Analysis of Senior High School Student’s Difficulty in Resolving Trigonometry Conceptual Problems

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Abstract. Trigonometry is one of the topics in mathematics in senior high school that must be studied and has an important effect in the development of students' creative thinking skills, but in reality there are some difficulties experienced by students. This research focuses on analysis difficulty in resolving trigonometry conceptual problems among senior high school students in every creative thinking skills level. This research used a descriptive method aimed to identify the difficulties and cause of the difficulties experienced by five students. The difficulties are associated with concept of trigonometry and related problems. Data collection was done based on students’ work through test, interview, and observations. The results revealed that students’ difficulties in understanding the concept of trigonometry can be found at almost every level of creative thinking skills. The difficulty is identifying the application of trigonometric concepts in daily life and seeing the interrelationships between the problems given.

1. Introduction
Mathematics is the most important part in the development of world science and technology and is one of the subjects studied by students. Mathematics is important for development of students' mathematical thinking. Mathematics is a subject that cannot be separated from life daily. Activities carried out by humans always present mathematical concepts such as counting, dividing, adding, and subtracting. Learning mathematics is also able to train someone to think logically and accurately. The big role of mathematics for human life makes mathematics a subject that makes it a prerequisite for student graduation to continue to a higher school [1].

Based on mathematical material to be studied in school, trigonometry is one part of mathematics that must be studied in senior high school. Trigonometry is a very important subject in mathematics. It is a subject that is taught in schools and a basic concept that are also used in other subjects such as geometric, algebraic and graphical ways of thinking. Trigonometry can be defined as the science of measuring the angles and borders of a triangle. Trigonometry is a branch of mathematics that deals with triangle angles and trigonometric functions. Trigonometry is a branch of mathematics that is commonly used to accurately measure lengths or angles. Trigonometry plays an important role in architecture, navigation, engineering and several branches of physics [2].

Trigonometry helps students develop cognitive strategies, such as problem solving through students' reasoning and proving abilities. Trigonometry is one of the very few school subjects liked and only some students are successful in learning trigonometry, only students who have good faith in successful trigonometry [3]. Trigonometry is a material that is considered difficult by most students in mathematics subjects so that students experience confusion in its application. Trigonometry is an area of mathematics...
Students have difficulty applying formulas in solving trigonometric problems. Most students only memorize formulas and tend to learn on the notes given by the teacher, as a result the understanding obtained is not satisfactory, which is known from the results of student test scores that are still below the KKM [6]. Problem solving in trigonometry can be considered very difficult for high school students, also for prospective teachers to be mastered [7] and [8]. There are several studies related to analyzing problem solving in trigonometric problems. One of which is a study of 80 senior secondary students in Nigeria. The researchers used the Mathematics Achievement Test (MAT) and the Trigonometry Diagnostic Test (TDT) to investigate the type of errors that were done by the students, the results indicated that students still struggled to solve trigonometry problems [9].

Solving math problems including trigonometry needs IDEAL problem solver, such as identifying problems, defining the problem, exploring solution, acting on strategies, also looking back and evaluate [10]. The students must follow those steps so they can handle the math problems. It is very important to understand, how the students solve their math problems, so the teacher can give some suggestions. Hopefully, in the future they can solve more math problems. Most teachers have observed that children have numerous misconceptions about trigonometry. This occurs when teachers discuss proof on trigonometry problem. Trigonometry objects are considered abstract by some student. As a result, students do not believe in mathematics even though they recognize and understand that mathematics is important. Students will also have difficulty in understanding the concepts of trigonometry and students to be passive in learning study results decreased. The teacher needs to make a diagnosis of students' difficulties in learning. The teacher's perspective on learning difficulties and how he attempts to diagnose student learning difficulties is an important step in designing and managing the learning process [11]. Need to do a detailed diagnosis of student difficulties in learning mathematics. In addition to focusing on the aspects of mathematics to be taught, teachers must also pay attention to students' thought processes.

If students have difficulties, students will tend to make mistakes. It can be said that errors are the main source for finding out students' difficulties in solving trigonometric problems. The mistakes students can make don't just happen by accident. Students' errors in solving problems can be seen when using and implementing procedures or steps to solve trigonometric problems [12]. On the other hand, teachers are less able to distinguish between diagnostic, evaluation, or predictive tests, while the strategy most often used by teachers to diagnose student learning difficulties is to analyze student test results [11]. Too many guesses that cause students to have difficulty in solving trigonometric problems. The types of questions teachers give on trigonometry material also vary. Too many guesses that cause students to have difficulty in solving trigonometric problems. The types of questions teachers give on trigonometry material also vary. However, with an inadequate knowledge base, students may be ending with guessing and checking methods or using a scale to estimate the best tree height, without having to understand or apply trigonometric knowledge.

Students must try more to be able to solve trigonometric problems, because it can be said that students have considerable difficulty [1], [2], [6], [12]–[15]. To support the results of previous studies, the authors consider that it is necessary to hold an analysis of students' difficulties in understanding the concept of trigonometry. So far the strategy that tends to be used to diagnose student learning difficulties is to analyze their test results. While the learning process of students during teaching and learning activities is not observed and is used to diagnose student learning difficulties. However, the observation of student learning processes during teaching and learning activities is rarely carried out by the teacher to diagnose student learning difficulties, this is because the diagnostic ability of teachers still needs support, especially for diagnosing difficulties in students' mathematical thinking processes [11].

Therefore, the aim of the study is to analyze students' difficulties in understanding in trigonometric conceptual problems. This study uses strategies that not only diagnose student learning difficulties through observing student results, but also observe student learning processes during teaching and
learning activities, one of which is through interviews with students who have difficulty completing data so that it is more accurate. This is important for teachers, so they can pay more attention to overcoming problems and emphasize the steps that are usually taken in situations and find ways to sharpen students' skills in problem solving. In addition, so students can know what difficulties and errors are often found and they do not repeat the same mistakes in the future.

2. Research Methods
This study used descriptive qualitative research to describe how students answer the trigonometry problems. This method gets information about the “human” side of an issue [16], so we can gain many factors that affect students’ abilities to solve the problems. The selection of research subjects in this study was carried out intentionally (purposeful) or not randomly to collect the desired data. The data of this study were the answers of trigonometry submitted by five students of grade 10th at one of the Senior High Schools in a district located in the Province of Yogyakarta. The five students whose answers were analyzed were students who had homogeneous abilities and came from the same class.

Data collection procedures are through: (1) Students answer three trigonometric essay problems, (2) The teacher observes and analyzes students' difficulties based on their test results. The results of the three test numbers of questions and 3 are classified into 3 types of errors, namely mathematical statements, concepts, and error calculations. Then the total number of students who made each type of error is summed and the percentage is calculated. (3) In-depth interviews about students' difficulties in answering the given problem, and (4) Documentation of all data. Document analysis is used as a systematic procedure for reviewing or evaluating documents. Interviews will enrich data collection and document analysis to find out more about how students solve problems.

Data was collected using essay tests and short interviews to know where the students’ difficulties are in which the subjects of the study were asked to write down the steps of their answers in solving the problem. In the interview, the students were asked about the steps they used to solve the given problem and where did they find difficulties in solving it. The language originally used in essay tests and short interviews was Bahasa, but the researcher translated it into English for the convenience of the readers. By using student responses, the researcher will identify students’ difficulties in solving problems related to trigonometry conceptual.

3. Research Result
Based on Table 1, it is found that 14% of errors are due to mathematical statements, 20% due to concept errors and 7% due to calculate errors.

| Kind of student’ mistakes   | Questions | Total | %  |
|-----------------------------|-----------|-------|----|
| Mathematical statement      | 1         | 0     | 1  | 14%|
| Concept                     | 1         | 1     | 3  | 20%|
| Error calculation           | 0         | 0     | 1  | 7% |
• The students’ answers analysis:
  1) Based on the analysis that has been carried out on the answers to the student's description tests, it was found that one student had difficulties in understanding mathematical statements (Figure. 1).

![Figure. 1. First student’s answer for first question](image1)

2) One students had difficulties understanding the concept or the intent of mathematical statements, but were wrong in using the concepts used to complete the description (Figure. 2).

![Figure. 2. Second student’s answer for first question](image2)

3.2 Second Question

• Fandi, Tami, and Baim play on a field. The position of the three people forms a triangle. The distance between Fandi and Tami is 9 meters. The distance between Tami and Baim is 7 meters, and the distance between Baim and Fandi is 10 meters. Determine one of the angles formed by the three children.

• The students’ answers analysis:
  1) Four people answered correctly the math problems. One person had difficulties in understanding the concept (Figure. 3).

![Figure.3. First student’s answer for second question](image3)

3.3 Third Question
• Giri with a height of 1.5 m will measure the height of the flagpole. From Giri’s spot, the flagpole top was seen with an angle elevation of 45° from the point of view of Giri. The horizontal distance from Giri to the flagpole is 18 m.
  1) Make the illustration of the story
  2) How long is the height of the flagpole?

• The students’ answers analysis:
  1) One students have difficulty understanding mathematical statements, this can be seen from the illustration that is still wrong (Figure. 4).

![Figure. 4. First student’s answer for third question](image)

  2) One students can understand mathematical statements well shown by being able to draw illustrations correctly, but students are still having difficulty in determining the concept of trigonometric formulas used in solving this question (Figure 5).

![Figure. 5. Second student’s answer for third question](image)

  3) One person understood the problem and concept, but was not careful in calculating (Figure. 6).

![Figure. 6. Third student’s answer for second question](image)

Based on the results of the interview, it was also known that students still experienced difficulties in understanding the sentences of mathematical statements. They were confused in choosing the right concepts of trigonometry to solve the problems, so they ran out of time. The students have not been familiar to solve real life problems. In the classroom, the teacher focuses more on teaching the discovery of formulas and how the students can use the formula. The student should obtain and understand the concept well, not just memorize it. Therefore, problem solving were not trained specifically. In the trigonometry textbook, there are already problem solving, but the teachers does not discuss specifically and asked the students to study on their own, discuss it with classmates and ask the teacher for any queries. However, students had low motivation to do it. They gave up before they tried to answer. They prefer working on routine questions to implementing the concepts.
Numerous studies have shown that mathematics is experienced as a difficult subject for many students at various levels of education. In high school, Coskun revealed that students experience difficulties [11]. A general perspective on students' difficulties in mathematics is given by Russell, O'Dwyer, and Miranda who find that students' difficulties in mastery concepts occur due to students' inability to connect between the knowledge they learn and the previous knowledge they have [18]. The complexity of trigonometry problem solving is that it involves not only trigonometry ratios but also other knowledge bases, such as Pythagoras theorem or the concept of elevation and depression angles [19]. How to illustrate or make triangular modeling on trigonometric problems will also increase the complexity of the given problem. Modeling a mathematical problem of this type is included in the higher-order thinking skills (HOTS) level. Teachers' knowledge about HOTS and its teaching and learning tactics is a key to successful education [20]. A teacher must be aware of the importance of teaching higher order thinking skills, but many teachers have difficulty teaching HOTS [21].

4. Discussions
The finding from this study were leading to most of the theoretical concept in the beginning of this paper. From the all students’ answers and the interview, we can gain many understanding about what was happening in the class when the teachers explained trigonometry concept. We can find the answer also, about what the teacher should do in the future classes.

The questions were answered by five students. The first question was quite difficult for them that only had one right answer, but that answer involved guessing by the students. This is in line with [22] in their research that students tend to guess if they do not know how to solve the math problem. The second questions were so somehow familiar to the students, so each questions got four right answers. The third one was the most difficult one for the students.

The students’ difficulty to understand math statements or to apply math concepts appeared in all numbers. It can be said that the mistakes most often made by students in solving problems in trigonometry include understanding errors, transformation errors and process skill errors. Most of the errors understood occur in students not being able to solve the trigonometric problems given from the concept. Students often incorrectly answer questions. This might be caused by too many teachers helping in simplifying concepts as they arise. It might also be due to learning to memorize on the part of students. Especially, in question number three. The students could not understand mathematics concept and choose the correct trigonometry concept. The other problem is that when the students understand the concept but could not apply it, or calculating it wrongly.

Mistakes made by students in trigonometric learning can be useful for teachers in evaluating their teaching so as to correct student understanding [3]. Therefore, the teacher must ensure that mathematical concepts must be compatible with arithmetic skills. From that evaluation, we can conclude that the teacher must bring a new perspective to the class that mathematical problems can be applied with logical strategies [10]. Therefore, students can arrange ways of thinking, so they solve problems. Then, if students have problems related to mathematics in general or trigonometry in particular they can solve it with confidence. Teachers can take various actions to overcome problems in their findings in diagnosing students' difficulties in learning mathematics. The main action that can be taken by teachers is an improvement in the form of re-teaching [11]. The teacher should also provide question exercises to make students more accustomed to reducing student learning difficulties. In addition, teachers need to develop teaching strategies and media that are suited to each student's learning difficulties.

5. Conclusions
The results showed that students had difficulty in understanding the information provided to solve problems. Most mistakes made by students regardless of the method used are transformation errors and process skill errors. It further shows that in general, students independent of different cognitive abilities are vulnerable to errors in solving problems in trigonometry. Difficulties experienced by students especially in understanding the purpose of mathematical statements. That situation has caused errors in applying the concept of trigonometry to get a solution to the problem. Students are not careful in
calculating the results. They are not used to mathematical problems in real life. The results of this study can be used as a basis for further research on solving mathematical problems in trigonometry. The teacher can also use the results of this study to evaluate learning methods and how to motivate students to practice mathematical questions, especially trigonometry material.

Based on the results of the study it can be noted that the teacher as a facilitator of the teaching and learning process must encourage students to concentrate at one point at a time and proceed gradually in a logical way to reduce the difficulty of the officers encountered in trigonometry. The teacher must also make trigonometry lessons interesting by encouraging group work with frequent activity-based demonstrations to eliminate the difficulties encountered in problems involving trigonometry. The teacher must also give students enough opportunities to do the practice questions regularly because this will greatly help them and improve their reasoning skills. In addition, teachers and researchers can also conduct research concepts similar to this study for other mathematical material.

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