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ANALYSIS OF STUDENTS' ERROR IN SOLVING TRIGONOMETRY COMPARISON PROBLEMS WITH THE POLYA CRITERIA GUIDEN

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Abstract

Student mistakes in solving trigonometry problems have an impact on low student learning outcomes. This study aims to determine the percentage of student errors in solving trigonometry problems and describe the causes of these errors based on the Polya Criteria guidelines. This research is descriptive qualitative type. The subjects of this study were 35 students of class X.J SMA N 1 Wonosari. Data collection techniques used in this study were tests and interviews. The validity of the data is based on the triangulation process. Data analysis techniques in this study use data reduction techniques, data presentation, and drawing conclusions. Based on the results and discussion, it can be concluded that the students' mistakes in solving trigonometry problems with the Polya Criteria guide are as follows: 1) Understanding the problem (12.99%), 2) Developing a solution plan (30.30%), 3) Implementing a settlement plan (26.19%), 4) Checking again (30.52%). The causes of these errors, namely: students cannot understand the purpose of the questions given, students rarely solve problems by knowing, asking, answering, and concluding, students are confused about applying the trigonometry formula to solve problems, students are hasty and careless in solving problems, students are not used to it and feel no need to write conclusions at the end of the answer.

Keywords: error, trigonometry, polya criteria

Abstrak

Kesalahan siswa dalam menyelesaikan soal trigonometri berimbas pada hasil belajar siswa yang rendah. Penelitian ini bertujuan untuk mengetahui persentase kesalahan siswa dalam menyelesaikan soal trigonometri dan mendeskripsikan sebab dari terjadinya kesalahan tersebut berdasarkan panduan Kriteria Polya. Penelitian ini berjenis deskriptif kualitatif. Subjek penelitian ini adalah 35 siswa kelas X.J SMA N 1 Wonosari. Teknik pengumpulan data yang digunakan dalam penelitian ini adalah tes dan wawancara. Keabsahan data didasarkan pada proses triangulasi, Teknik analisis data dalam penelitian ini menggunakan teknik reduksi data, penyajian data, dan penarikan kesimpulan. Berdasarkan hasil dan pembahasan dapat disimpulkan bahwa kesalahan siswa dalam menyelesaikan soal trigonometri dengan panduan Kriteria Polya adalah sebagai berikut: 1) Memahami masalah (12,99%), 2) Menyusun rencana penyelesaian (30,30%), 3) Melaksanakan rencana penyelesaian (26,19%), 4) Memeriksa kembali (30,52%). Penyebab terjadinya kesalahan tersebut, yaitu: siswa belum dapat memahami maksud dari soal yang diberikan, siswa jarang memecahkan masalah dengan diketahui, ditanyakan, dijawab, dan menyimpulkan, siswa bingung mengaplikasikan rumus perbandingan trigonometri untuk memecahkan soal, siswa tergesa – gesa dan ceroboh dalam menyelesaikan soal, siswa tidak terbiasa dan merasa tidak perlu menuliskan kesimpulan pada akhir jawaban

Kata kunci: kesalahan, trigonometri, kriteria polya

INTRODUCTION

Mathematics is the main pillar of knowledge. Mathematics is widely used in solving problems. Mathematical problems are mathematical problems whose answers are not always understood by students (Kusuma et al., 2022). (Polya, 1973: 154-155) describes two types of mathematical problems, namely problems to find and problems to prove. The problem of searching is a student's problem when looking for and determining information about what is

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known and asked. While the problem of proving is a problem that occurs in a step in determining a true or false statement. Each student has a different way of presenting their understanding (Hitalessy et al., 2020). This means that students' skills in solving problems is the goal of learning activities.

Mathematical problem solving is a mechanism for solving mathematical problems in the context of solving mathematical problems. Problem solving develops skills that involve logical, systematic, critical, creative, careful, effective, and efficient thinking. Problem solving is applied as a means to observe the thinking processes used by students during the problem solving process (Maryanti & Qadriah, 2021). Problem solving in mathematics is usually applied to solving story problems (Mulyani & Muhtadi, 2019). Students are faced with word problems that require critical thinking and are required to solve them in detail (Setiana et al., 2021). The results of problem solving obtained by students are used to identify the causes of errors.

Error is a form of deviating from a truth. Student mistakes in solving problems are used as a guide to explain student mastery of the material (Rofi'ah et al., 2019). Student errors when solving problems are usually caused because students take a long time to understand the problem, it is not uncommon for students to be confused during the process of finding solutions so that they spend a lot of time solving problems, students are also in a hurry during the calculation process which causes student work to be sloppy, and it is not uncommon students write down the answers randomly even students do not write the conclusions of the answers. Therefore, analyzing student errors is very important in solving trigonometry problems.

Trigonometry is one of the mathematics lessons with an ever-evolving solution process flow (Derek et al., 2022). The trigonometry studied in class X SMA is comparative trigonometry. Comparison of trigonometry is a mathematics study that studies the relationship between side lengths and angle sizes in right triangles. Trigonometry comparisons are classified as the most difficult material for students (Cholid et al., 2022). Based on the results of previous research by Gradini, et al (2022) it was found that students' mistakes in solving Trigonometry problems were: (i) Misunderstanding of Trigonometry problems (57.73%); (ii) Errors in preparing settlement plans (9.27%); (iii) Failure to implement the settlement plan (15.83%); and (iv) Errors in re-examining (17.16%).

Based on these problems, research on the analysis of student errors in solving trigonometry comparison questions is very important to do. The mistakes that students make need to be analyzed so that students avoid repeating mistakes (Fauziah & Astutik, 2022). The error analysis process in this study applies the Polya criteria guidelines. The Polya criteria guide is a step - a step that helps students to solve math problems in an effort to get a solution. The steps for solving word problems with the Polya stages are considered simple and easy for students to interpret (Pradana & Murtiyasa, 2020). (Polya, 1973: 5) states that solving mathematical problems consists of four steps, namely (1) understanding the problem, (2) devising a plan, (3) implementing the plan, and (4) re-checking the answers. The Polya criterion emphasizes a mindset in solving problems mathematically (Gradini et al., 2022).

This research has the objective of knowing how big the percentage of errors of class X.J students of SMA N 1 Wonosari in solving trigonometry problems based on the Polya Criteria guide and to describe the causes of these student errors. The types of errors referred to are (1) errors in understanding the problem, (2) errors in compiling a settlement strategy, (3) errors in implementing the settlement plan, (4) errors in re-examining.

METHODS

The research was conducted in a qualitative descriptive manner at SMA N 1 Wonosari in the even semester of the 2022/2023 school year with 35 X.J students as subjects. This qualitative research was used to analyze student errors in solving trigonometry comparison questions using the Polya Criteria Guide. This analysis involves a systematic approach to solving problems on a given test item. Therefore, a problem solving indicator is needed based on the Polya Criteria guidelines to make it easier to analyze student errors. Error indicators based on the Polya Criteria guidelines are presented in Table 1

Table 1. Error Indicators Based on the Polya Criteria Guide

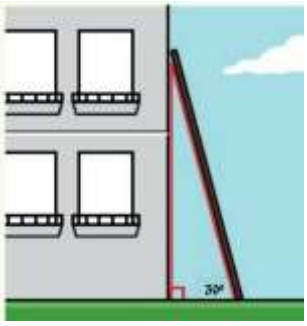
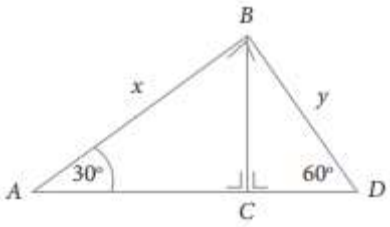
Number	Polya Completion Criteria	Error Indicator
1.	Understanding the problem	Students make mistakes in writing down what is known and asked in the problem
2.	Devising a plan	Students make mistakes in determining the formula to be used
3.	Carrying out the plan	Students make mistakes in the counting process in solving problems with predetermined formulas

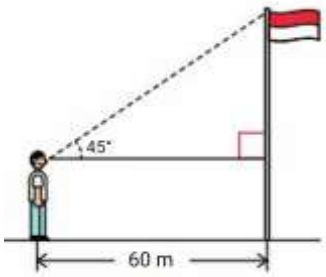
4.	Looking back	Students make mistakes in writing conclusions after obtaining the final answer from the completion results

Source: (Polya, 1973)

The data in this study were collected through tests and interviews. The first technique is a test in the form of five questions describing the trigonometry comparison material. The questions were then worked on by the students. The following test questions tested are presented in Table 2.

Table 2. Test questions

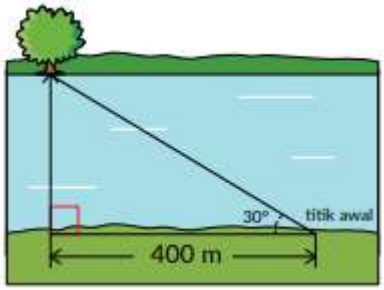
Question Number	Question
1	Mr. Aryo put the ladder right outside the window of the 3rd floor building with an angle of 30^0 as shown below.  If the height of one floor in the building is 11 meters. How long is the ladder?
2	On the classroom wall there is a painting of a right triangle. If the right triangle is assumed to be a right triangle ABD, $\angle B = 90^0$, $\angle A = 30^0$, and AD = 10 cm. BC is the high line that intersects AD like the image below.  What is the perimeter of the triangle ABD?
3	Tono is trying to find the height of the flagpole. Using a clinometer, he estimated the angle between the eye and the flagpole to be 45^0.



If the distance between Tono and the flagpole is 60 meters.

Find the length of the opposite side based on the known angles and distances!

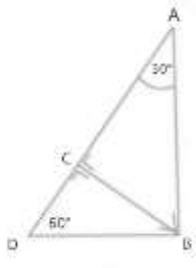
4 An architect will build a bridge so that residents can easily cross the river to get to the other village. First, the architect marked his starting point and saw a large tree across the river.



Then he walked until his position was parallel to the tree. The distance he covered was 400 meters. He then returned to the starting point and measured the angle of rotation to the position of the tree with the theodolite. It gets an angle of 30^0.

How long will the bridge be made?

5 Pak Rohmat wanted to tile the floor, so that it would be more aesthetic, Pak Rohmat chose ceramic tiles with a right-angled triangle as shown below.



If the length of AB is 30 cm. Determine the length of BC!

Reference source: (Sinaga et al., 2017; Susanto et al., 2021)

The items in Table 2 refer to the Mathematics book by Sinaga, et al (2017) and the Mathematics book by Susanto, et al (2021) by taking pictures and the essence of the problems in the Trigonometry Comparison Chapter. The difference lies in the information that is known

in the problem, such as the elevation angle and information related to the size of length, distance, and height. These items have been modified into word problems which contain contextual problems and have been adapted to problem solving indicators based on the Polya Criteria guidelines. The purpose of this test is to collect data about the results of student work at the completion of the tests which are then analyzed to obtain student errors based on the Polya Criteria guidelines. Prior to being tested, the test items were validated by one of the lecturers in the mathematics education study program at the Muhammadiyah University of Surakarta and one of the mathematics subject teachers at SMA N 1 Wonosari. This validation test was carried out to improve the questions before being tested on students until they were declared valid by both of them and agreed to be tested. The second technique is the interview. Interviews were conducted after students collected answers. Interviews were conducted to obtain more detailed information about student errors in the process of working on the questions. Data analysis techniques in this study used data reduction techniques, data presentation, and drawing conclusions. The data reduction technique is carried out by examining the answers that have been collected by students, conducting interviews with students and summarizing the data by selecting important parts to be used in research. Presentation of data is done to make it easier to explain student mistakes. Conclusions are made to conclude the data collected.

RESULTS AND DISCUSSION

Analysis of student errors was carried out after students collected answer sheets from the completion of the given trigonometry questions. Student errors were analyzed based on the Polya Criteria guidelines. The following is presented in Table 3 which describes the percentage for each type of error made by students based on the results of previous calculations.

Table 3. Percentage of Student Errors Based on Error Analysis Using the Polya Criteria Guide

Question Number	Error Type			
	K1	K2	K3	K4
1	13	29	14	22
2	10	33	21	34
3	11	28	32	22
4	12	33	33	35

5	14	17	21	29
Total	60	140	121	141
Percentage	12,99%	30,30%	26,19%	30,52%

Informasi:

K1 = error in understanding the problem

K2 = error in devising a plan

K3 = error in carrying out the plan

K4 = error in looking back

Based on the results of analysis of test data and interviews, the following presents the proportions of various types of errors and descriptions of the causes of these student errors.

Error in understanding the problem

Table 3 shows that there were 60 student errors in the type of error in understanding the problem with a percentage of 12.99%. A description of the error in understanding the problem is shown in Table 4 below.

Table 4. Description of Errors in Understanding the Problem

Question Number	Error Description	n	Percentage
1	Students write wrongly known and asked	13	21,67%
2	Students write wrongly known and asked	9	15,00%
	Students do not include known and asked	1	1,67%
3	Students write wrongly known and asked	10	16,67%
	Students do not include known and asked	1	1,67%
4	Students write wrongly known and asked	8	13,33%
	Students do not include known and asked	4	6,67%
5	Students write wrongly known and asked	8	13,33%
	Students do not include known and asked	6	10,00%

It is known from Table 4 that misunderstandings occur when students write wrongly and do not include the information they know and the information they ask. Most of the comprehension errors came from question number 5 which totaled 14 students. The results of students' misunderstandings can be seen in Figure 1.

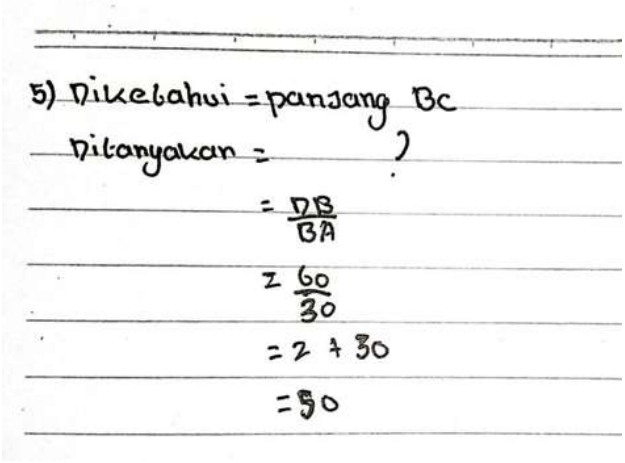


Figure1. Answers to SP-31

Figure 1 shows that SP-31 misunderstood the problem, that is, SP-31 incorrectly included the information that was known and the information that was asked. SP-31 writes that what is known is the length of BC and writes down what is being asked = ? = $\frac{DB}{BA}$ = $\frac{60}{30}$ = 2 + 30 = 50. Students should write down what is known is ∠A= 30^0, ∠D = 60^0, and long AB = 30 cm and wrote that what was asked was the length of BC. Based on the results of interviews with SP-31, it was found that the subject could not understand the intent of the questions presented and rarely solved problems by knowing, asking, answering, and concluding. Referring to the results of student interviews, errors in understanding the questions occurred because the subject's ability was still lacking in understanding the questions and was not used to using the problem-solving process, such as knowing, asking, answering, and concluding. In accordance with research by Murtiyasa & Asiyah (2022) that misunderstandings occur because students do not understand the meaning of the questions. Agree with research by Syahda & Pujiastuti (2020) which states that misunderstandings about questions occur because students do not understand the meaning of the questions given, so students are wrong in taking information about what is known and asked. According to Fauziah & Astutik (2022) errors in understanding the problem can affect the next stage, namely the stages of developing a settlement strategy, carrying out a settlement plan, and re-examining.

Error in devising a plan

Based on table 3 shows the percentage of errors in compiling a settlement strategy of 30.30% with 140 errors. The following description of errors in compiling settlement strategies is shown in Table 5.

Tabel 5. Persentase Kesalahan dalam Menyusun Strategi Penyelesaian

Question Number	Error Description	n	Percentage
1	Students write the wrong formula to be used	1	0,71%
	Students do not write down the formula that will be used	28	20,00%
2	Students write the wrong formula to be used	25	17,86%
	Students do not write down the formula that will be used	8	5,71%
3	Students write the wrong formula to be used	13	9,29%
	Students do not write down the formula that will be used	15	10,71%
4	Students write the wrong formula to be used	16	11,43%
	Students do not write down the formula that will be used	17	12,14%
5	Students write the wrong formula to be used	4	2,86%
	Students do not write down the formula that will be used	13	9,29%

It is known from Table 5 that mistakes in strategizing occur when students write wrongly and do not write formulas to use in solving problems. The most mistakes in compiling strategies came from question number 2 which totaled 33 students. The results of students' strategy mistakes can be observed in Figure 2.

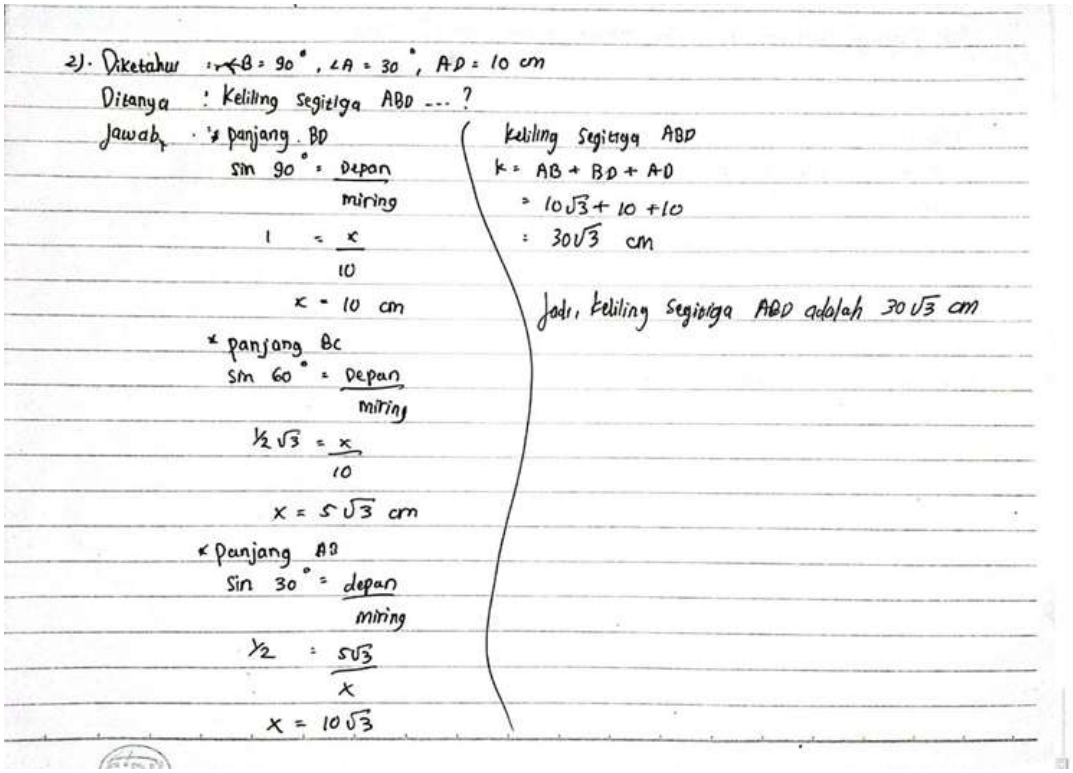


Figure 2. Answers to SP-16

From Figure 2 it appears that SP-16 made a mistake in formulating a settlement strategy, namely SP-16 was wrong in determining the formula to obtain the value of the side lengths of

a right triangle. SP-16 uses a comparison formula $\sin 90^0$ to determine the length of BD, using the comparison formula $\sin 60^0$ to determine the value of the length of BC, and use the comparison formula$\sin 30^0$ to determine the length of AD. SP-16 should use the comparison formula $\sin 60^0$ to determine the length of AB and use the comparison formula $\sin 30^0$ to determine the length of BD, and there is no need to look for the AD value anymore because it is already known. Based on the results of interviews with SP-16, it was found that the subject was confused about applying the trigonometry comparison formula to solve problems. Referring to the results of student interviews, the causative factor for mistakes in strategizing is the ability to apply the trigonometry ratio formula is still lacking. In line with research by Kamila & Adirakasiwi (2021) that student errors at the stage of compiling a solving strategy were caused by students' lack of ability to plan and describe the information contained in the problem into a mathematical formula or model. This also agrees with research by Nurizlan, et al (2022) that students are confused in choosing the formula to use and still have difficulty changing the solution strategy to an arrangement of mathematical models.

Error in carrying out the plan

Based on table 3 shows the percentage of errors in compiling a settlement strategy of 26.19% with 121 errors. The following description of the error in carrying out the settlement plan is shown in Table 6.

Table 6. Percentage of Errors in Implementing the Completion Plan

Question Number	Error Description	n	Percentage
1	The student made a mistake in the counting process	13	10,74%
	Students do not do the counting process	1	0,83%
2	The student made a mistake in the counting process	18	14,88%
	Students do not do the counting process	3	2,48%
3	The student made a mistake in the counting process	26	21,49%
	Students do not do the counting process	6	4,96%
4	The student made a mistake in the counting process	22	18,18%
	Students do not do the counting process	11	9,09%
5	The student made a mistake in the counting process	12	9,92%
	Students do not do the counting process	9	7,44%

It is known from Table 6 that errors in carrying out the settlement plan occur when students are wrong and do not carry out the counting process. Errors in carrying out the

settlement plan were not only made in number 4, but also in problem number 3, which totaled 32 students. The results of errors in carrying out student completion plans can be observed in Figure 3.

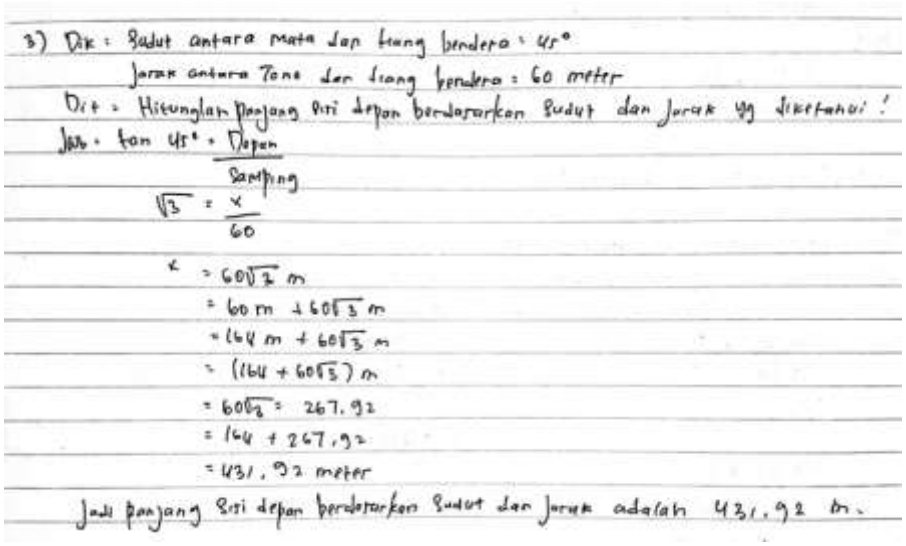


Figure 3. Answers to SP-17

From Figure 3 it can be seen that SP-17 made a mistake in carrying out the settlement plan, that is, it can be seen that the calculation process for SP-17 was wrong when solving the problem. SP-17 throws an error when substituting values $\tan 45^0$. SP-17 substitute value $\tan 45^0$ with $\sqrt{3}$. The students should substitute the value $\tan 45^0$ corresponds to the special angles of the trigonometry, that is 1 not $\sqrt{3}$. This causes errors until the final result is completed. Based on the results of the interview with SP-17, it was found that the subject was hasty and careless in solving the questions. Referring to the results of the SP-17 interview, the factors that caused errors in carrying out the settlement plan were the lack of practice working on trigonometry comparison questions and being careless in the calculation process. According to Kurniawan, et al (2021) the causes of student errors in carrying out settlement plans are haste and a lack of mathematical operation training regarding problem solving. Agree with research conducted by Doren, et al (2019) that the causes of student errors in carrying out the settlement plan, namely lack of ability in the calculation process, haste in the process of solving problems, and lack of accuracy in solving the problems given.

Error in looking back

Table 3 shows the percentage of errors in checking again at 30.52% with 141 errors. The description of errors in checking again is shown in Table 7 below.

Table 7. Percentage of Errors in Rechecking

Question Number	Error Description	n	Percentage
1	Students do not include conclusions in the final answer	14	9,93%
	The student wrote the wrong conclusion in the final answer	8	5,67%
2	Students do not include conclusions in the final answer	23	16,31%
	The student wrote the wrong conclusion in the final answer	11	7,80%
3	Students do not include conclusions in the final answer	16	11,35%
	The student wrote the wrong conclusion in the final answer	6	4,26%
4	Students do not include conclusions in the final answer	22	15,60%
	The student wrote the wrong conclusion in the final answer	13	9,22%
5	Students do not include conclusions in the final answer	24	17,02%
	The student wrote the wrong conclusion in the final answer	4	2,84%

It is known from Table 7 that errors in re-checking occur when students are wrong and do not write their conclusions at the end of the answer. The mistake of checking back the most answers came from question number 4 which totaled 35 students. The results of students' strategy mistakes can be observed in Figure 4.

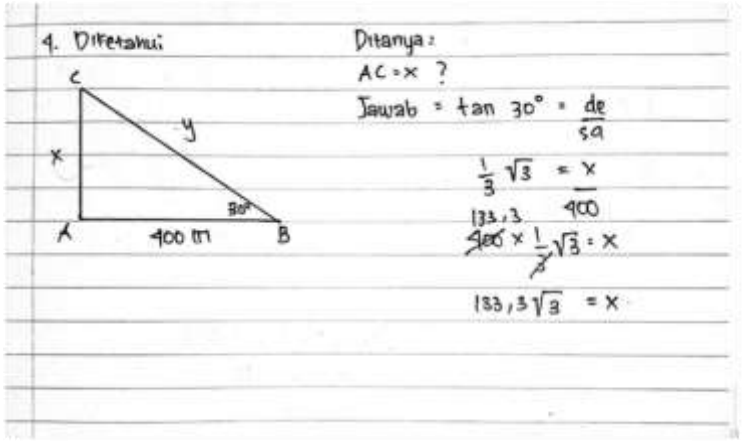


Figure 4. Answers to SP-09

From Figure 4 it appears that SP-09 made a mistake in re-examining, namely not writing a conclusion at the end of the answer. Based on the results of the interview with SP-09, it was found that the subject was not used to it and did not feel the need to write a conclusion at the end of the answer. Referring to the results of the SP-09 interview, the factors causing the misunderstanding of the questions were that students were not used to writing final answers because they felt it was not important to write down final answers, and they thought that it could take time to write conclusions at the end of answers. According to Murtiyasa &

Wulandari (2020) the cause of errors in checking again is that students are not used to writing conclusions (final answers). Agree with Fauziah & Astutik (2022) that students do not write conclusions at the end of completion because students are not used to double-checking the answers they get so students think that re-checking calculation results can take time.

CONCLUSION

Based on the results of research conducted in class X.J SMA N 1 Wonosari, it was concluded that students still make many mistakes in solving trigonometry comparison questions. The mistakes made by students were errors in understanding the problem with an error percentage of 12.99%, errors in formulating a settlement strategy with a percentage of 30.30%, errors in carrying out plans with a percentage of 26.19%, errors in checking again with a percentage as much as 30.74%. The causes of these errors, namely: students cannot understand the purpose of the questions given, students rarely solve problems by knowing, asking, answering, and concluding, students are confused about applying the trigonometry formula to solve problems, students are hasty and careless in solving problems , students are not used to it and feel no need to write conclusions at the end of the answer.

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