Student A effectively applies the formula by recognizing that cos 135° falls within the second quadrant; (2) Student A adeptly performs algorithmic calculations, accurately subtracting -cos(180°-135°); (3) Student A establishes a connection with the concept that cos 135° resides in the second quadrant, leading to a negative value due to its quadrant placement; (4) Student A exhibits awareness of the problem-solving process, executing the steps correctly and comprehensively without omitting any.

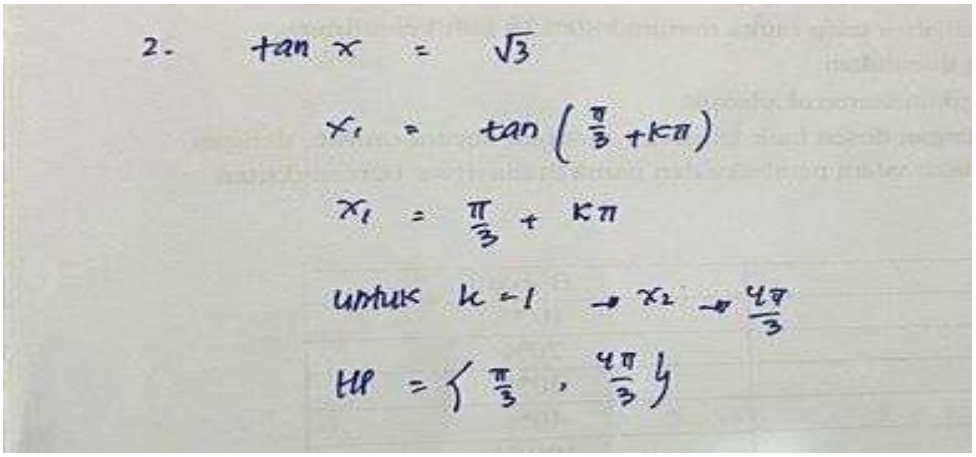

Figure 2. Results of Student A's Exercise Question Number 2

Based on the provided response, student A fails to meet all the indicators of mathematical conceptual understanding because: (1) Student A struggles to apply the formula used for question 2. The formula used by student A is incorrect (π/3+kπ), whereas it should be using the formula π+2kπ; (2) Student A faces difficulty in solving question 2 because of a lack of attention to detail. Student A fails to substitute the value for k = 0 initially; (3) Student A struggles to connect the concept in question 2 as they do not resolve the result of x1 accurately; (4) Student A overlooks the process they are working on. There is a lack of precision in the calculations and resolution of question 2.

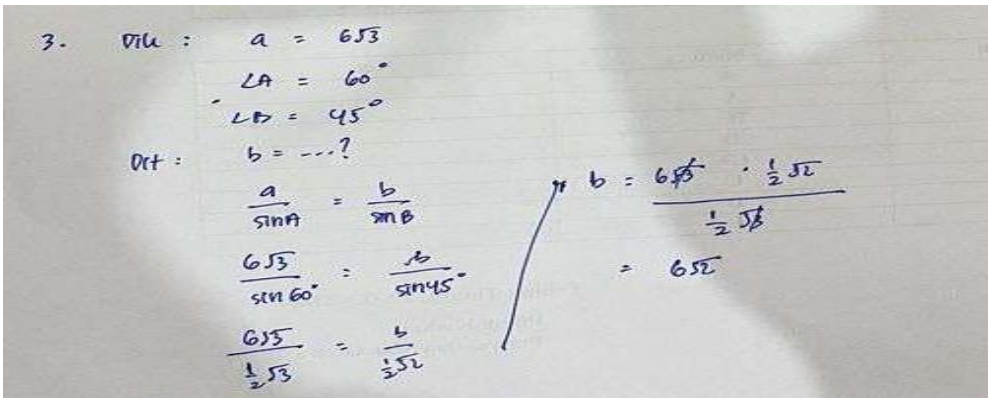

Figure 3. Results of Student A's Exercise Question Number 3

Based on the provided response, student A is able to meet all the indicators of mathematical conceptual understanding because: (1) Student A successfully applies the formula for question 3, which is the sine rule formula; (2) Student A also performs algorithmic calculations effectively. This is evident in student A's response, where they input the values for side a, angle A, and angle B. The calculation process is correctly and systematically organized; (3) Student A can also relate the concept of comparison by using the sine rule formula; (4) Student A is aware of the process in solving the problem in question 3. They can work through the steps correctly and without omission.

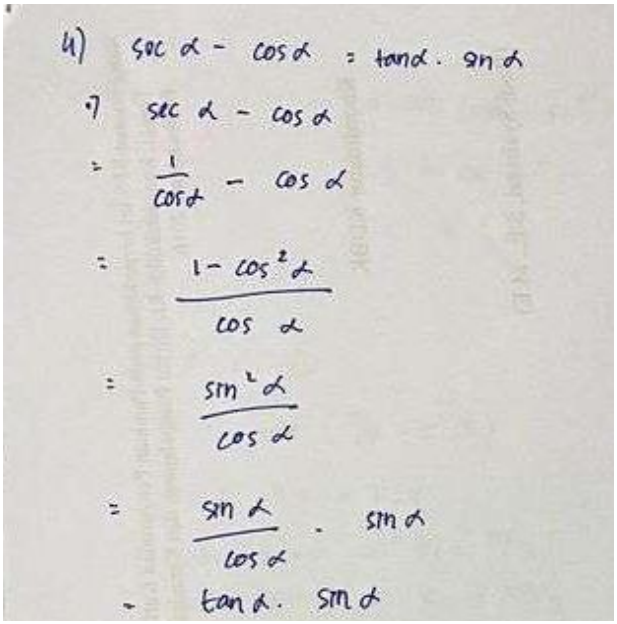

Figure 4. Results of Student A's Exercise Question Number 4

Based on the given response, student A is able to fulfill all the indicators of conceptual understanding abilities because: (1) Student A can use the correct formula; (2) Student A can perform calculations that are accurate, systematic, and well-executed; (3) Student A is capable of linking one concept to another. Student A can transform the given equations such sec $\alpha = \frac{1}{\cos \alpha}$, $1 - cos^2\alpha = sin^2\alpha$; (4) Student A is aware of the process undertaken and does not overlook any stages of the procedure.

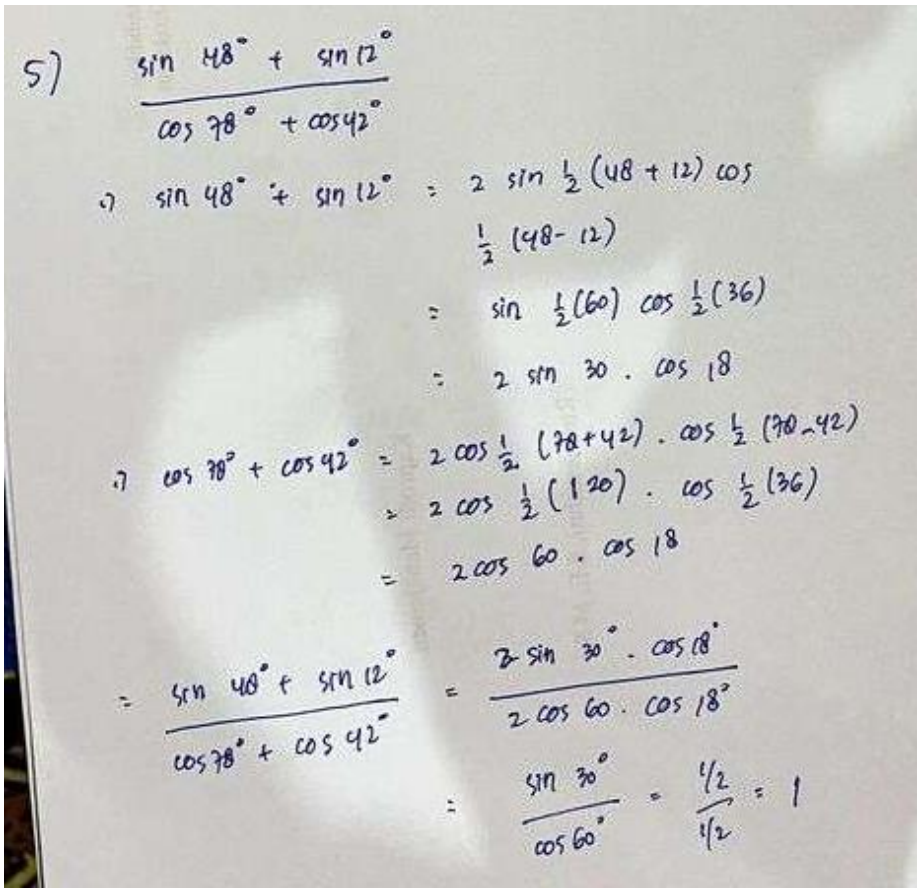

Figure 5. Results of Student A's Exercise Question Number 5

Based on the given response, student A demonstrates proficiency in conceptual understanding abilities because: (1) Student A can apply the required formulas, namely $\sin A+\sin B= 2\sin\frac{1}{2}(A+B)\cos\frac{1}{2}(A-B)$ dan $\cos A+\cos B= 2\cos\frac{1}{2}(A+B)\cos\frac{1}{2}(A-B)$; (2) Student A can perform algorithmic calculations well, accurately, and meticulously. The calculation process employs sequential and detailed steps; (3) Student A is also capable of connecting one concept to another. Student A first works on and elaborates the solution of sin 48° + sin 12°, then solves cos 78° + cos 42°, and finally operates and simplifies the results until reaching the final outcome; (4) Student A is aware of the process of solving problem number 5. Student A acknowledges an error in omitting the digit "2" in the response, but the calculation results are correct, and the steps used are accurate and appropriate.

2. Moderate Category on Students' Mathematical Conceptual Understanding Ability

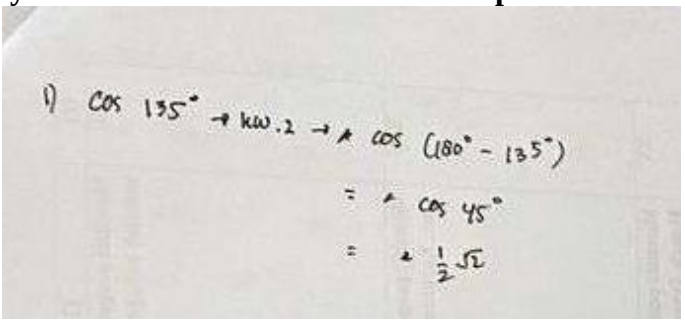

Figure 6. Results of Student B's Exercise Question Number 1

Based on the provided response, student B demonstrates achievement in the indicators of conceptual understanding abilities as follows: (1) Student B is less capable of applying the calculation formula because, in the first step, student B correctly answered that cos 135° is in the second quadrant. However, student B

incorrectly stated that cosine is positive when, in fact, in the second quadrant, cosine should be negative; (2) Student B can perform calculations correctly; (3) Student B is unable to relate one concept to another. In the first concept, the student correctly answered that cos 135° is in the second quadrant, but then student B incorrectly stated that cosine is positive when it should be negative; (4) Student B is not aware that their answer is incorrect because the cosine value in the second quadrant should be negative, not positive.

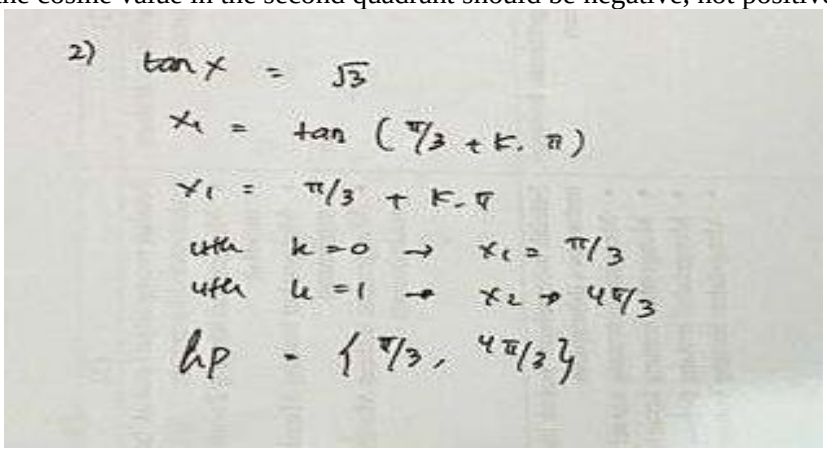

Figure 7. Results of Student B's Exercise Question Number 2

Based on the provided response, student B demonstrates achievement in the indicators of conceptual understanding abilities as follows: (1) Student B is unable to apply the formula used for question 2. The formula used by Student B is incorrect because for question 2, tan x = √3 is within the interval $0 \leq x \leq 2\pi$. Therefore, the correct formula is $x = \pi + 2k\pi$; (2) Student B's calculations to solve the problem are correct even though the wrong formula was used; (3) Student B can also relate one concept to another. After obtaining the result for the value of x, Student B substitutes the values k = 0 and 1 into the result of $x = \frac{\pi}{3} + k\pi$; (4) The process carried out by Student B is less accurate because they did not use the formula that corresponds to the information in the question. Thus, it can be said that Student B is less aware of the process they are working on.

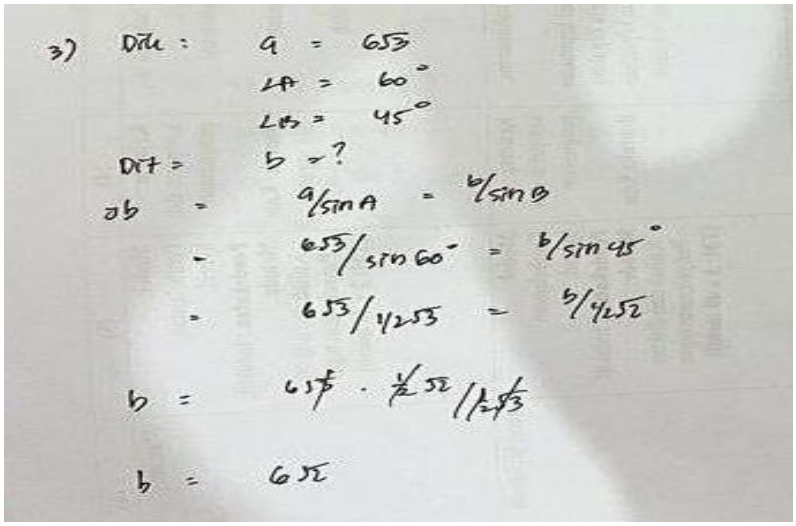

Figure 8. Results of Student B's Exercise Question Number 3

Based on the provided response, student B demonstrates achievement in the indicators of conceptual understanding abilities as follows: (1) Student B is able to apply the appropriate formula for question 3, namely using the sine rule formula; (2) Student B's calculation process also follows correct and precise steps; (3) Student B can relate concepts by using the sine rule formula. Then, they use a comparative method to find the length of side b; (4) The process carried out by student B from start to finish is correct, precise, and in line with the information provided in the question.

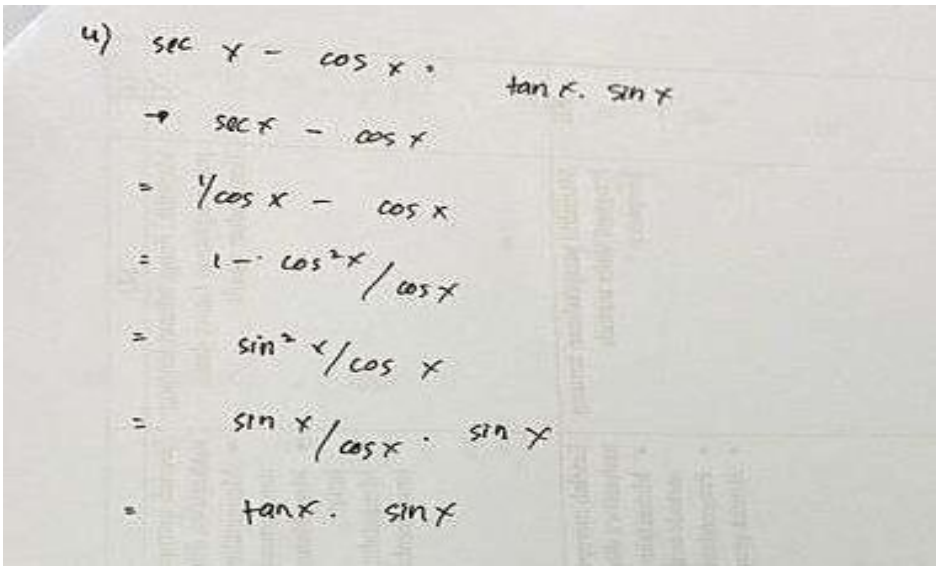

Figure 9. Results of Student B's Exercise Question Number 4

Based on the given response, student B shows achievement in the indicators of conceptual understanding abilities as follows: (1) Student B is able to apply the appropriate formula for question 4; (2) In the calculation process, there is an error in the second step of the answer, where student B responds with $1-\frac{cos^2x}{\cos x}$, whereas the correct answer should be $\frac{1-cos^2x}{\cos x}$. The misplacement of the division sign can lead to a difference in meaning; (3) Student B can relate the concept that sec x = $\frac{1}{\cos x}$, $\frac{\sin x}{\cos x} = \tan x$; (4) The student is unable to realize that in the process of solving question 4, there is a misplacement of the division sign, causing a difference in meaning and errors in the numerator and denominator values.

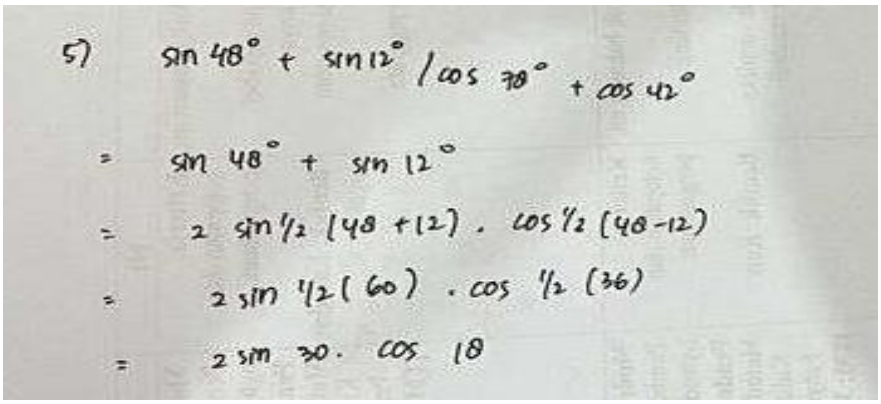

Figure 10. Results of Student B's Exercise Question Number 5

Based on the given response, student B demonstrates achievement in the indicators of conceptual understanding abilities as follows: (1) In question 5, there are two parts, namely the numerator and denominator, which must be elaborated one by one using the respective formulas. However, student B only applies the calculation formula for the numerator; (2) Since student B only calculates the numerator, the calculation is incorrect. However, for the calculation of the numerator, student B performs it correctly; (3) For the calculation of the numerator, student B is able to relate to other concepts; (4) Student B is aware that the process of solving question 5 is not correct because student B does not work on the solution for the denominator.

3. Low Category on Students' Mathematical Conceptual Understanding Ability

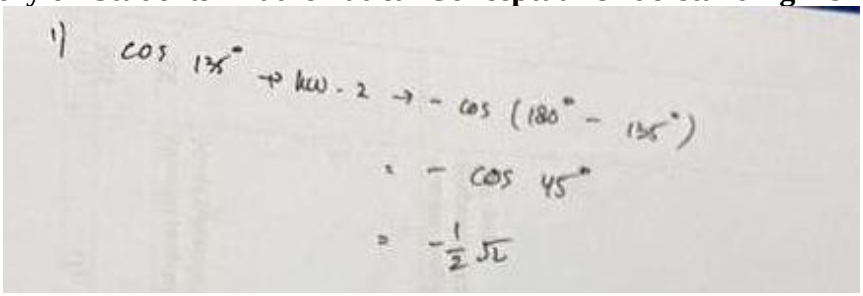

Figure 11. Results of Student C's Exercise Question Number 1

Based on the provided response, student C demonstrates achievement in the indicators of conceptual understanding abilities as follows: (1) In applying the calculation formula for question 1, student C is able to correctly apply the formula as required in question 1; (2) After applying the formula for question 1, student C can perform algorithmic calculations correctly; (3) Student C is also able to relate one concept to another. Student C knows that cos 135° is in the second quadrant, and if cosine is in the second quadrant, then cosine is negative; (4) Student C is aware of the process and works through it with correct steps, resulting in no errors in the steps taken by student C. The outcomes of student C's practice on question number 2 are:

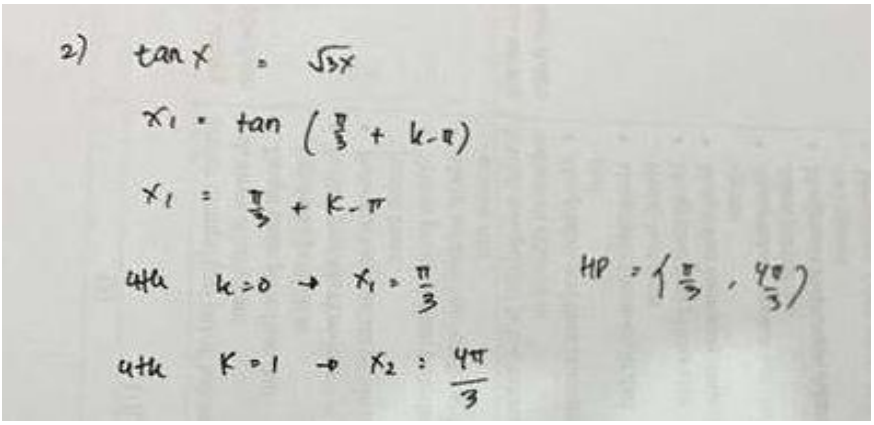

Figure 12 Results of Student C's Exercise Question Number 2

Based on the provided response, student C demonstrates the following achievements in understanding mathematical concepts: (1) Student C is unable to apply the appropriate calculation formula for question number 2. In question number 2, it is known that $\tan x = \sqrt{3}$ is within the interval $0 \leq x \leq 2\pi$. However, student C uses the formula $\frac{\pi}{3} + k\pi$, while it should be $\pi + 2k\pi$; (2) Student C also fails to perform algorithmic calculations correctly. Since in question number 2, $\tan x = \sqrt{3}$, the calculation process should be $\pi + 2k\pi$, but student C answers $\frac{\pi}{3} + k\pi$; (3) Student C cannot relate one concept to another, as in question number 2, the condition is given that $\tan x = \sqrt{3}$ is within the interval $0 \leq x \leq 2\pi$, and student C connects this concept with the wrong one by using the formula $\frac{\pi}{3} + k\pi$, which should be $\pi + 2k\pi$; (4) Student C is unaware that the process they worked on is incorrect. Despite the condition in the question, the formula used by student C for question number 2 does not align with the requirements, making the steps taken by student C incorrect.

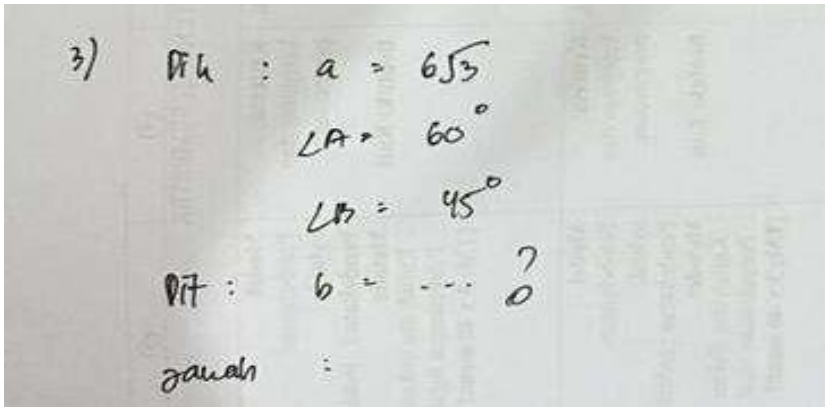

Figure 13 Results of Student C's Exercise Question Number 3

Based on the provided response, student C shows the following achievements in understanding mathematical concepts: (1) Student C is unable to apply the calculation formula for question number 3 because they cannot answer it. Student C only knows what is given and what is asked in question number 3; (2) Student C cannot answer question number 3, so they are unable to perform the calculations; (3) Student C is also unable to relate one concept to another. They cannot connect the known and the unknown in question number 3 to link it with the formula that should be used to solve question number 3; (4) Student C is also unable to connect one concept to another. They cannot link the known and the unknown in question number 3 to connect it with the formula that should be used to solve question number 3.

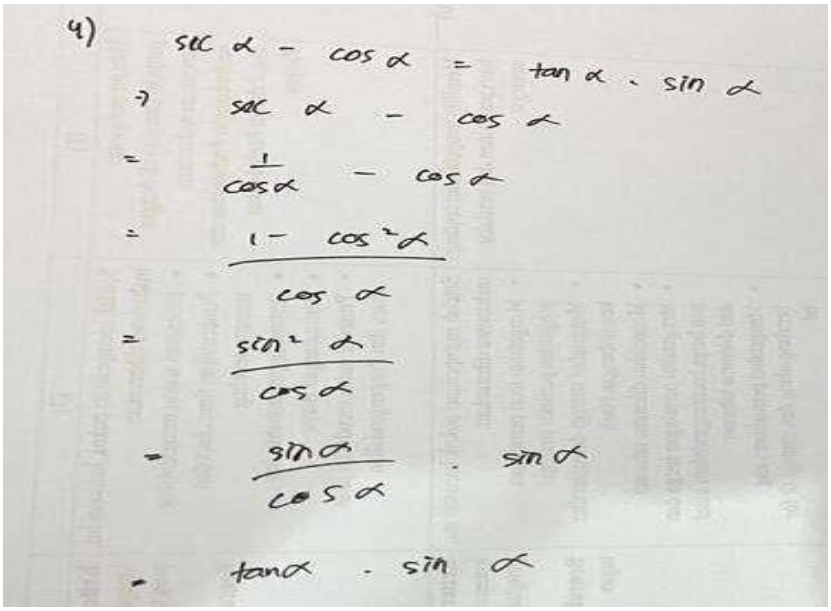

Figure 14. Results of Student C's Exercise Question Number 4

Based on the provided response, student C demonstrates the following achievements in understanding mathematical concepts: (1) Student C is able to apply the formula used to solve question number 4, which involves transforming the equations $\sec\alpha = \frac{1}{\cos\alpha,}$ $1 - cos^2\alpha = sin^2\alpha, \frac{\sin\alpha}{\cos\alpha} = \tan\alpha$; (2) Student C can perform the calculations for question number 4 with correct step-by-step procedures; (3) Student C is capable of connecting the concept that if $\sec\alpha = \frac{1}{\cos\alpha,} 1 - cos^2\alpha = sin^2\alpha, \frac{\sin\alpha}{\cos\alpha} = \tan\alpha$; (4) The process undertaken by student C aligns with the instructions in the question, employing correct and appropriate steps.

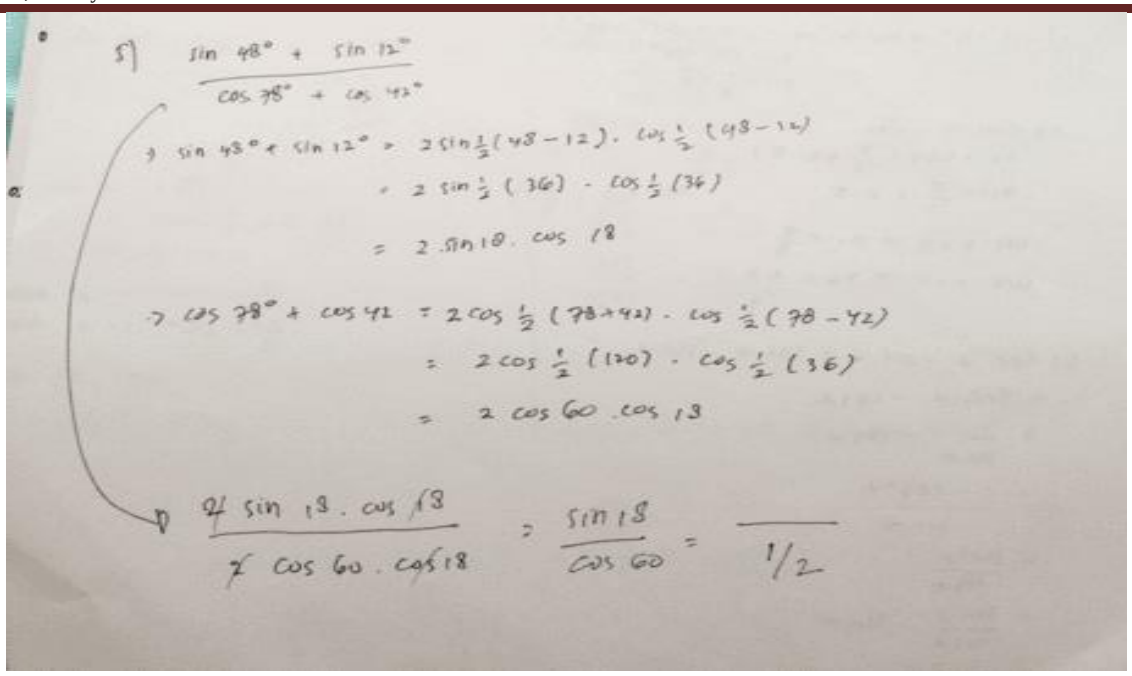

Figure 15. Results of Student C's Exercise Question Number 5

Based on the provided response, student C demonstrates the following achievements in understanding mathematical concepts: (1) Student C is unable to apply the appropriate formula to solve question number 5. The formula used by student C is $2sin\frac{1}{2}(A-B)cos\frac{1}{2}(A-B)$, whereas the correct formula for question number 5 should be $2sin\frac{1}{2}(A-B)cos\frac{1}{2}(A-B)$; (2) Student C is unable to perform logarithmic calculations because they cannot answer the result of $\sin 18°$, resulting in no final answer for question number 5; (3) Despite the incorrect formula used by student C in simplifying $\sin 18° + \sin 12°$, they connect the final result of $\sin 18° + \sin 12°$ and $\cos 78° + \cos 42°$; (4) Student C is not aware of the process undertaken, as it is evident that the formula used for solving $\sin 18° + \sin 12°$ does not align with the information provided in the question, and the final result does not match the question's requirements.

D. CONCLUSION AND SUGGESTIONS

In the investigation of 10th-grade students' comprehension of mathematical concepts (class X-3), the findings reveal that students fall into different categories regarding their understanding of trigonometry-related problems. Specifically, the high category encompasses 11.42%, consisting of 4 students with an average score of 77.5. The moderate category comprises 48.57%, with 17 students achieving an average score of 50.58. On the other hand, the low category represents 40%, involving 14 students who secured an average score of 19.21. Notably, the highest percentage is within the moderate category, precisely at 48.57%, with 17 students holding an average score of 50.58..

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