Senior high school students’ problem-solving ability in completing sine rule problems

S Wahyuni¹, and J A Dahlan²

¹Program Studi Pendidikan Matematika, Sekolah Pascasarjana, Universitas Pendidikan Indonesia, Jl. Dr.Setiabudi No. 229, Bandung 40154, Indonesia
²Departemen Pendidikan Matematika, FPMIPA, Universitas Pendidikan Indonesia, Jl. Dr.Setiabudi No. 229, Bandung 40154, Indonesia

*Corresponding author’s email: selawahyuni@upi.edu

Abstract. One of the 21st-century skills and also the primary goal of students learning mathematics is mathematical problem-solving. To achieve one of the 21st-century skills, students can practice solving problems in various forms of questions, including mathematics word problems. Completing the mathematics word problem requires an understanding of the problem context, making a mathematical model, developing a resolution strategy and reviewing the strategies used. The purpose of this research is to describe the students’ problem-solving ability to solve sine rules word problems. This research was conducted by a qualitative approach. Data were collected from 34 tenth grade senior high school students. Problem-solving for each student was scored by using a holistic rubric. Then the solution was reviewed by using the Polya Problem Solving Strategy. The results showed that least students had been written the solution, but the methods that they used could not be understood (problem number 1) and indicates that they were unskilled in understanding and planning problem-solving. Then there were only four students who were able to solve the problem solving correctly (problem number 2). Thus students had been able to implement the four steps of Polya’s problem-solving strategy properly.

1. Introduction

The learning process in class is closely related to the development of potential and thinking skills of students. The main goal of students in learning mathematics and also one of the 21st century skills is mathematical problem solving [1]. Problem solving can be interpreted as an effort to find strategies to overcome problems where the solution is not immediately available. In solving mathematical problems, the combination of understanding, knowledge and previous experience is needed to build the new knowledge [2].

Through the learning to solve problems, students can associate knowledge of various mathematical concepts with daily situations, develop various resolution strategies that lead to high-level thinking skills [3], as well as they can develop positive attitudes, such as never give up and diligent [4]. Problems in mathematics must require the students to elaborate on understanding of known problems and concepts or related to the problems. The results of the elaboration can be used to develop a settlement strategy. By understanding the problem, the students can represent it through images, diagrams and tables [5]. In other words, problem solving requires a combination of various skills in
the solution including the meaning of information, planning a settlement strategy, checking again, and trying other alternatives [6,7].

In learning mathematics, problem solving skills can be trained and developed. The students can practice solving problems in various forms of questions, including the word problem. Mathematical problems in the form of word problems are presented through a series, both written and oral sentences that are meaningful without symbols of mathematical operations [8]. In solving word problems, students need a variety of abilities in understanding problems, gathering information related to the needed concepts, planning solutions with mathematical models, and completing the models made then interpreting the solutions to the obtained solutions [7]. The obtained solution contains the completion and procedure for resolving problems with various steps of the settlement strategy.

This study aims to describe the ability of tenth grade students in high school to solve mathematical word problems about sine rules. Through this research, it is expected to be able to obtain information about the abilities of students as a preparation to do developing learning to improve the problem-solving skills and other high-level abilities.

2. Methods
This study uses a descriptive study approach to obtain information students’ ability to solve trigonometry word problems especially for sine rules. Student results of the solution are scored using a holistic rubric by Charles et al. [9].

Table 1. The holistic rubric of problem solving in mathematics.

| Description                                                                 | Score |
|----------------------------------------------------------------------------|-------|
| a. Students do not write settlement                                        | 0     |
| b. Students write what is known and asked but they do not show their understanding of the problems | 1     |
| c. There is a wrong answer and no other work is displayed                   | 2     |
| a. Students write what is known and asked correctly, there were steps of solutions, but the ways used is incorrect | 3     |
| b. Students tried the completion strategy but have not succeeded             | 4     |
| c. There is a correct answer but there is no solution                       | 5     |
| a. Students use inappropriate strategies and solutions are wrong, but the work shows an understanding of the problem |       |
| b. Students use the correct strategy, but have not reached a solution or applied incorrectly so the answer is wrong |       |
| c. There is a right answer, but the way is incomprehensible or wrong         |       |
| a. Students apply the right strategy but misunderstand part of the problem, or ignore certain conditions |       |
| b. Students apply the right strategy, but                                    |       |
|   i) wrong in answering without explanation                                  |       |
|   ii) no final answer given                                                  |       |
| c. There are correct answers and have chosen the right strategy, but the application is not completely correct |       |
| a. Students make correct strategies, apply correctly, and write correct answers |       |
| b. Students choose the right strategy, apply the strategy correctly, but there are few errors in the calculation |       |

2.1 Participants
The participants came from one of the classes recommended by the teacher with 34 tenth-grade senior high school students at one of SMA Negeri in Cimahi, Indonesia.
2.2 Task
At each problem a question is asked about the reason why the students choose the method which are used to solve the problem given. The purpose of using reason is to find out the extent to which students understand various related concepts to be used in developing the ways of solution, and interviews were also conducted. The word problems used is as follows:

Table 2. Descriptions of two word problems about sine rules

| No. | Problems on sine rules                                                                 |
|-----|----------------------------------------------------------------------------------------|
| 1.  | Mr. Donald wants to know the height of a tower. First, Mr. Donald stood at location A, the tip of the tower was seen with an elevation angle 30°. Then Mr. Donald walks to the tower as far as 50 m (location B), the tip of the tower is seen with an elevation angle of 60°. |
| a.  | Help Mr. Donald to calculate the height of the tower!                                   |
| b.  | Explain your answer by giving a reason why this method is used!                         |
| 2.  | Ani, Budi and Candra stood on a flat ground, all three of them are not on one line. The position of Ani, Budi and Candra forms a triangle. If the distance between Ani and Budi is 4 m, the angle formed by the position of Ani, Candra and Budi is 45°. The angle formed by the positions of Ani, Budi and Candra is 60°. |
| a.  | Help Budi to calculate the distance between Ani and Candra!                              |
| b.  | Explain your answer by giving reasons why this method is used!                          |

2.3 Procedure
Students are given a test then the results of the solution are scored using a holistic rubric [9]. Students are selected based on which answers represent each score obtained. The purpose of selecting five students using this category is to represent problem solving abilities of students on each score. Qualitative approach was carried out on students' completion writing which was reviewed using Polya's problem solving strategy perspective.

3. Result and Discussion
3.1. Result
The purpose was to describestudents' problem solving ability to solve the sine rules word problems. The completion of each student who has been scored uses a holistic rubric with a score range of 0-4 and students are chosen according to who represent each score obtained. Then each category is analyzed using perspective of Polya's settlement strategy. The following are the results of the tests given to students.

Table 3. Distribution of scores for each problem.

| Problems | 1 | 2 |
|----------|---|---|
| Score 0  | 15 | 3 |
| Score 1  | 19 | 16 |
| Score 2  | 0  | 8 |
| Score 3  | 0  | 3 |
| Score 4  | 0  | 4 |
| Average  | 0.56 | 1.68 |

Table 3 shows that the average score of students' problem solving ability to solve problems is 2.24. In problem number 1, there were no students who got a score of 4, students scores were in the range 0-1. While in problem number 2 as many as 4 students were able to get a score of 4. This shows that
most students are in the range of scores 0-1 on both problems, which means that on average students have not been able to solve both problems correctly and right.

![Figure 1](image1.png)

**Figure 1.** Percentage of students’ problem solving ability on each problem

Figure 1 shows the distribution of student score percentages for each given problem. Based on the data presented, it can be seen that in problem number 1 the maximum score is 1 with a percentage of 55.88%. Furthermore, problem number 2 obtaining the maximum student score is 4 with a percentage of 11.76%. In problem number one and problem two, students with a score of 0 are students who did not write down any solutions or in other words the student only rewrites data known in the problem. It does not represent an understanding of the problem. This is reinforced by students' acknowledgment that they do not have any plan to solve the problem, because they do not know what to do with the data on the problem.

![Figure 2](image2.png)

**Figure 2.** Students’ solution to problem number one score 1

Figure 2 is the completion of students with a score of 1, indicating students have written what is known and asked, but how to solve it and the results written incorrectly. The first problem that was asked was the height of the tower (TD) where TD = TE (tower height to the tip of the observer head) + ED (the height of the observer that has been known), so students need to find TE height first. But students immediately use the sine comparison rule by substituting the known numbers, also not utilizing a special sine angle. In problem number 1 and 2, the students with a score of 0 or 1 there is no reason to solve the problem.

The students with a score of 2 give the answer for problem number two as follow: side b and sine B is known and sine C and side c are also known.

So, it can be used \( \frac{b}{\sin B} = \frac{c}{\sin C} \)
students do not write what is known and are asked but interpret it through images. They have used the right solution strategy but have not reached the correct solution. The results of his work have shown an understanding of the problem but mistakenly used the special sine angle values in this case sine30° and sine60°.

In the completion of students score of 3, students represent what they known through figures, then try to solve problems using the sine comparison rules. Students have implemented the correct strategy but when going to the end of the settlement students stop and do not continue completion. Students do not write down the reasons why using the strategy. From interviews it was found that students tried to use the strategy based on previous memories without knowing why to use comparisons, as well as forgetting how to complete fraction calculations. When asked if there are other ways to solve the problem, students state there is none because they do not try and do not know any other way.

In the completion of students score of 4, the students write what is known, then interact in the form of images, use the right solution strategy and reach the correct solution. The results of their work have shown an understanding of the problem and applied the strategy that was chosen correctly. From the four students who got a score of 4 on problem number 2, none of the students wrote why they used the resolution strategy.

3.2. Discussion

The results of the study show that students with a score of 0 because students do not understand the problems faced, so it means students cannot represent known data into their mathematical model. Therefore students are difficult to find a solution to be used. The need for regular practice in understanding the problem of the type of word problem so that students are accustomed to reading the data provided so that it is easy to make a solution plan.

Students with a score of 1 due to not use data that is known to the problem, so students cannot make a correct settlement plan. The first step in the problem solving step by Polya [8] is to understand the problem in the form of a determination that is known and asked. This settlement shows that at least students have tried to reach the goal by direct applying the new rules learned, but without considering important information in the problem. The students misunderstood the problem that ended in the students just applying the relevant formula without considering what components were not yet known, and supporting the problem solving. If it is viewed from the perspective of problem solving by Polya, students are still weak in understanding the problem, making it is difficult to plan problem solving strategies. In other words, the knowledge which is possessed by the students is meaningless knowledge. Students with a score of 0 or 1 can be classified as inexperienced problem solvers only related to number manipulation [10].

Students with a score of 2 are students who at least have understood the problem so try to plan the right way to solve it, but have not been able to carry out the plan that was made correctly. This is caused by students who have not utilized various related concepts in order to solve problems, as well as being ignorant of existing information. In other cases, students write the correct answer but the way to solve it is difficult to understand. When asked why the solution was like that, students claimed to guess the answers they made and tried to write down what they remembered even though there were doubts. This means that students only apply trial and error in which the results they get are based on presumptions that are made without a basic understanding of concepts that are true and solid.

A student with a score of 3 was caused by strategies that have not been implemented correctly. Students have not linked the relevant concepts and past experience in implementing problems solving strategies. Sometimes students have almost reached the right and right solution but students are wrong in applying the algebraic concepts that they have learned, meaning students ignore some conditions in solving problems. Concepts that are meaningful to students will be easily used by students in order to solve the problems encountered. The inability of students to concentrate also results in students being unfocused or in a hurry during the completion of the completion strategy and results in the non-implementation of the third step of the completion strategy which is completing the mathematical model created and evaluating the completion step [8]. If viewed from the perspective of problem-
solving by Polya, the student is considered weak in problem-solving planning and it is difficult to evaluate the steps has made. These students can be categorized as routine problem solvers, which are oriented to structured behavior but do not verify solutions [10].

Students with a score of 4 are students who have used the strategy and obtained the correct results. If it is viewed from Polya's perspective, students have implemented all four steps to solve the problem properly, but the solutions given have not used other strategies by looking at it from a different perspective. Students who are able to find different problem solving strategies can be said to be good problem solvers [10]. Thus, even though the students have been able to solve problems using the four steps of completing Polya, students are still classified as routine problem solvers [10]. This means that no students are able to solve both problems with different perspectives or are good problem solvers. It can be said that students have not been able to develop high-level thinking skills. This is a challenge for teachers to develop the ability to think of problem solving and other high-level abilities.

4. Conclusion
Based on the results obtained can be concluded that there are quite a lot of students who are classified as Naive problem solvers or are inexperienced in problem 1 or 2. Less experienced problem solvers can be categorized in the 0-1 score range with the same type at least students have written down what is known about the problem even though it has not been able to make a solution plan, and or there is a solution but the method used cannot be understood. Causative factors, 1) lack of understanding of related concepts, 2) lack of skilled use of algebraic calculations, 3) misunderstanding of information that leads to mistakes in making plans, 4) misinterpretation of data on the problem, 5) lack of exploring the solutions made. Students who can be classified into routine problem solvers are students who score 2-3, meaning that at least students are able to understand the problem and or write down the problem solving steps but have not been able to verify the solution. Students with a score of 4 should be categorized as good problem solvers, but the solution is still not using a different perspective. In other words, most students are still not in the category of good problem solvers so that they have not been able to develop high-level thinking skills.

5. References
[1] NCTM 2000 Principles and Standards for School Mathematics (Reston: Virginia)
[2] Sari D R Ramdhani D and Surtikanti H K 2019 Analysis of elementary school students’ misconception on force and movement concept Journal of Physics: Conference Series. IOP Conf. Series 1157 022053
[3] King F J Goodson L and Rohani F 2016 Higher Order Thinking Skills, Assessment and Evaluation Educational Series.
[4] Pimta S Tayruakham S and Nuangchalerm P 2009 Factor influencing mathematics problem solving ability of sixth grade students Journal of Social Sciences 5 381-385.
[5] Sternberg R J and Sternberg K 2012 Cognitive psychology 6 ed (Belmont, CA: Wadsworth Cengage Learning)
[6] Muir T, Beswick K and Williamson J 2008 “I’m Not Very Good at Solving Problems”: An Exploration of Student’s Behaviours The Journal of Mathematical Behaviour, 27:228-241.
[7] Polya G 1973 How to solve it: A New Aspect of Mathematical Method (New Jersey: Pricenton University Press)
[8] Ashlock 2003 Guiding each child’s learning of mathematics (Colombus: Bell Company)
[9] Charles R Lester F and O’Daffer P 1987 How to evaluate progress in problem solving (Reston,VA: NCTM Inc)
[10] Harun L Darhim D and Dahlan J A 2019 Students’ gesture of naive, routine, and shopisticated behavior oriented on mathematical problem solving Journal of Physics: Conference Series. IOP Conf. Series 1157 042074