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Analysis of Problem Solving Skills in the Vocational High School Using Direct Current Electricity as A Case Study

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ABSTRACT

This study examines problem-solving as one of fundamental cognitive processes required for the 21st century skills. In this context, physics learning is generally directed to focusing on how students in schools attain this ability, which includes analyzing, evaluating, and reflecting activities to find solutions to a problem based on student's own knowledge and experience. The aim of the current study is to determine student's profiles on problem-solving skills at the initial stage for a given subject of electric circuits in a classroom setting. Students of Muhammadiyah 3 Vocational High School, Gresik, Indonesia specialized in electrical engineering were sampled as targetted people. The method used was a descriptive approach, where instruments for data collection were developed using Polya's steps. Research findings were derived from student performance indicators, namely understanding a given problem which scored 55.9%, planning strategy for a solution to the problem which achieved 48.7%, implementing the strategy which obtained 7.7%, and checking the solution which marked 13.85%. In conclusion, the results showed that students' skills on problem-solving was found to be at a very low level.

INTRODUCTION

The rapid development of science and technology is impacting all areas of human life and is inevitable in the 21st century and one of them is the field of education. Efforts to overcome this is to train a person to adapt to the development of science and technology and be able to compete globally in order to have sufficient scientific skills. Science is a process of seeking and collecting knowledge about natural phenomena, concepts, and principles and applying them in daily life (Tursinawati, 2013). Science learning is learning about natural objects and phenomena, so that learning is always linked to thinking skills (Fitriyati, 2017). Thinking skills can be developed with one of them through problem solving. Skill to solve problems requires students to think critically, systematically, logically, and have a resigned attitude in finding solutions to problems faced (Nengsih, 2019). Problem-solving skills is an intellectual activity in analyzing, translating, logical, predicting, evaluating, and reflecting to find problem-solving solutions from the students 'own knowledge and experience (Ulya, 2016; Citra et al., 2021).

Problem solving is one of the important skills in science teaching (Yuliati et al., 2018). Problem solving is one of the goals in the learning process in terms of curriculum aspects that are important for students in physics learning (Cahyani et al., 2016; Ida et al., 2017). In addition, problem solving is used as a mechanism for learning physics and evaluating concepts that have been taught (Docktor et al., 2016). Problem-solving skills are becoming a major focus in physics learning in the 21st century (Jayadi et al., 2020).

This is reinforced in the Partnership for 21st Century Skills which states that problem solving skills are one of the skills that need to be mastered to succeed in life and work (Kurniawan, et al., 2018). Problem-solving skills is the ability of an individual to think through several steps in solving a physical problem. According to Polya (1973), there are four steps that can be taken to solve a problem, namely (1) understanding the problem, (2) planning strategy, (3) implementing the strategy, and (4) checking the solution.

The importance of problem-solving skills can be seen from many current studies that examine problem-solving skills. Several studies related to problem-solving skills such as by Riantoni (2017), Sari et al (2018), and Kurniawan (2018) show the results of problem-solving skills analysis in electric circuits. Based on some of these studies, problem solving skills is one of the important skills to be analyzed. Physics learning should not focus on mastery of materials to solve problems, but connect students to explore knowledge and experiences gained during learning in school (Astutiani, 2017). Moreover, Physics as a science that studies natural phenomena and interactions with objects in the environment around us (Asiyah et al., 2019).

Meanwhile, problem-solving studies have been extensively conducted, yet the concept of direct current electricity related to problem-solving skills is rarely performed (Yuliati et al, 2018). The concept of electricity is one of the important concepts in physics learning that must be mastered by students, because in their daily lives they use the concept of electricity. Direct current electricity is one of the learning materials presented to students at the secondary school level. Direct current electricity energy is electrical energy that flows due to the movement of charge per unit time known as electric current. The electric current comes from the negative pole to the positive pole in other words it moves from the negative pole to the low potential. Differences in these conditions cause potential differences that cause electric currents (Serway & Jewett, 2014; Giancoli, 2014). Electric circuits' energy is a material that cannot be directly observed and is difficult to learn if only based on theory, but practicum activities are needed to strengthen students 'understanding in understanding the concept of dynamic electricity (Rizaldi et al., 2020). Basic concepts of Electric circuits such as Ohm's law, electric current, voltage, series and parallel resistance, electric energy and power are important concepts that must be mastered by students (Riantoni et al., 2017).

One of the factors that make it difficult for students to solve dynamic electrical problems is the low skills of students to apply concepts in the problem-solving process (Riantoni, 2017). Problem solving is a key element in science learning and is one of the essential skills in physics concepts. Problem-solving skills focus on characteristics and reasoning as well as the ability to relate various representations related to physical concepts (Docktor et al, 2016). Several physics researchers have investigated problem-solving skills by observing how expert students and novice students solve physics problems (Yuliati et al., 2018). Expert students parse qualitative problem information by finding solution strategies before giving answers, apply problem-solving concepts in an organized way, organize knowledge in an organized way, have ways of facilitating problem solving and have a strong understanding of concepts (Hull et al., 2013; Docktor et al., 2016).

Novice students, on the other hand, give answers that match the problem statement, focus on the quantitative value of existing problems, have little conceptual understanding and are not structured and consist of random facts, are slow to find alternatives in case of difficulty, and have low comprehension and comprehension.

Skills in applying knowledge so as to become a barrier in problem solving (Hull et al, 2013). Students in solving physics problems often require mathematical calculations. This makes it difficult for students to solve problems (Sari, et al., 2018). In addition, students tend to ignore conceptual information which is also a factor influencing students' low problem-solving skills (Irawan et al., 2016). Based on this, the researcher intends to know and analyze the ability to solve the initial problems of vocational high school students on direct current electricity.

RESEARCH METHOD

General Background

This type of research is descriptive quantitative research. This study describes the skill to solve problems students of vocational high school on electric circuits. The method used in this study is survey method. The study data used test result data describing the initial skills of vocational students in electric circuits' materials.

Participants

The population in this study was students of grades 10, 11 and 12 of the electrical engineering specialty program. The subjects of this study are a total of 39 students of grade 10 and 11 electrical engineering expertise program at Muhammadiyah 3 vocational high school, Gresik academic year 2021/2022 which consists of 2 classes.

Instrument and Procedures

Data collection techniques use problem-solving skills test instruments on electrical circuits' materials. The research flow of this research is shown in Figure 1.

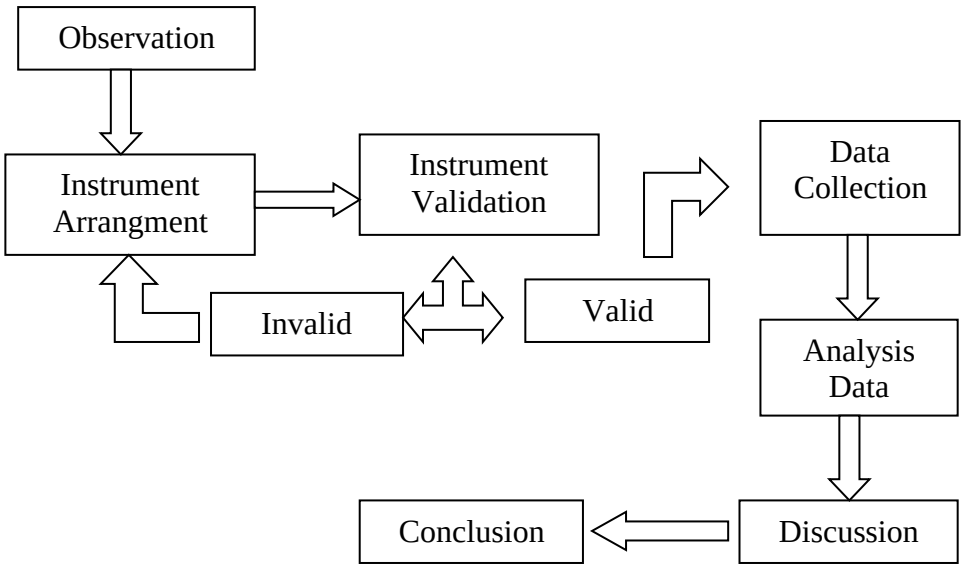


Figure 1. The research flowchart.

Data Analysis

The instrument used in the form of a description of 5 questions compiled based on four indicators of problem-solving skill namely, 1) understanding the problem, 2) planning strategy, 3) implementing the strategy, and 4) checking the solution. The instrument was validated by 3 validators consisting of three expert validators. Validity and

reliability test analysis was conducted using SPSS version 23 to ensure and analyze the level of validity of the instrument used based on the validation values obtained from students' answer sheets. The instrument is declared valid and shows conformity if it meets the criteria according to Table 1.

Table 1. Category basic decision making for instrument validity.

Basic of decision making	Explanation
r count > r table	Valid
Sig < 0,05 dan positive value	Valid

(Shohib et al., 2021)

Apart from the validity test, the instrument is declared valid and subsequently tested for its reliability. Instruments that have been tested for their validity and reliability, automatically the research results (data) become authentic and reliable (Sugiyono, 2017). Instrument reliability calculations using Cronbach Alpha analysis using SPSS version 23. A problem-solving skills test instrument is said to be reliable if the Cronbach Alpha value is > 0.6 (Sugiyono, 2017). Problem-solving skills data on electrical circuits' materials were then analyzed based on the problem-solving skills categories listed in Table 2 using a scale range of 0–100 with very low to very good criteria. The criteria for the value range of problem solving skills are described in Table 2.

Table 2. Criteria for the average value of problem solving skill.

Score	Criteria of problem solving
85-100	Very high
70-84	High
55-69	Medium
50-54	Low
0-49	Very low

(Mawaddah, 2015)

RESULTS AND DISCUSSION

The test result data were tested for validity and reliability using SPSS. The validity of the test conducted by the expert verifier states that the problem-solving skills on the developed electrical circuits' material is valid. Test the validity and reliability of the data with SPSS version 23 are presented in Table 3 and Table 4.

Table 3. Validity results using SPSS.

Problem solving questions	r-count	Sig	Explanation
1	0,806	0,000	Valid
2	0,767	0,000	Valid
3	0,838	0,000	Valid
4	-0,275	0,090	Invalid
5	0,513	0,001	Valid

Based on the data in Table 3, shows the value of r-count > r table are r count > 0.316. This is shown in questions numbers 1, 2, 3, and 5 are said to be valid the question has r - count value> r table. Question number 1 has r-count> r table 0.806> 0.316. Question number 2 has r-count> r table 0.767> 0.316. Question number 3 has r-count > r tables 0, 838> 0, 316. Question number 5 has r-count tables> r 0.513> 0.316. While question

number 4 is said to be invalid, the value of r -count <r of the table is -0.275 > 0.316. It can therefore be concluded that the instrument that has been developed is valid. The instrument can be used to measure what is to be measured. In addition, the validity value of the problem-solving skill is tested for reliability to determine whether the instrument is reliable or not. Reliability tests using SPSS version 23 are shown in Table 4.

Table 4. Reliability statistics using SPSS.

Problem solving questions	Cronbach alpha if item delete	Explanation
1	0,593	Reliable
2	0,619	Reliable
3	0,641	Reliable
5	0,791	Reliable

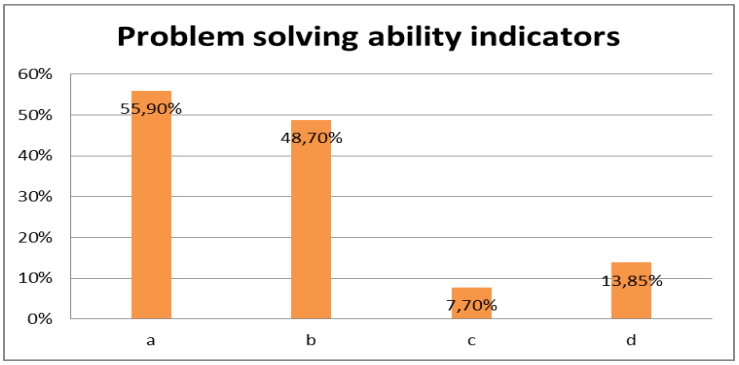
Based on the data in Table 4, the results of the reliability test using SPSS version 23 found that the questions are reliable with a Cronbach's alpha coefficient value of 0.733, meaning that the instrument is consistent if the measurement is repeated. Students problem-solving skills was measured using descriptive question -shaped tests, then analyzed individually, overall scores, each problem-solving indicator, and the percentage of each problem-solving indicator were used to determine the extent of students' problem-solving skills. Data related to the solving skills of each student can be seen in Table 5.

Table 5. The results of the analysis of students' problem solving skills.

Intial Students	Score	Category	Intial Students	Score	Category
1	36	Very low	21	20	Very low
2	44	Very low	22	20	Very low
3	32	Very low	23	24	Very low
4	36	Very low	24	20	Very low
5	36	Very low	25	24	Very low
6	36	Very low	26	16	Very low
7	24	Very low	27	20	Very low
8	32	Very low	28	20	Very low
9	24	Very low	29	24	Very low
10	28	Very low	30	20	Very low
11	28	Very low	31	4	Very low
12	24	Very low	32	12	Very low
13	32	Very low	33	20	Very low
14	36	Very low	34	8	Very low
15	20	Very low	35	20	Very low
16	44	Very low	36	24	Very low
17	48	Very low	37	20	Very low
18	36	Very low	38	20	Very low
19	28	Very low	39	20	Very low
20	4	Very low			
Average score		**25**			**Very low**

Based on the data in Table 5, we can see that none of the students have excellent problem-solving skills. 39 students had problem-solving skills with very low categories.

Based on the marks of 39 students, the average problem-solving skills is 25, meaning that students in class X and XI at Muhammadiyah 3 vocational high school, Gresik have low problem-solving skills regarding electrical circuits. After analyzing each individual's problem - solving skills, an analysis of the achievement of each problem - solving indicator is carried out in Figure 2.



Information:
a : understanding the problem
b : planning a strategy
c : implementing a srategy
d : checking the solution

Figure 2. Analysis of problem solving skills indicators.

Based on the graph above, it can be concluded that 39 students have the level of problem-solving skills on electrical circuits' materials which is categorized in very weak category. The problem-solving skills of students is seen from each of the problem-solving indicators that can be seen in Figure 2. Students are able to understand the problem including formulating the problem. Problem formulation becomes the most important reference before research activities. Some students were able to formulate problems with a percentage of 55.90%. We can see in Table 2 that understanding the problem indicator has the highest percentage of achievement, when compared to other indicators. This indicates that the problem comprehension indicator is the most mastered indicator by students in problem solving problem solving.

In the second indicator which is planning strategy, it is measured by the skills to determine the problem variables and formulate hypotheses from the results of the analysis, the percentage is 48.70%. This shows that students are able to relate the reciprocity (cause and effect) of existing problems well. Students can understanding the problem well, will tend to be able to plan strategies (Hidayatulloh et al., 2016). In this indicator, students are required to assume and process various information obtained correctly, but when wrong, then actions taken by students at the problem-solving skill level will also experience errors (Nyachwaya et al., 2014). This is in line with a study conducted by (Mason & Singh, 2016) who stated that problem-solving students do not use problem-solving approaches involving the same physical principles, but most of them use logic rather than using physical principles to answer conceptual problems physics

In the third indicator which is implementing the strategy, students do not understand the given question, almost all students are deceived by the problem presented in the question and do not fully explain the concepts used in the question. The data obtained, almost all students could not solve the problem well which is a percentage of 7.7%. This third indicator is the indicator that has the lowest percentage of achievement among other indicators in problem-solving skills. Adequate categories obtained in this third indicator indicate that students still face difficulties in implementing the strategies or problems created. This difficulty stems from illogical

solution planning and deviates from existing theories, so that the answers are incorrect, in fact there are many students who leave the answer sheets blank. Students are also rarely trained in problem-solving skills. This is in line with the study of Rasiman (2013) who stated that the limitations of students in understanding the material make it difficult for students to relate existing information with the completion plan to be carried out.

Problem-solving plans will be well designed, if supported by good student knowledge (Hadi, 2019). In addition, the factor is the lack of accuracy of students in reading the questions. Questions in the form of long text make students less thorough, so that the problem planning made is also less optimal and even illogical. This suggests that students who design problem solutions but are not logical, will make the implementation of the plan inappropriate and not in accordance with the intended solution plan (Yanti, et al., 2016). At this stage students 'numeracy skills are required in problem solving (Syahril et al., 2021).

The fourth indicator is to checking the solution or evaluate the solution (evaluate the solution), students are expected to draw conclusions in response to the problem given in the question. There are still a handful of students who can draw conclusions correctly based on theory, a percentage of 13.8% can be seen, which can be seen in Figure 2. Students have not been able to draw conclusions by rewriting the theory of the problem. This is in line with the study of Sanjaya, et al (2017) who stated that students tend to feel confident and satisfied with the solutions developed, without having to look for other alternatives. The skills to draw conclusions, identify errors in calculations, use formula errors, check the match between what has been found with what was asked as well as being able to explain the truth of answers are indicators of achievement from checking answers (Mawaddah & Anisah, 2015).

The measurement of problem-solving skills is based on the process carried out by students on the answer sheets in solving problems which are arranged according to the problem-solving steps according to Polya. The following is presented in Table 6 regarding the analysis of problem-solving skills in solving electrical circuits' problems. Data were taken from 1 answer of 39 students of class X and XII of electrical engineering specialty programs.

Table 6. Analysis of problem solving skills in solving dynamic electrical problems.

Intial Students	Polya step solution			
	1	**2**	**3**	**4**
1	√	√	√	√
2	√	√	√	-
3	√	√	-	√
4	√	-	-	√
5	√	√	√	√
6	√	√	√	-
7	-	√	-	-
8	√	√	√	√
9	√	√	-	-
10	√	√	√	-
11	√	√	√	√
12	√	√	√	-
13	√	√	-	√

Intial Students	Polya step solution			
	1	2	3	4
14	√	√	√	√
15	√	√	-	-
16	√	√	√	√
17	√	√	√	√
18	√	√	√	√
19	√	√	√	-
20	-	-	-	-
21	-	√	-	-
22	-	√	-	-
23	-	√	-	-
24	-	√	-	-
25	-	√	-	-
26	-	√	-	-
27	-	√	-	-
28	-	√	-	-
29	-	√	-	-
30	-	√	-	-
31	-	-	-	-
32	-	√	-	-
33	-	√	-	-
34	-	√	-	-
35	-	√	-	-
36	-	√	-	-
37	-	√	-	-
38	-	√	-	-
39	-	√	-	-
Total	18	36	13	11

From the problem-solving skills test results, there are 2 students who have not been able to solve the question according to Polya step, 3 students can solve the question up to the third step, and 9 students can solve the question up to the fourth step or can solve the question completely and correctly. 18 students could only solve the problem in the second step, 3 students could solve the problem up to the second step, and 4 other students could not solve the problem according to Polya's step. It can be concluded that there are still many students who do not understand the material well. Limitations in understanding the material make it difficult for students to relate information to problem-solving design. Also, most students were less careful in reading the questions and rushed to answer the questions. This is in line with the study conducted by Maemunah, et al (2019) who stated that problem solving at the problem solving stage takes a long time in its process and cannot be done in a hurry. The skills to practice problem solving in the learning process can give rise to critical thinking and problem solving perceptions (Hidayatulloh et al., 2020).

CONCLUSION

Based on the research results, problem-solving skills required for the 21st century education, where a number of students from Muhammadiyah 3 Vocational High

School, Gresik specialized in electrical engineering were involved as targeted people. In general, students' problem solving skill on all indicators are in the low category. The current study aims to determine student's profiles on the skills at the initial stage for a given subject of electric circuits in class activities using the descriptive method, where the instruments for data collection were made using Polya's steps. The findings were thus obtained from performance indicators: understanding the problem (55.9%), planning strategy for the solution (48.7%), implementing the strategy (7.7%), and checking the solution (13.85%). In conclusion, the results shows that students' skills on problem-solving was found at a very low level. These reflect the effects of assessment, learning model, learning materials used in the study. For future work, it is interesting to see whether PBL-STEM based worksheets with PhET is applicable to improve students' problem-solving skills in the vocational high school students.

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