Exploring the Students' Scientific Communication-Ability in the Learning of Direct Current of Physics

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ABSTRACT

This descriptive-survey research aims to explore the scientific communication skills of students at Public Islamic Senior High School (MAN) 1 Pontianak on direct current electricity. A sample of 106 students was drawn using a simple random technique. Data were collected using a written essay-achievement test consisting of 16 questions with a duration of 120 minutes. The scientific communication skills studied consist of; (1) create tables/graphs, (2) describe tables/graphs, (3) interpret tables/graphs, and (4) draw conclusions from tables/graphs of direct current electricity material. Based on data analysis, it was found that the scientific communication skills of students at MAN 1 Pontianak in Electric Current were in the medium category and there were different in terms of its aspects. Scientific communication skills are also influenced by students' mastery of teaching materials. These findings can be taken into consideration for improving learning practices in schools.

Keywords: explore; scientific communication ability; direct current electricity

INTRODUCTION

In the 21st century education system, students are expected to be able to master four main skills, namely; critical thinking and problem solving, collaboration, creative and innovative, and communication. These skills are very important in every aspect of global life (Soh et al., 2010). Thus, the education system does not only emphasize mastery of material, but also mastery of skills. Students' learning success is no longer seen from how much students master the concepts of teaching material, but also soft skills (Yunarti, 2016), one of which is communication skills. According to Dani Or (2021), the path of scientific communication are: (1) define the question; (2) gather information and resources; (4) formulate hypothesis; (5) perform experiment & collect data; (6) analyze data; (7) interpret and draw conclusions for new hypotheses; (8) publish/communicate results

Communication is a basic skill that must be mastered by every individual to convey a message to the recipient of the message by paying attention to ethics and rules in communication so that communication does not harm the recipient (Sandy et al., 2009). Communication skills need to be trained and developed while students are in education (Dewi, 2022).

In Minister of Education and Culture concerning Implementation of the 2013 Curriculum, it is emphasized that communication skills need to be one of the goals of every learning process in schools. Students must have language skills to communicate and reason according to their objectives. Students must have the ability to understand, process, interpret and evaluate and be able to write down ideas, thoughts, views and metacognitive knowledge in the learning process. Communication skills are one of the competencies used to convey thoughts and ideas in various life situations. Teachers not only act as providers of information (transfer of knowledge), but also as a motivator for students in learning (stimulation of learning) so that students can construct their own knowledge through various activities including communication aspects (Umar, 2012).

The results of the 2000-2018 PISA survey show that Indonesia is a country that has low scientific competence (Kalsum et al., 2023). These results also reflect that science learning in Indonesia has not been able to empower students' scientific communication skills. The ability to communicate in accordance with science is called scientific communication (Hybels et al., 2007; Auliasari et al., 2019). Scientific communication

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emphasizes students to play a more active role in the learning process so that students not only memorize formulas and write answers but also understand the process of getting those answers. Scientific communication skills include cognitive processes, classifying and making tables so that scientific communication skills Students can be measured using written tests in the form of essay test questions. (Indrawati & Wardono, 2019; Auliasari, 2019). One form of scientific communication ability is the ability to interpret or describe written data (in the form of tables, graphs, diagrams) and represent it in the form of verbal information and the ability to make conclusions (Nurlaelah et al., 2020).

According to Sitompul (2022), there is a relationship between multiple representation abilities and communication abilities. In scientific communication, the ability to interpret graphics is needed by students and teachers or prospective teachers (Kilic et al., 2012). A person's understanding of graphic representation is related to understanding a concept and this is an important skill in scientific concepts. Graphics are a type of representation that functions to summarize data, process and interpret new information from complex data. Graphs are often considered a mathematical tool because communicating through graphic representations requires mathematical competencies such as visual perception, logical thinking, plotting data, predicting line movements, deducing relationships between variables and others (Kilic et al., 2012). Apart from the ability to represent graphics, scientific communication skills that are also needed by students are the ability to describe tables/pictures/diagrams in the form of verbal information, the ability to interpret and the ability to make conclusions (Pane et al.,2020).

One of the physics materials that requires scientific communication skills is direct current electricity. Unfortunately, the scientific communication skills of high school students in many schools in Indonesia, regarding this material, are still low (Kurniawan, 2013; Puspandari, 2018; Kilic et al., 2012; Mustain, 2015; Levy, 2009; Nurlaelah, 2003; Akbar & Delvira, 2022), which also occurs in many schools in Pontianak. Based on the results of an interview with one of the physics teachers, the information was obtained that many students were unable to describe unidirectional electric circuit diagrams,for example; a graph of the relationship between voltage and current as a form of visualization of the magnitude of the comparison between voltage and electric current. Many students experienced difficulty in conveying their opinions and ideas during the learning process. Students also still had difficulty observing and writing down observational data from experiments that have been carried out. Apart from that, students are not yet able to represent data from observations or experiments in other forms such as tables and graphs.

Based on searches of several journals, it is believed that there has not been much research that reveals the profiles of aspects of high school students' scientific communication abilities in direct electrical material and the differences between these aspects. Which aspect of scientific communication in direct current material is not clear and still questionable. In fact, information about the low scientific communication skills of high school students in detailed direct electrical material can be followed up by teachers to carry out remediation and improve learning practices in schools. Thus, this research is considered rational to carry out. The main focus of this research is to explore aspects of scientific communication capabilities in the learning of direct current.

METHOD

A survey-descriptive research was applied in this study (Sugiyono, 2018). The target population in this research is all students in class The number of samples taken (n) using the simple random technique (Sugiyono, 2018), by using the Slovin's formula:

$$n = \frac{N}{1 + N(e)_2}$$

$$n = \frac{144}{1 + 144(0.05)^2}$$

$$n = 105.88 = 106$$

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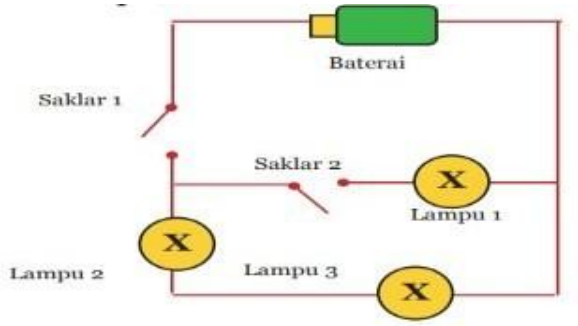
The measurement technique used for gathering data in the form of an essay achievement test with a total of 16 questions which were developed by the researcher himself by adapting to the scientific communication ability indicators used with a grid which can be seen in Table 1. Scientific communication abilities in this research include; (1) ability to create tables/graphs; (2) the ability to describe tables/pictures/diagrams in the form of verbal information; (3) ability to interpret; and (4) the ability to make conclusions. The test is given with a duration of 3 x 40 minutes.

One example of a test question (number 6), to measure the ability to describe tables/graphs is as follows;

Below is a direct current electric circuit consisting of three lamps(lampu), two switches (saklar), and an electric current source (baterai).



From the series above, determine what would happen if:

1. Switch 1 is open and switch 2 is closed
2. Switch 2 is open and switch 1 is closed
3. Switch 1 is closed and switch 2 is closed

Table 1. Blueprint of Scientific Communication Test

No.	Aspects of Scientific Communication	Indicators	Items Number
1.	Create the tables/graphs	To create the tables/graphs of Ohm's law, the relationship between voltage (V) and resistance (R), the relationship between current strength (I) and resistance (R), and power (P) and resistance (R).	1,2, 3, 4
2.	Describe tables/pictures/diagrams in the form of verbal information.	To describe verbally the tables/graphs of Ohm's law, the relationship between voltage (V) and resistance (R), the relationship between current strength (I) and resistance (R), and power (P) and resistance (R) .	5,6, 7, 8
3.	Interpret the tables/pictures/diagrams	To interpret the tables/graphs of Ohm's law, the relationship between voltage (V) and resistance	9,10, 11,12
		(R), the relationship between current strength (I) and resistance (R), and power (P) and resistance (R) .	
4.	Make conclusions	To draw a conclusion of the tables/graphs of Ohm's law, the relationship between voltage (V) and resistance (R), the relationship between current strength (I) and resistance (R), and power (P) and resistance (R) .	13,14, 15,16

To give scores to students' test answers, a rubric is used as explained in Table 2. The maximum score obtained by students is (32/16 items x2) x 100 = 100.

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Table 2. Rubric for Scoring Scientific Communication Ability

Score	Rubrics
0	No answer at all or all answers are wrong
1	There is an explanation of the relationship between tension in the graph or image which is correct but does not make the graph or graph wrong. Or, there is no explanation of the relationship between the voltage between the electrical parameters of the transfer that is correct or the explanation is wrong
2	There is a correct explanation of the relationship between the voltage in the line or the right picture, you can make a graph. And, there is an explanation of the relationship between voltage and electrical parameters which is correct according to scientific concepts.

The validity of the description test instrument was tested using the *Aiken V* construct validity test after being weighed or validated by an expert. Obtained construct validity coefficient of 0.79 (high). The test reliability test used the *Cronbach's Alpha*, which was obtained at 0.84 (the question items were declared reliable in the high category).

To describe the categories of scientific communication abilities in direct current electricity, student test answer scores were analyzed descriptively using Table 3.

Table 3. Category of Scientific Communication Ability

Score Interval	Category
$\times > \bar{x} + 0.5$ SD	High
$\bar{x} - 0.5$ SD $\leq x \leq \bar{x} + 0.5$ SD	Medium
$\times < \bar{x} - 0.5$ SD	Low

To analyze the differences in scientific communication abilities in direct current electricity material in terms of aspects of scientific communication abilities, the data were analyzed using one-way ANOVA (if the data was normally distributed) or the Kruskal-Wallis test (if the data was not normally distributed).

RESULTS

Profiles of Scientific Communication Ability

Based on data analysis, standard deviation (SD) and average (Mean) research test scores were obtained to classify students' scientific communication abilities into 3 (three) categories, namely high, medium and low. It was found that the category of scientific communication skills in each aspect, as shown in Table 4.

Table 4. Profiles of Students' Scientific Communication-Ability in terms of Its Aspects

Aspects of Scientific Communication	Mean Score	Category
Create the tables/graphs	80.66	High
Describe tables/pictures/diagrams in the form of verbal information.	61.32	Moderate
Interpret the tables/pictures/diagrams	47.29	Low
Make conclusions	51.06	Low
Total	60.08	Moderate

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From Table 4 above shows that the total average score for scientific communication skills is 60.88 (in the medium category). In detail, the highest aspect of students' scientific communication abilities in direct current materials is the ability to make tables/graphs (average = 80.66) and the lowest is the aspect of interpreting ability (average = 47.29). If we look at the number of students per level of student scientific communication ability (high, medium, low) in each aspect, the profiles are obtained as presented in Table 5.

Table 5. Profiles of Students' Scientific Communication-Ability

Aspects of Scientific Communication	**High (%)**	**Moderate (%)**	**Low (%)**
Create the tables/graphs	(58%)	(22%)	(6 %)
Describe tables/pictures/diagrams in the form of verbal information.	(36%)	(15%)	(10%)
Interpret the tables/pictures/diagrams	(21%)	(18%)	(8%)
Make conclusions	(30%)	(19%)	(2%)
Total	(60 %)		

From Table 5 above, it can be seen that the better the mastery of direct current electricity teaching material, both concepts and principles, the better the students' scientific communication skills in all aspects. In other words, the scientific communication ability is also influenced by mastery of teaching material.

Differences of Scientific Communication-Ability among its Aspects

Because scientific communication skills consist of 4 (four) aspects and after being tested using the Kolmogorov test it was concluded that the scores had a non-normal distribution, the difference tests were analyzed using Kruskal-Wallis nonparametric statistics (*H* test) and the output is presented in Table 6.

Table 6. Results of Differences Test of Scientific Communication-Ability among its Aspects

Aspects of Scientific Communication	**Mean**	**H-*value***	**Asymp. Sig**
Create the tables/graphs	80.66	79.99	0.000
Describe tables/pictures/diagrams in the form of verbal information.	61.32		
Interpret the tables/pictures/diagrams	47.29		
Make conclusions	51.06		

Because the asymp value sig. (p) = 0.000 < α = 0.05, then Ho is rejected. It was concluded that there were differences in students' scientific communication abilities in terms of their aspects. In detail, after using the UMann Withney test, it can be concluded as follows;

1. Students' scientific communication skills in the aspect of the ability to make tables/graphs are higher than the other three aspects.
2. Students' scientific communication skills in the aspect of the ability to describe tables/pictures/diagrams in the form of verbal information are not significantly different from the ability to make conclusions.
3. Students' scientific communication skills in the aspect of interpreting ability are lower than the other three aspects.

DISCUSSION

Profiles of Scientific Communication Ability

The research concluded that scientific communication skills in direct current electricity totally are in the medium category. The scientific communication capabilities of direct current electricity per aspect are discussed below.

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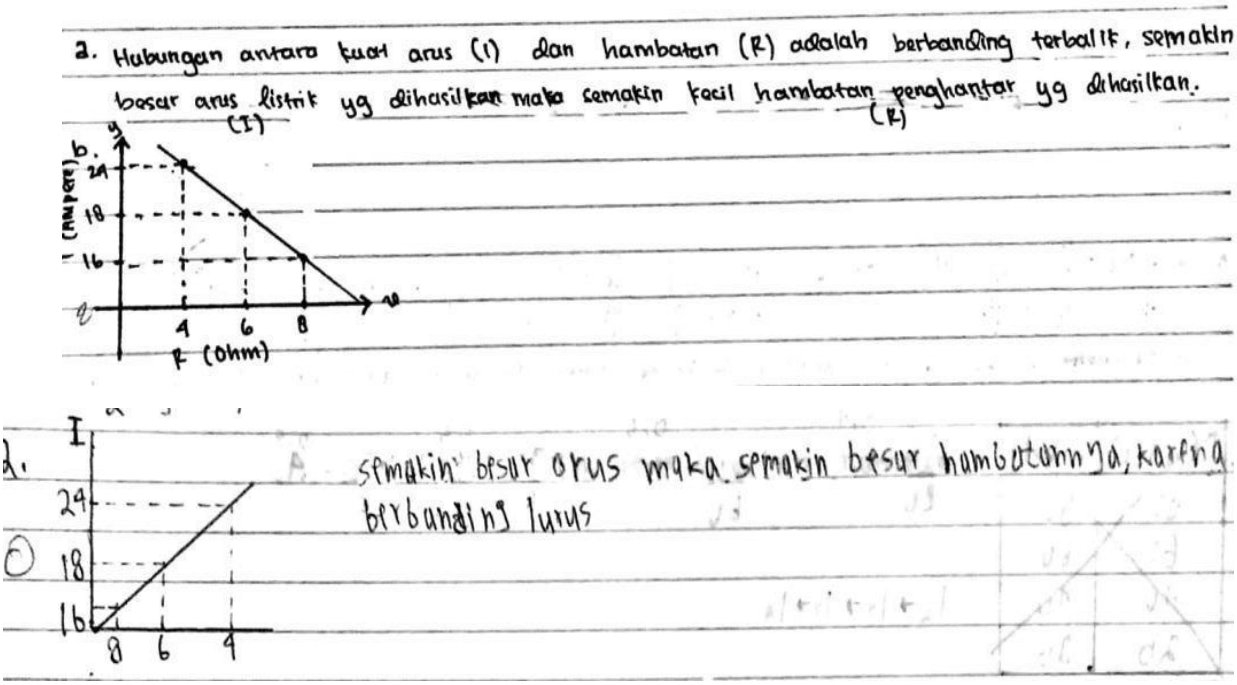
Ability to create the tables/graphs

In the aspect of the ability to make tables/graphs, students are asked to change the form of a relationship into a graph that shows the same relationship in the table. In the process of collecting data, researchers found that students could solve questions on the aspect of the ability to make tables/graphs well. This can be seen from the results of solving questions that students have carried out. However, there are also students who experience difficulty in solving the questions given regarding aspects of making tables/graphs. The results of solving questions carried out by students can be seen in Figure 1.

Figure 1. An exemplar of student's answer regarding the ability to create the tables/graphs



Based on Figure 1a, it can be seen that there are students who are able to solve the questions well. Students can understand the question and are able to explain the relationship between current (I) and resistance (R). Students can also graph the relationship between (I) and obstacles (R) correctly. However, there are also students who are unable to solve the questions (as seen in Figure 1.b).

The findings of this research are in line with several previous findings (Mustain, 2015; Nurlaelah at al., 2020; Akbar & Delvira, 2022) and it was also found that the majority of students (more than 50% of the sample) had difficulty understanding pictures and graphs. Theoretically, reading and making tables/graphs is still considered difficult by many high school students. by students. Akbar (2022) states that making tables/graphs can train students' thinking skills, develop memory and the ability to define part by part what is in the question. Students need to be trained to process data presented correctly from tabular form to graphical form or vice versa.

Mustain (2015) confirmed that the presentation of graphs, data tables, symbols, maps and diagrams consisted a certain information, organizes data showed the relationship between patterns and communicates scientific knowledge. Many scientists carried out some demonstrations in various presentations of writing graphs and tables. They created and connected to express ideas, interpreted the meaning, explained phenomena, made predictions and used in communication (Kozma et al., 2000; Mustain, 2015).

Ability to describe tables/pictures/diagrams in the form of verbal information

The findings of this research showed that there are still many students who are not able to describe the meaning of questions correctly. This can be seen from the problem solving in Figures 2a, 2b.

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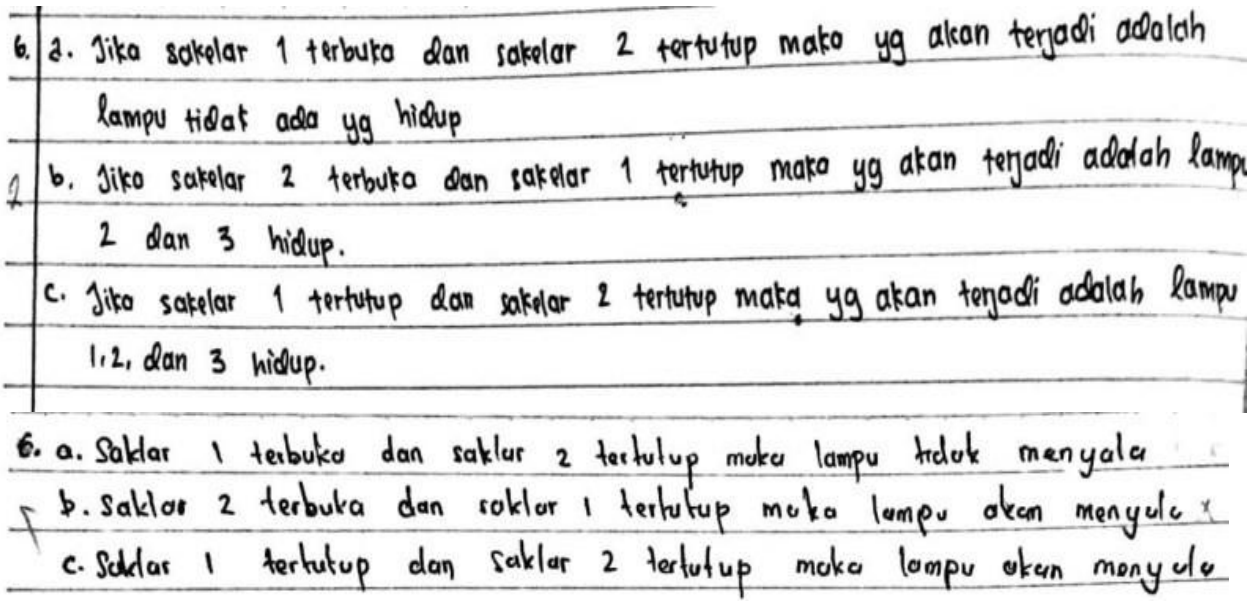
Figure 2. An exemplar of student's answer regarding the ability to describe the tables/graphs



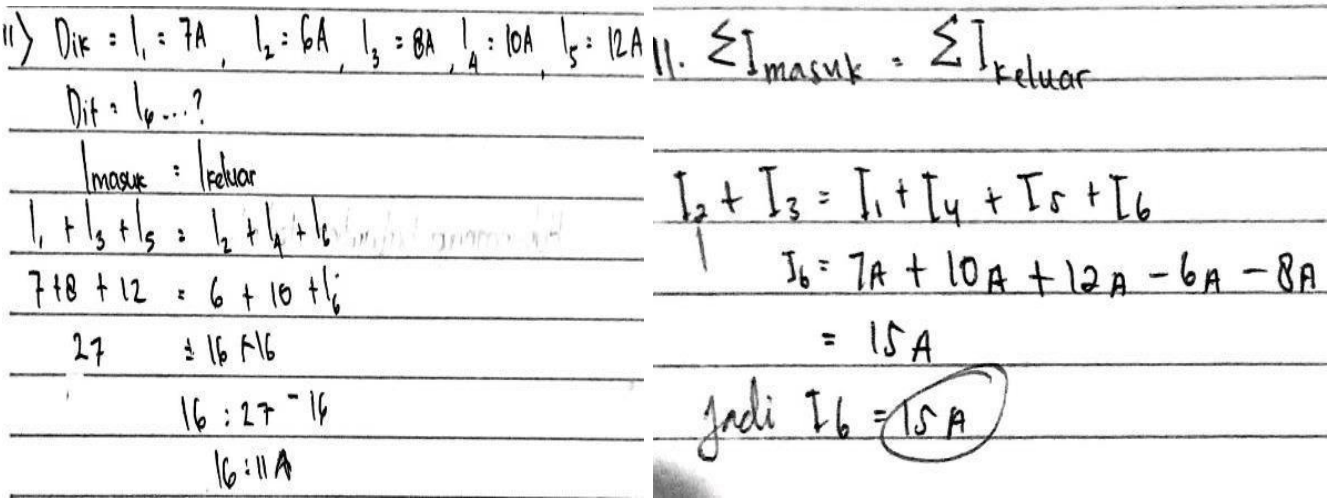
In the test questions, students are asked to describe how the light will turn on if there is an open electrical circuit or a closed electrical circuit that carries an electric current. From the questions given, there were students who understood the meaning of the question and the picture of the electrical circuit given so that they were able to answer correctly as in Figure 2a. However, there are also students who still do not properly understand the meaning of the questions asked (Figure 2b).

This finding is in line with research by Mustain (2015) which found that the majority of students had difficulty reading/describing tables/pictures.Theoretically, according to Aristotle's statement (in Hikmat & Efendi, 2011), "without pictures, it is impossible for humans to think", so that when a concept has been changed to a visual format, it will be easier for students to accept the concept well because it In essence, humans are visual learning creatures. Yusup (2009) emphasized that skilled students often using qualitative representations, including using pictures, graphs and diagrams.

Ability to interpret tables/pictures/diagrams

The research found that students' scientific communication skills in the aspect of interpreting ability were lower than the other three aspects. The majority of students have not been able to solve the questions correctly. Examples of students' problem-solving results can be seen in Figures 3a and 3b.

Figure 3. An exemplar of student's answer regarding the ability to interpret the diagram



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In Figure 3a, students can identify the data known in the question and what is asked in the question clearly. Students can also determine the mathematical equations that will be used to solve problems and carry out calculations correctly. However, in Figure 3b, students experience difficulty in carrying out calculations. This is in line with research by Mustain (2015), which concluded that the majority of students cannot interpret graphs and data. Students do not understand how the relationships between variables in data and graphs. In general, low interpreting abilities are caused by students' very low conceptual abilities and a lack of self-training to interpret data correctly (Tamyiz & Yusup, 2020). Yustiandi & Saepuzaman (2017) stated that graphic interpretation is a basic ability that must be mastered by a scientist (scientist). Creating and interpreting graphs is very important because it is part of an experiment or the heart of physics which is closely related because physics cannot be separated from a collection of experimental data that must be interpreted.

Ability to draw the conclusions

To make conclusions, students must be able to understand the meaning of the questions well so that students can solve the questions correctly. Examples of the results of students' work on questions in the aspect of making conclusions can be seen in Figures 4a, 4b.

Figure 4. An exemplar of student's answer regarding the ability to draw conclusion

Figure 4a is the right answer

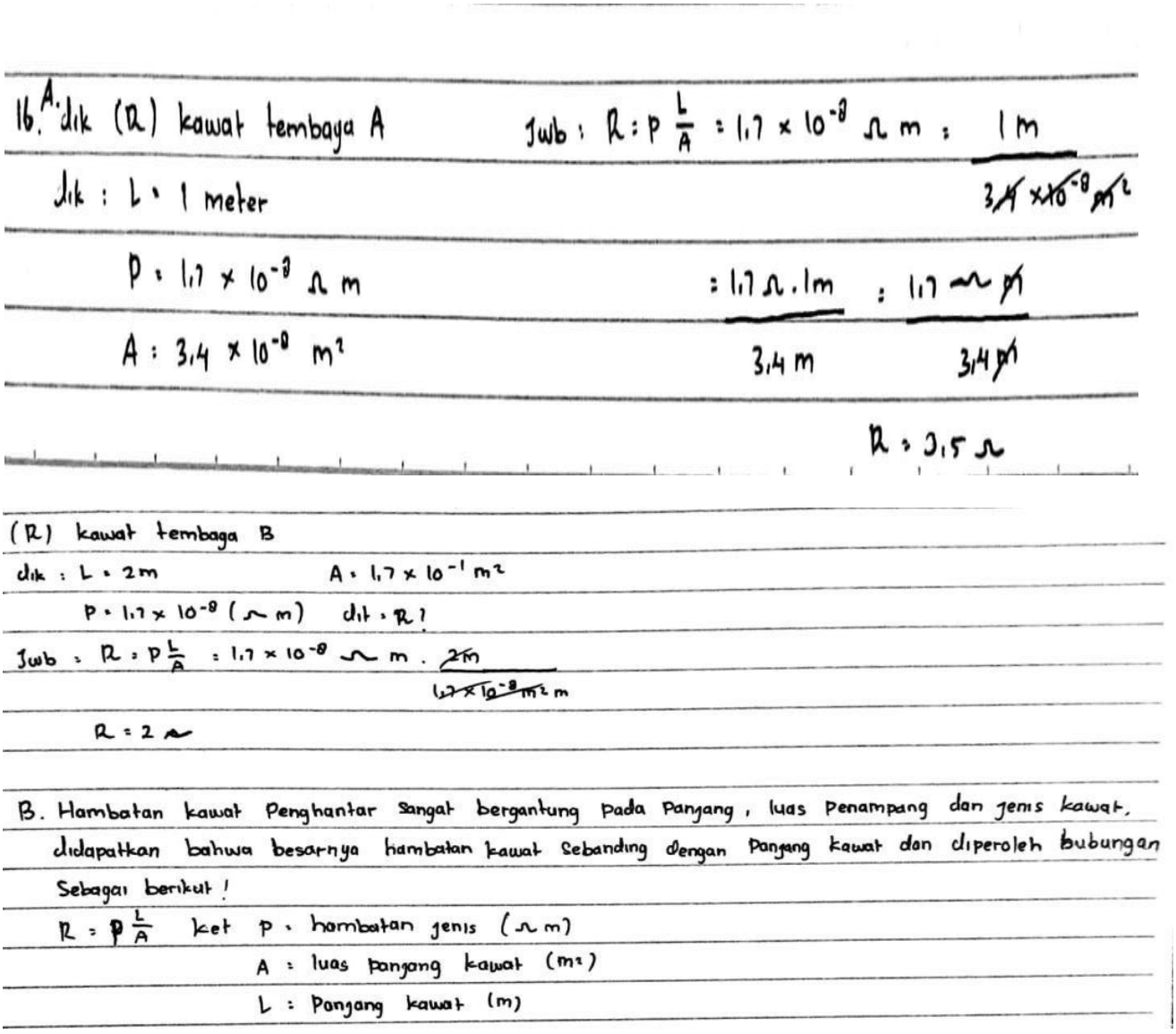

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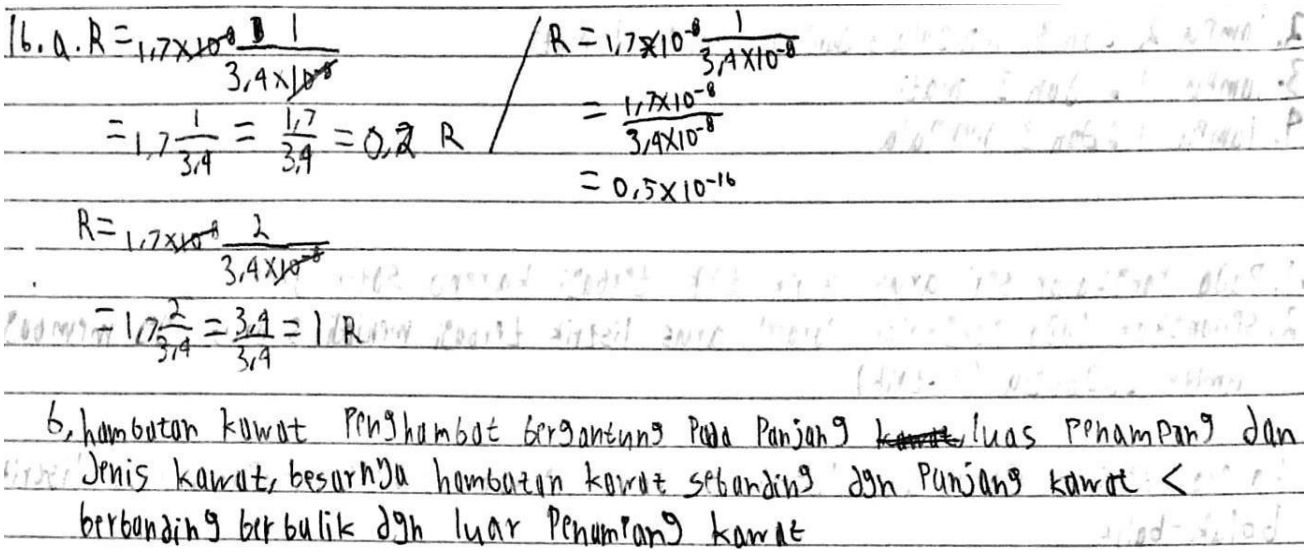
Figure 4b**.** is the wrong answer



In Figure 4a, students could answer the questions systematically and could provide appropriate conclusions regarding the questions given. However, in Figure 4b, students have not been able to conclude the questions given. Students also still experience difficulties in working on calculation questions so that the answers given by students are still wrong. Apart from that, based on the answers given by students, they still make mistakes in giving the units of existing quantities. Where the correct resistance unit is Ohm (Ω) not R.

The findings of this research are in line with research by Pane et al. (2018) who concluded that the majority of students have not been able to show the expression of their ideas in making conclusions through writing well, students have not been able to understand, interpret and evaluate their ideas in writing. Zainuddin et al. (2021) stated that one of the difficulties experienced by students in working on physics questions is that students do not understand how to use existing basic concepts. Mahfuz (2017) emphasized that the causes of mistakes made by students were not understanding the physical symbols of the data mentioned in the question, misinterpreting the meaning of the question, not being careful in reading and not understanding the meaning of the question.

2. Differences of Scientific Communication-Ability among its Aspects

This research concluded that in total there are differences in scientific communication abilities in terms of their aspects. The results of this research are in line with research by Suryaningsih et al. (2015) who concluded that the level of students' conceptual understanding of interpreting indicators was still relatively low.

Theoretically, the differences in scientific communication abilities can be caused by several factors. *First*, students' understanding in identifying questions and mastery of the material. The factor of students' understanding in identifying questions greatly influences the quality of the answers given by students. Mastery of the material, the ability to read carefully and the habit of analyzing clues obtained from questions influence the quality of the answers given. Suraji et al. (2018) found that many students made mistakes in understanding the questions so they were confused about which concepts they should use. This causes students not to understand the questions well.

Second, conceptual understanding. Students need an understanding of concepts in interpreting the questions given. A high understanding of concepts will make students able to solve the questions given correctly. On the other hand, low understanding of the concept will make it difficult for students to solve the questions given. The cognitive process dimension that describes understanding individual concepts from Bloom's taxonomy can make it easier for teachers to create instructional taxonomies, one of which is in the understanding category, namely constructing meaning from instructions which includes interpreting, exemplifying, classifying, making conclusions and explaining (Santrock, 2010). Research by Parmalo, et al. (2016) found that one of the factors that causes errors in interpreting and interpreting data/graphs includes students' low conceptual abilities and

spatial abilities. The causes of errors made by students are translation errors caused by students not understanding the data mentioned in the question, not understanding the physical symbols for the data mentioned in the question, not being careful in carrying out calculation operations (Sari et al., 2013).

As a field of study, scientific communication is heavily influenced by other disciplines, which means that practitioners as well as researchers bring in a rich variety of knowledge, related to their own backgrounds. The variety of communication approaches and roles for communicators, as well as their different backgrounds, make the field of science communication complex, challenging, and interesting (Dijkstra, et al., 2017).

CONCLUSION

In line with the objectives of this research, the conclusion that can be drawn is that the total scientific communication ability on direct current electricity material is in the medium category and there are differences in scientific communication ability in terms of its aspects. The highest aspect of students' scientific communication skills in direct current electricity is the ability to make tables/graphs and the lowest is the ability to interpret. In addition, the scientific communication ability is also influenced by mastery of teaching material.

The limitations of this research included that students' scientific communication abilities were only measured based on the results of written essay tests only. Besides that, not all aspects of scientific communication were comprehensively explored in this research. For further researchers could carry out in-depth interview and apply mixing method-research to deepen these findings, researchers can consider some factors e.g initial mathematical concept abilities, mastery of teaching materials, and language skills that apply descriptive-comparative research or apply multiple regression analysis.

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