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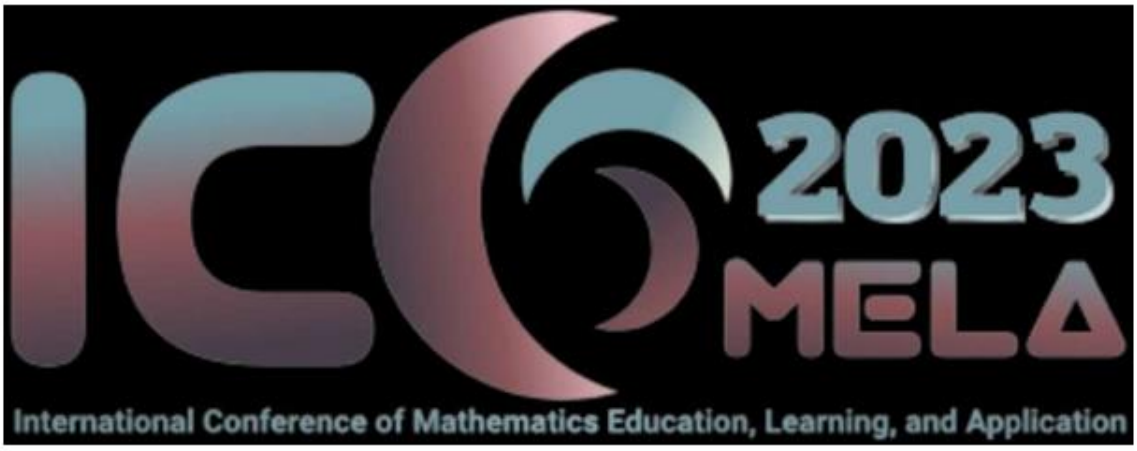
Editors • Dian Kurniati, Rafiantika Megahnia Prihandini, Ridho Alfarisi and Robiatul Adawiyah



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Difference in Results: High School Students' Mathematical Reflective Thinking of Science and Social Studies

Muntazhimah[1, a)], Hidir Efendi[2], Purnama Syaepurohman[1], Slamet[1], Joko Soebagyo[1], Sigid Edy Purwanto[1], Khoerul Umam[1]

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Abstract. A growing body of literature has showed that mathematical reflective thinking ability plays a crucial role in the learning process. Nevertheless, students' mathematical reflective thinking ability are not always in a good condition. Therefor The overarching objective of this qualitative study sought to explore the mathematical reflective thinking abilities of senior high school students in the science and social studies specialization program. A total of ten senior high school students in west java participated in the study. The data collecting used were observation, tests, and interviews. Triangulation strategy used to develop a comprehensive understanding of phenomena. The results showed that senior high school on science program were unable to fulfil all the indicators in each phase of reflective thinking. The phase that was mastered by students is the reacting phase, the phase that is sufficiently mastered by students is the elaborating/comparing phase, while the contemplating phase for students is still diverse. conversely the average subject on social program were only mastered the comparing phase where the subject could explain the answers obtained and could relate the problems asked to the problems they had faced. Furthermore, the reacting and contemplating phases were still not optimal because there were still subjects who did not write down and state what was asked and known and did not make final conclusions correctly.

INTRODUCTION

The COVID-19 pandemic has influenced all sectors globally, including the education sector, to utilize digital technology in their daily lives. The optimal use of digital technology is one of the characteristics of the 4.0 Industrial Revolution[1]. Dealing with the 4.0 Industrial Revolution requires high adaptation and consistency so that careful preparation is a must[2]. One of the important elements to consider is preparing and improving the competence of graduates who have 21st-century skills (Learning and Innovations Skills).

The 21st-century skills have five main domains; one of them is the thinking skill. In addition, the thinking skill is also an aspect of life skills that need to be developed through the educational process[3]–[6]. Through thinking skills, a person can observe and solve all life problems, including mathematics. When a person does mathematics, whether it is only to understand mathematical concepts, use them in solving mathematical problems, or use mathematics in everyday life, of course, must be accompanied by thinking skills. Therefore, thinking skill is essential that for every student at every level of education.

One of the thinking skills included in the Higher Order Thinking Skill (HOTS) is the ability to think reflectively [7]. The reflective thinking ability is called "the capacity of human minds and brains in understanding and creating knowledge" [8]. In comparison, [9] defined the reflective thinking skill as a process of interpreting one experience to the next one by making a deeper understanding of the relationship and connecting other experiences or ideas. Furthermore, it is stated that reflective thinking ability will certainly be critical in solving mathematical problems, called mathematics reflective thinking ability [10]–[12].

The previous research mentioned above has not captured students' mathematical reflective thinking abilities for science and social studies classes, so this research will fill this gap. This research aims to photograph and examine in depth the mathematical reflective thinking abilities of high school students majoring in science and social studies.

METHODS

This study used qualitative research methods. The qualitative research method is one of the methods that can be used to solve a research problem by using these data, such as narratives derived from interviews, observations, analysis of other supporting documents [13].

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This research interprets the qualitative data and describes it in order to get an in-depth picture of the description of the reflective thinking abilities of high school students in trigonometry both Science and Social Studies. This research was carried out at one of the high schools in Indonesia and the participants were 5 students in both class X science and social studies.

Data collection techniques in this study were using written test techniques, interviews, and observations. In the written test technique, the researcher gave two types of written tests, namely the initial mathematical ability test and the mathematical reflective thinking ability test. The mathematical reflective thinking ability test consists of 6 questions which contain material on the sine rule, cosine rule and the area of an arbitrary triangle. This test is then strengthened through interviews. The interview guide consists of 13 questions arranged according to indicators of reflective thinking.

This study uses the reflective thinking phase [14],where there are 3 phases, namely: reacting, elaborating/comparing, and contemplating. The following is a table explaining the indicators of mathematical reflective thinking ability according to [15]:

TABLE 1. Indicators of Mathematical Reflective Thinking Ability

No	Phase	Indicator
1.	*Reacting*	a. State what is being asked. b. State what is known. c. Mention the relationship between what is asked and what is known. d. Being able to explain what is known is enough to answer what is asked.
2.	*Elaborating/Comparing*	a. Explain the answers or solutions that have been obtained. b. Relate the problems asked to the problems that have been encountered.
3.	*Contemplating*	a. Determine the intent of the problem. b. Detect errors in answers. c. Correct and explain if an error occurs in the answer. d. Make the right conclusions.

In this study, the ability to think mathematically reflectively was grouped into 3 categories, namely: reflective, less reflective and non-reflective. Students are said to be reflective if students can do all phases of reflective thinking well; students are said to be quite reflective if students are unable to go through a phase of reflective thinking; and students are said to be less reflective if students are unable to go through one/two phases of reflective thinking and cannot go through one/two phases of reflective thinking [16].

RESULTS AND DISCUSSION

The results section of this research will present the results of research on students majoring in science, then continued with the results of research on social studies students. Five subjects from each department were selected based on several aspects including the results of discussions with mathematics teachers, students' ability to communicate well, and students' willingness to be subjects in this research. analysis of several research findings obtained from answers and interviews conducted with research participants regarding trigonometry comparison material.The results for participants from the science group will be presented first as follows. One of the answers from IPA-1 Participants is as shown in Figure 1 below:

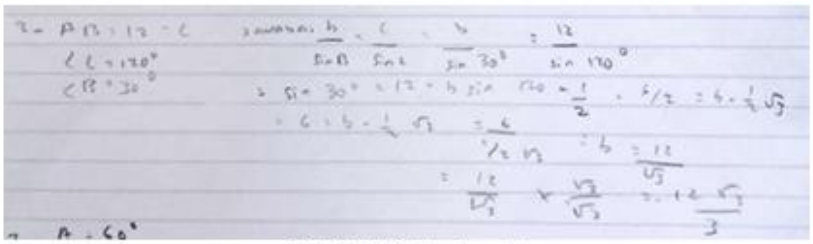


FIGURE 1. IPA-1 work results

Then interviews were conducted with IPA-1 participants as in table 1 below:

TABLE 2. IPA-1 Participant Interview Results

R	: In your answer, number 2 didn't you write down what was asked, right? Can you please state what is being asked and what is known from number 2?
IPA-1	:Known = Angle C 120°, Angle B 30°, Side AB 12cm
R	: Do you think there is a connection between what is asked and what is known?
IPA-1	: Asked? = AC side = b
R	:Then do you think the existing information is enough to answer the question?
IPA-1	:That's enough bro, that's enough

In the reaction phase, in Figure 1, the IPA-1 subject was only able to write down what he knew. However, when the IPA-1 subject was interviewed, he was able to state what was known and what was asked. In the interview excerpt above, it can also be seen that the IPA-1 subject stated that there was a relationship between what was known and what was asked. Furthermore, the IPA-1 subject stated that the information provided in the questions was sufficient to answer the questions given.

In the elaborating/comparing phase, the IPA-1 subject was able to describe the solution process obtained from beginning to end according to Figure 1. RP subject stated that he had never faced a similar problem before.

In the contemplating phase, based on the results of the interview, the IPA-1 subject revealed that he had little understanding of the meaning of the questions given. There are deficiencies in the results of the IPA-1 subject (figure 1), but the IPA-1 subject can detect where the deficiencies or errors are in the answers and is able to correct the errors. Furthermore, the IPA-1 subject was able to make conclusions from the answers even though the conclusions given were not correct.

Based on the analysis above, IPA-1 subjects can go through all the reacting phase indicators, can go through all the elaborating/comparing phase indicators, and can go through all the contemplating phase indicators. From this analysis, the IPA-1 subject can be said to be reflective in its mathematical reflective thinking abilities.

Furthermore, the results of the answers from IPA-2 are as shown in Figure 2 below:

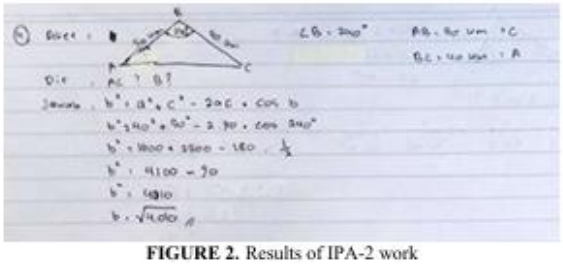


FIGURE 2. Results of IPA-2 work

In the reaction phase, the IPA-2 subject can state what is known and what is asked according to the information in the question. Furthermore, from the results of the interview, the IPA-2 subject said that there was a relationship between

what was known and what was asked and the IPA-2 subject stated that the existing information was sufficient to answer the questions given.

In the elaborating/comparing phase, the IPA-2 subject is able to describe the solution process obtained from start to finish according to Figure 2 and believes the solution is correct. Furthermore, the IPA-2 subject stated that he had never faced a similar problem before.

In the contemplation phase, the IPA-2 subject stated that he understood the questions given. Furthermore, it was shown that the IPA-2 subjects were unable to detect exactly where the error was in their work, but when they were told the location of the error, the IPA-2 subjects were able to correct the error. Based on the results of their work, the IPA-2 subjects did not make conclusions, but when interviewed, the IPA-2 subjects were able to explain the conclusions obtained from their work. The results of interviews conducted with IPA-2 are shown in table 2 below:

TABLE 3. IPA-2 Participant Interview Results

R	: Well, the answer is correct. What is the conclusion of the problem?
IPA-2	: So, the distance from a to c is 10 root 61 km.

Based on the analysis above, the IPA-2 subject can go through all the reacting phase indicators, can go through all the elaborating/comparing phase indicators, and can only go through some of the contemplating phase indicators. From this analysis, the IPA-2 subject can be said to be less reflective in his mathematical reflective thinking abilities.

The results of the answers obtained from IPA-3 research participants are as shown in Figure 3 below:

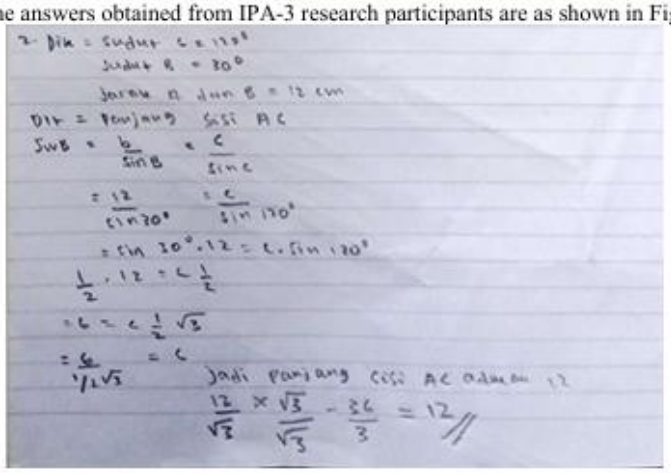


FIGURE 3. Results of IPA-3 work

TABLE 4. IPA-3 Participant Interview Results

R	: So, do you think there is a connection between what is known and what is asked?
IPA-3	: There is
R	:Okay. So do you think the existing information is sufficient to answer this question?
IPA-3	: Already

In the reaction phase, as seen from Figure 3, the IPA-3 subject was able to state what was known and what was asked. During the interview, the IPA-3 subject stated that there was a relationship between what was known and what was asked. Furthermore, the IPA-3 subject stated that the available information was sufficient to answer the questions.

In the elaborating/comparing phase, the IPA-3 subject is able to describe the solution process obtained from start to finish according to Figure 3 and believes the solution is correct. However, the IPA-3 subject stated that he had never faced a similar problem before.

In the contemplating phase, from the results of the interview, the IPA-3 subject stated that he understood the meaning of the questions given. The IPA-3 subject was confident in the answers he had worked on and said that he had checked his answers again. In Figure 3 there are slight errors in the results of the IPA-3 work, but IPA-3 cannot detect the location of the error in the answer and also cannot correct the error. Furthermore, the IPA-3 subjects were able to make correct conclusions. The following is an excerpt from the interview:

TABLE 5. IPA-3 Participant Interview Results

R	: For number 1, do you understand what the question means? What is being asked?
IPA-3	: Distance between city A and city B
R	: Then for number 2, have you checked the answer yet?
IPA-3	: Already
R	: Are you sure that this answer is correct? Is there something wrong or not?
IPA-3	: I don't think so
R	: In number 2, you made a mistake in the final answer, in the part about rationalizing fractions. Do you think you can fix that?
IPA-3	: The result is 12 roots 3 over 3 ka
R	: Can you simplify the fractions further?
IPA-3	: You can't do it

Based on the analysis above, the IPA-3 subject can go through all the reacting phase indicators, can go through all the elaborating/comparing phase indicators, and can only go through some of the contemplating phase indicators. From this analysis, the science-3 subject can be said to be less reflective in his mathematical reflective thinking abilities

Then for the science subject-4. The results of the answer can be seen in Figure 4 below:

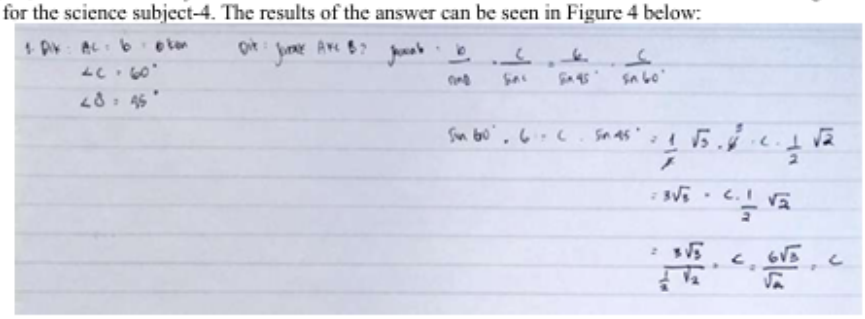


FIGURE 4. IPA-4 work results

In the reaction phase, in Figure 4, the Science-4 subject was able to state what was known and what was asked on the answer sheet. From the interview results, it can be seen that the IPA-4 subjects revealed that there was a relationship between what was known and what was asked. Furthermore, the IPA-4 subject stated that the information provided in the questions was sufficient to answer the questions given.

In the elaborating/comparing phase, the IPA-4 subject is able to describe the solution process obtained from start to finish according to Figure 4 and believes the solution is correct. The IPA-4 subject stated that he had never faced a similar problem before.

In the contemplating phase, the IPA-4 subject stated that he understood a little about the meaning of the questions. Then, there were some shortcomings in the results of his work or it could be said that the answer he gave was not correct. The IPA-4 subject can mention the shortcomings of his work, but he cannot correct his answer. In the results of his work, the IPA-4 subject did not write conclusions in all his answers, but during the interview the IPA-4 subject was able to draw appropriate conclusions from the answers he gave and was confident in his conclusions.

TABLE 6. IPA-4 Participant Interview Results

R	: Then for number 1, can you try to explain the answer you gave?
IPA-4	: here I can explain that this was well explained by given answers.
R	

	: This means that for number 1, you are still not rational enough for the final result,
IPA-4	right?
	: Yes, because as I see that here.
R	: But if for example, I told you to rationalize the end result, could you? How do you rationalize it, you know?
IPA-4	: No, sir.

Based on the analysis above, the IPA-4 subject can go through all the reacting phase indicators, can go through all the elaborating/comparing phase indicators, and can only go through some of the contemplating phase indicators. From this analysis, the science-4 subject can be said to be less reflective in his mathematical reflective thinking abilities.

And for the final participant from the science department, namely IPA-5. The results can be seen in the table below:

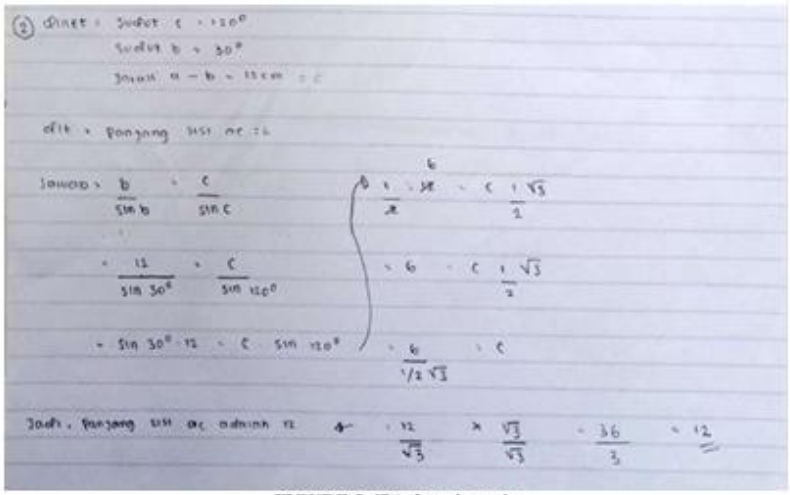


FIGURE 5. IPA-5 work results

Based on the results of the work above, IPA-5 shows a reaction phase, namely being able to write down what is known and what is asked according to the information available on the problem given. The IPA-5 subject revealed that there was a relationship between what was known and what was asked. The interview results showed that the IPA-5 subjects felt that the existing information was sufficient to solve the problems in the questions.

In the elaborating/comparing phase, the IPA-5 subject is able to describe the solution process obtained from start to finish according to Figure 5 and believes the solution is correct. Furthermore, the IPA-5 subject stated that he had never faced a similar problem before.

In the contemplating phase, based on the results of the interview with the IPA-5 subject, he said that he understood the meaning of the questions. Based on the results of the work on the IPA-5 subject above, a few errors were found in the answers. However, IPA-5 cannot detect where the error is in the answer. IPA-5 subjects cannot correct errors in their work. Based on the results of the IPA-5 written test, you can draw conclusions from existing problems correctly and precisely. The following is an excerpt from the interview:

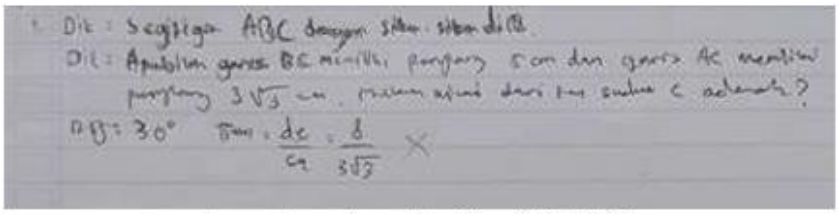
TABLE 7. IPA-5 Participant Interview Results

R	: I want to ask again, do you think your answer number 2 is correct or not?
IPA-5	: Wait a minute, bro
R	: OK
IPA-5	: This one is wrong, right? (while showing the answer) it should be $6=1\sqrt{3}$, right?
R	: No, that's correct

IPA-5	: Ohh, I thought I was wrong
R	: So you think your answer is correct, right?
IPA-5	: That's right bro, is it really wrong, bro?

Based on the analysis above, the IPA-5 subject can go through all the reacting phase indicators, can go through all the elaborating/comparing phase indicators, and can only go through some of the contemplating phase indicators. From this analysis, the IPA-5 subject can be said to be less reflective in his mathematical reflective thinking abilities.

The next presentation of the results is for social studies students. For the social studies subject-1, of the five questions given, they only worked on two questions, namely numbers 1 and 2, which can be seen in Figure 1 below:

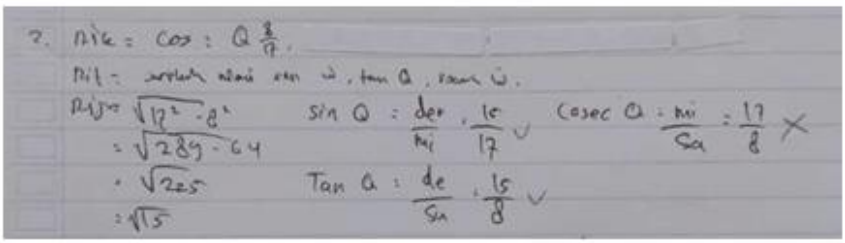


Answer to question number 1 from Subject IPS-1

Translation

Given: Triangle ABC with a right angle at B.
Asked: If line segment BC is 5 cm long and line segment AC $3\sqrt{3}$ cm long, what is the value of tan C?

(a)



Answer to question number 2 from Subject IPS-1

Translation

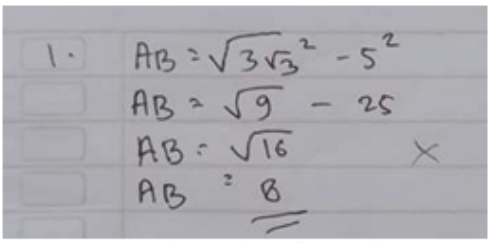
Given: $Cos = Q\frac{8}{17}$
Asked: Value of $Sin\ Q, \tan Q, cosec\ Q$

FIGURE 6. IPS-1 Subject Answers

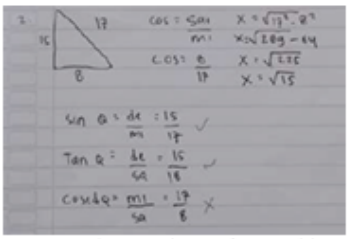
Based on Figure 1, IPS-1 subjects were unable to fulfill the indicators of reflective thinking in the reaction phase. This is because IPS-1 is less able to express correctly what is known and asked in the question clearly, knowing that there is a relationship between what is being asked and what is known but cannot be stated. IPS-1 also confirms that what is known is sufficient to answer what is asked. In the IPS-1 comparing phase, we were unable to explain the answers to the IPS-2 questions obtained. IPS-1 can relate the IPS-2 question being asked to the IPS-2 period they have encountered by mentioning the material, but the similarities are not mentioned in detail. Then IPS-1 does not go

through the contemplating phase because it cannot determine mIPS-3ud from permasaIPS-2an, let alone detect saIPS-2an errors in the answers and cannot correct answers when saIPS-2an errors occur. Apart from that, IPS-1 subjects were also unable to make correct conclusions. Based on this analysis, it can be concluded that the IPS-1 subjects did not fulfill the reacting, comparing and contemplating phases. Thus, the IPS-1 subject's mathematical reflective thinking is still very lacking.

The IPS-2 subject was also only able to answer two of the five questions which can be seen in Figure 2 below:



Answer to question number 1 from Subject IPS-2

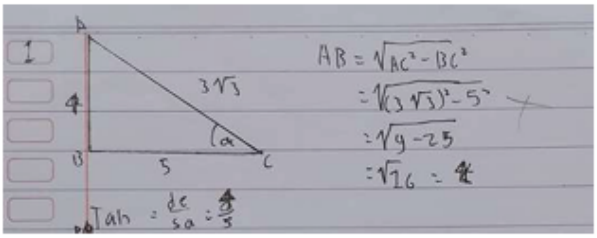


Answer to question number 2 from Subject IPS-2

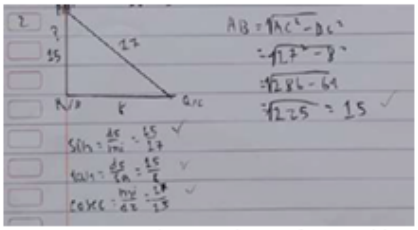
FIGURE 7. IPS-2 Subject Answers

Based on Figure 2, in the reaction phase IPS-2 does not write down what is known and asked in the questions, but during the interview IPS-2 can mention it. IPS-2 knows that there is a relationship between what is asked and what is known but cannot explain it, IPS-2 also emphasizes that what is known is sufficient to answer what is asked. Furthermore, in the comparing phase, IPS-2 was less able to explain the answers to the IPS-2 questions obtained. IPS-2 can relate the IPS-2 period being asked to the IPS-2 period that has been encountered by mentioning the material, but the similarities are not mentioned in detail. In the contemplating phase, for number 1 IPS-2 could not determine mIPS-3ud from problemIPS-2an well, but for number 2 IPS-2 was able to determine mIPS-3ud from problem. Apart from that, IPS-2 subjects cannot detect errors in answers and cannot correct answers when an error occurs. IPS-2 also cannot draw conclusions correctly.

The IPS-3 subject also only answered two of the five questions which can be seen in Figure 3 below:



Answer to question number 1 from Subject IPS-3



Answer to question number 2 from Subject IPS-3

FIGURE 8. IPS-3 Subject Answers

Based on Figure 3, in the reaction phase IPS-3 did not write down what was known and asked in the questions, but when interviewed IPS-3 was able to mention it. Knowing that there is a relationship between what is asked and what is known but cannot explain it, IPS-3 also emphasizes that what is known is sufficient to answer what is asked. In the comparing phase, number 1 IPS-3 was unable to explain the answers to the problems obtained, while number 2 IPS-3 was able to explain the answers obtained correctly. IPS-3 can relate the problem being asked to problems that have been faced by mentioning the material, but the similarities are not mentioned in detail. In the contemplating phase, IPS-3 can determine mIPS-3ud from the problem well, but IPS-3 subjects cannot detect errors in answers and cannot correct answers when errors occur. Then, the IPS-3 subjects were also unable to draw conclusions correctly for number 1, while number 2 IPS-3 was able to draw conclusions correctly.

For the IPS-4 subject, you are able to do one of the five questions available. The answer can be seen in Figure 4 below:

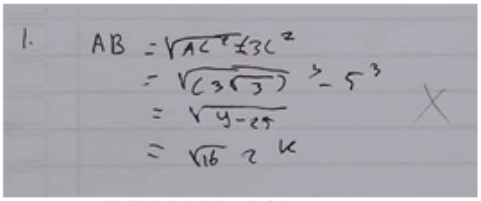


FIGURE 9. IPS-4 Subject Answers

Based on Figure 4, in the reaction phase IPS-4 did not write down what was known and asked in the questions and when interviewed was also unable to mention it. Knowing that there is a relationship between what is asked and what is known but cannot explain it, IPS-4 also emphasizes that what is known is sufficient to answer what is asked. IPS-4 does not go through the comparison phase, because it cannot explain the answers to the problems obtained, it cannot relate the problems asked to those that have been faced. IPS-4 also does not go through the contemplating phase because IPS-4 cannot determine the meaning of the problem, let alone detect errors in answers, and cannot correct errors in answers. Apart from that, IPS-4 also cannot make conclusions correctly because it does not complete the answer correctly.

For the IPS-5 subject, they only do one of the five questions given as in Figure 10 below:

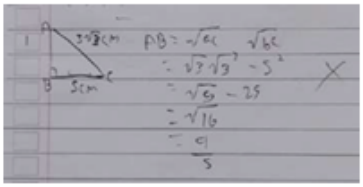


FIGURE 10. IPS-5 Subject Answers

Based on Figure 8, in the reaction phase IPS-5 cannot write down what is known and asked in the questions. Knowing that there is a relationship between what is asked and what is known but cannot explain it, IPS-5 also emphasizes that what is known is sufficient to answer what is asked. In the comparing phase IPS-5 cannot explain the answers to the problems obtained, it can relate the problem being asked to problems that have been faced by mentioning the material, but the similarities are not mentioned in detail. IPS-5 does not go through the contemplating phase because IPS-5 cannot determine the meaning of the problem, let alone detect errors in answers and cannot correct errors in answers. Apart from that, IPS-5 also cannot draw conclusions correctly because it does not solve the questions correctly.

From the research discussion regarding students' mathematical reflective thinking abilities in terms of low prior knowledge, it can be concluded that students' mathematical reflective thinking abilities are still low.

CONCLUSION

Based on the results and discussion in this study, the conclusion of this study are The results showed that senior high school on science program were unable to fulfil all the indicators in each phase of reflective thinking. The phase that was mastered by students is the reacting phase, the phase that is sufficiently mastered by students is the elaborating/comparing phase, while the contemplating phase for students is still diverse. conversely the average subject on social program were only mastered the comparing phase where the subject could explain the answers obtained and could relate the problems asked to the problems they had faced. Furthermore, the reacting and contemplating phases were still not optimal because there were still subjects who did not write down and state what was asked and known and did not make final conclusions correctly.

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