Berkala Ilmiah Pendidikan Fisika
ISSN : 2337-604X (print)
ISSN : 2549-2764 (online)

Vol 8 No 2 2020
https://ppjp.ulm.ac.id/journal/index.php/bipf
page 59-72

Profile of Students' Problem-Solving Skills and the Implementation of Free Inquiry Model in Senior High School

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DOI:10.20527/bipf.v8i2.8230

Received : 29 March 2020 Accepted : 24 June 2020 Published : 30 June 2020

Abstract

This study aims to determine the profile of students' problem-solving skills and the implementation of free inquiry models in high school. This type of research conducted using preliminary research methods with data collection techniques in the form of written tests filled out by students, student interview questionnaires, and teacher interview questionnaires. The data obtained were analyzed descriptively qualitatively. The study was conducted on 30 students of class XII Science 5 of Senior High School 1 Driyorejo. The results showed that only a few students used the strategy of problem-solving skills in solving Dynamic Electric problems. Of all students studied, 16 students had moderate category problem-solving skills ranging from 1.00-1.99, and 14 students had low category problem-solving skills with a range of 0.00-0.99. The lowest problem-solving skills criteria are at point C (conceptualize the strategy). So it can be concluded that the implementation of a free inquiry learning model assisted by virtual laboratories (PhET) in schools does not optimally cause students to be inactive in class so that the problem-solving skills of students are not in the high category.

Keywords: inquiry; PhET; problem-solving skills

How to cite: Meisaroh, S., Achmadi, H. R., & Prahani, B. K. (2020). Profile of students' problem-solving skills and the implementation of free inquiry model in senior high school. *Berkala Ilmiah Pendidikan Fisika*, *8*(2), 59-68.

INTRODUCTION

The 21st century is a century of knowledge, marked by the rapid development of technology. In the 21st century, information can be accessed quickly and the abundant availability of knowledge is very broad. The rapid development of technology has an impact on various fields such as socio-cultural, political, economic, and educational that makes one country with other countries interrelated. From these fields, there is one thing that is most crucial in Indonesia, namely education, where the condition of education in Indonesia continues to experience changes. Over the last 20 years there has been a change in the education system in Indonesia, the change certainly leads to Information and Communication Technology (ICT) (Soderstrorm, From, Lovqvist, & Tornquist, 2011).

To create good quality human resources, education in Indonesia needs to implement the 4 pillars of education as stated by UNESCO, namely; learning to how, learning to, learning to be, and learning to live together. The four pillars must be preserved in-class activities, to improve student skills. Besides, the world of education today needs a movement in a more advanced direction so that future generations can compete globally through the development of 21st-century learning competencies that require students to have knowledge and skills, especially in the field of technology.

The learning model in the 21st century is a student-centered learning model, where during the learning process students are required to be more active than the teacher. One effort to improve the quality of education in Indonesia is to improve the curriculum (Yazid & Suprapto, 2018). In Indonesia, the curriculum has been changed many times, the latest curriculum change is the 2013 curriculum. Whereas the 2013 curriculum that is currently applied has referred to a scientific approach, students are conditioned in an atmosphere of active learning to make students have a variety of skills, one of which is solving skills problem. Thus students will be easier to solve all problems because in daily learning activities at school have been taught problem-solving skills by the teacher. Because based on learning in schools aims to improve problem-solving skills in students (Fitriyani, Supeno, & Maryani, 2019; Gok, 2015; Thersia, Arifuddin, & Misbah, 2019), problem-solving skills are essentially the main things in learning (Bogard, Liu, & Chiang, 2013) where these skills have covered all cognitive aspects students (Chang, 2010). Various problems can be solved by the existence of these problem-solving skills (Sagala, Rahmatsyah, & Simanjuntak, 2017; Salam, Miriam, & Misbah, 2017; Sitika, Muharjito, & Diantoro, 2015) to get the best solution for the existing problems (Markawi, 2013).

According to Heuvelen (Wijayanto, 2011), the results of a survey conducted by the American Institute of Physics in the United States stated that the competencies most commonly used were competencies in problem-solving, teamwork, and communication. Another survey conducted by the Science and Technology Council in the UK said that the problem-solving skills used by most people to solve problems were around 30%. It can be observed that problem-solving skills are very important possessed by each student so that they can solve problems properly and appropriately because someday students become superior human resources and able to improve the nation's intellectual. The problem-solving skills possessed by students were low, this was evidenced by the low index of problem-solving (Nikat, 2018). The problem-solving skills of students in Indonesia that are still low are also supported by research conducted at Senior High School 1 Driyorejo which shows that students at the school still have low levels of problem-solving skills, this is due to students not understanding the concept of the material especially if the material it is necessary to do a practicum. Students are never invited to do a practicum in the laboratory because the facilities to be used for practicum are inadequate, there is no laboratory at the school. So when given a problem, students are not allowed to find their way in solving problems but the teacher immediately provides answers to these problems as a result students are not skilled in solving a problem. Also, several factors cause students to have low problem-solving skills, including learning models used by teachers in teaching still using conventional learning models. Learning in the classroom is not fully active, only the teacher is active in learning, especially when studying physics. That is, learning physics has not been integrated with the development of science and technology and is dominated by teacher-centered learning (Fathiah, Kaniawati, & Utari, 2015). This is what causes the low problem-solving skills of students, students are not taught the stage of good problem-solving. Based on these data it is necessary to improve students' problem-solving skills through the application of inquiry learning models.

The inquiry learning model is a learning model that requires active students, so students can find their knowledge. According to Bruner (Trianto, 2011), Everyone learns to find knowledge so that the best results are obtained. With inquiry learning students will investigate existing problems. Through investigation, students will better understand the subject matter in depth. The steps of using inquiry learning methods are: (1) orientation is the teacher makes the class more active, (2) formulates the problem, (3) proposes a provisional conjecture, (4) collects data, (5) tests Hypothesis is the student tests his hypothesis based on data that has been collected. (6) Making conclusions, (7) applying conclusions where students use the conclusions obtained from the problem (Hamruni, 2012).

The application of the inquiry learning model is certainly very closely related to technology, wherein the era of the industrial revolution 4.0 the use of learning technology is a competency that must be possessed by professional teachers. The use of instructional media makes it easy for students to learn when applied with the help of technology will make it easier for students to remember lessons (Habibbulloh, Jatmiko, & Widodo, 2017; Lia, 2015; Zainuddin, Hasanah, Salam, Misbah, & Mahtari, 2019). Student interaction with the media can increase student involvement to play an active role in improving problem-solving skills (Hidayat, Hakim, & Lia, 2019). The relationship between the inquiry learning model and technology is in finding data, of course, students do a practicum. Because the facilities at the school are inadequate, practicum can be done using existing technology. One application that supports learning is a virtual laboratory in the form of Physics Education Technology (PhET).

PhET is a virtual laboratory that can facilitate teachers and students in learning in the classroom. PhET simulation is a simulation that is easy to operate on its own, almost all of the physics material is in the PhET application that can be downloaded by students through the website http://phet.colorado.edu so that when not under supervision the student can still do the practicum while students have the application Phet. Students can do practical work with mobile phones or laptops that have PhET installed. The advantages of virtual laboratories are that students can use the application for their practicum to make students directly involved in learning and can hone their creativity, practicum conducted by PhET does not require a lot of time when repeating data and there are illustrations of the movement of an electron so students are more familiar with the material discussed.

To identify the level of problem-solving skills of Driyorejo High School 1, it is based on NTEO and the Taxonomy of Introductory Physics Problems (TIPP) as well as by using the GW-ACCES protocol instructional strategy (Teodorescu, Bennhold, Feldman, & Medsker, 2013). The problem-solving steps of ACCES consist of (1) A-assess the problem, (2) C-create a drawing, (3) C-conceptualize the strategy, (4) E-execute the solution, (5) S -scrutinize the result. In the first stage, students identify physical principles related to existing problems, so they know in what way the problem can be solved. In the second stage, students represent problems in the form of images to solve problems. In the third stage, students describe the steps that will be used to solve problems so they can easily solve problems systematically. In the fourth stage, students apply the formula to solve the problem so they can get the right results by following the principles used and the formula applied in solving the problem. In the fifth stage, students write down the level of confidence in the answer, which is between sure and not sure along with the theory underlying the answer. This research was conducted because there were still many students in high school who were less skilled in solving physics problems, students had difficulty in solving physics problems, where previously students had been given material about concepts related to the problem by the teacher. With the low skills possessed by students turned out to be influenced by several aspects, including learning in class still using conventional learning models so that students are not enthusiastic about learning physics. Therefore it is necessary to change the conventional learning model with the innovative inquiry model of free inquiry, through the free inquiry learning model of students becoming more active in class, of course, free inquiry learning requires learning media to support student learning one of them by utilizing the PhET virtual laboratory media. With a virtual laboratory, students can do practicums easily and efficiently. So that student learning is easier to understand and remember because when students are given problems students can solve these problems properly. Based on the description above, the main purpose of the research is to find out the profile of students' problem-solving skills and the implementation of free inquiry models in senior high school. Whether in school students are taught by using a free inquiry learning model that is assisted by PhET simulations or not and whether students' problem-solving skills are good or not. By using the A-C-C-E-S problem-solving indicator criteria, it can be identified the level of students' problem-solving skills.

METHOD

The research used descriptive research design and not to test a hypothesis. The results of the study are used to find out appropriate learning models to be applied in improving problem-solving skills. This research was conducted in February 2020 of 30 students of class XII Science 5 of Senior High School 1 Driyorejo, Gresik. Data collection in this study was carried out by the interview method, the test method, and the questionnaire method given to students. To get the instrument data used are (1) teacher's interview sheet which contains the teacher's profile in teaching in class, (2) test questions sheet that contains three questions with dynamic electric material, (3) answer sheet that contains five steps of problem-solving (ACCES) to facilitate students in solving problems, and (4) student questionnaire sheets.

The data that has been obtained is analyzed using descriptive. The purpose of this analysis is to explain the learning conditions in the school through the results of the data obtained during the study. The results of the analysis will be presented in the form of graphic interpretation of the ability of students' problem-solving skills in working on problems divided into three categories, namely: (1) Low = If the value of problem-solving skills is less than 1. (2) Medium = If the value of problem-solving skills is more than equal to 1 and less than 2. (3) High = If the value of problem-solving skills is more than equal to 2 and less than 3.

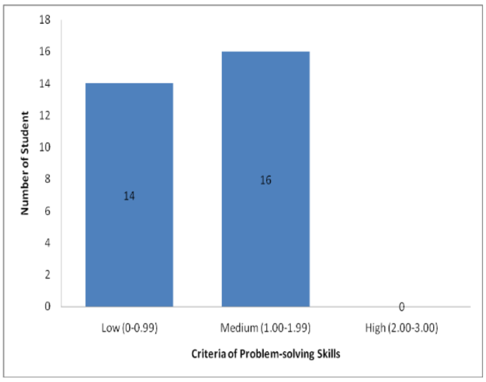

Figure 1 Figure Number of students on each problem-solving skills criteria

RESULTS AND DISCUSSION

The results of this study aim to determine the physics problem-solving skills, especially on Dynamic Electric material. The student test sheet consists of 3 questions that require the description of the answers. The answer sheets provided are equipped with indicators of problem-solving skills (A-C-C-E-S) and students are asked to enter their answers by following the indicators provided. Besides, students were given a questionnaire consisting of 4 questions about students' experiences while studying Physics at school.

Troubleshooting Skills Test on Dynamic Electric Material

Based on the data obtained, the value of the level of problem-solving skills is calculated based on respondents' answers. If the logical, complete, and systematic answer gets 3 points; if the answer only meets two elements (logical and complete or logical and systematic) get a value of 2; if the answer only meets one element only gets a value of 1; and if the answer is wrong (does not meet all three elements) get a value of 0.

Based on the assessment that has been carried out with the above criteria, the value of problem-solving skills is different between one student and another student. Some of them have moderate problem-solving skills and some are low, but there are no students who have high category problem-solving skills. There were 14 students in the low category and 16 students in the medium category. To determine the level of problem-solving skills students can be obtained based on student answers on the answer sheet that is equipped with criteria of problem-solving skills (A-C-C-E-S).

The results of problem-solving by one of the students can be presented in the picture below:

1. A-Assess the problem (identify the principles of the problem)

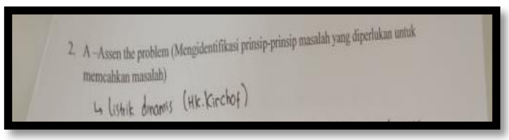

Figure 2 Answer students in criteria assess the problem

A-assess the problem (Identify the principles of the problem: find the voltage flowing at the point BC (V_{BC})

In Figure 2, students are asked to present any principles related to the existing problem, containing a law and symbols that are in the material of dynamic electricity. However, based on the students' answers the students are not yet right in identifying problems, which only answers the law used to solve problems. To solve these problems students should use Kirchoff's Law I and Kirchoff's Law II and look for I_{BC} values.

2. C-Create a drawing (translating words into drawing or drawing that contains instructions in solving problems)

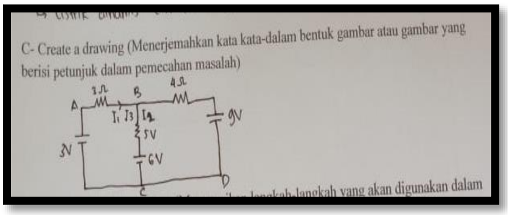

Figure 3 Answer students in criteria create a drawing

C-Create a drawing (Translate words into pictures or drawings that contain instructions for solving problems)

In Figure 3, students are asked to pour out their ideas that help in solving problems in the form of drawings, equipped with the current direction, the direction of the Loop, the symbols of a component and numbers by following the information obtained at the stage of identifying the principles of the problem. However, based on the students' answers, students in solving problems do not give directions to the right current direction and do not provide directions for Loop I and Loop II so that the circuit is difficult to understand and students cannot solve problems.

3. C-Conceptualize the strategy (outlining the steps that will be used in solving the problem

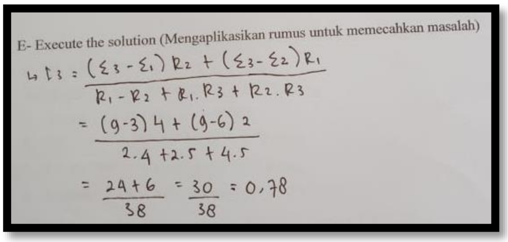

Figure 4 Answer students in criteria conceptualize the strategy

C-Conceptualize the strategy (Describes the steps that will be used in solving the problem)

$$I_3 = \frac{(\Sigma_3 - \Sigma_1)R_2 + (\Sigma_3 - \Sigma_2)R_1}{R_1.R_2 + R_1.R_3 + R_2.R_1}$$

$$I_3 = \frac{(9-3)4 + (9-6)2}{2.4 + 2.5 + 4.5}$$

$$I_3 = \frac{24+6}{38} = \frac{30}{38} = 0{,}78\ 0.78$$

In Figure 4, students are asked to describe the steps to solve the problem. However, based on students' answer sheets, it is known that students do not describe the steps to solve problems, students only write the formulas that will be used to solve problems. The formula written on the answer sheet is wrong and does not fit the theory.

4. E-Execute the solution (apply the formula to solve the problem)

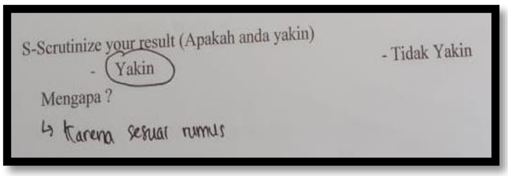

Figure 5 Answer students in criteria execute the solution

S-Scrutinize your result (Are you sure)

- Sure - Not sure

Why?

In Figure 5, students express the level of confidence in the answer through writing along with theoretical reasons that support their choice. However, students based on the answer sheet above only chose to be sure they did not explain clearly why they could choose to be sure.

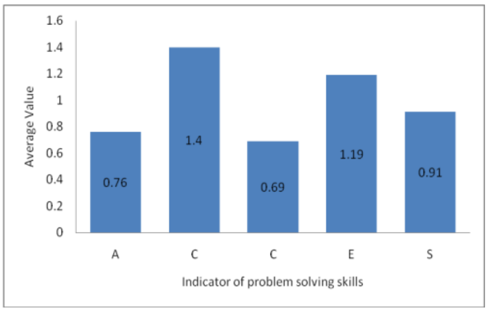

Figure 6 A Figure of the average value of students' problem-solving skills at each problem-solving skills

From Figure 6, the lowest value on the problem-solving skills indicator C (conceptualize the strategy) students cannot describe the strategy properly to solve the problem. That is because students experience misconceptions that are indicated by the value obtained by students on problem-solving skills A (Assess the problem), students do not understand the concepts related to the problems that have been presented sometimes some students only know the concept of the problem but do not understand. In problem-solving skills C (Create a drawing) and E (Execute the solution) the average value of students is better than the other three problem-solving skills, students can make drawings that contain instructions to solve problems such as giving the direction of the loop and the direction of the current in the circuit. While on problem-solving skills S (Scrutinize the result) students do not explain why he chose the answer "sure" on the answer sheet that has been provided. Most students choose to believe but are not able to explain the theories that support their choices, this shows that students are not confident in answering. This low problem-solving skill is because students do not actively participate in learning, where the learning process is still teacher-centered. This is in line with the opinion of (Sahyar & Fitri, 2017) who say that students are less selective in solving problems due to teacher-centered learning. Learning can be done in groups to practice problem-solving skills in students (Hamdayama, 2016).

Student Questionnaire Results

A total of 30 students of class XII Science 5 at Senior High School 1 Driyorejo were asked to fill out a questionnaire regarding problem-solving skills, a total of 4 questions were asked in the questionnaire whose results were presented in Table 1.

Table 1 Learners' responses to the questions given in the questionnaire

Number	Question	Score	
		Ever	Never
1	Have problem-solving skills been trained by the teacher?	30	
2	Have you ever applied problem-solving skills in physics?	30	
3	Have you ever done experiments on "Dynamic Electricity"?		30
4	Have you ever experimented with a PhET virtual lab?		30

In Table 1, students' responses to problem-solving skills are shown that all students in one class have been trained in problem-solving skills by the teacher and apply them in physics learning. All students said that they had never conducted experiments or practicum in learning physics especially on Dynamic Electric material due to the unavailability of laboratory facilities in schools, and all students had never conducted experiments with virtual laboratories because they were never taught by the teacher. Therefore, even though problem-solving skills have been trained by the teacher but have never been applied directly (explained about the theory only), students also find it difficult to solve a problem. Teachers should look for other alternatives so that students can practice, many alternative solutions can be used by teachers to support learning by utilizing virtual laboratory applications (PhET). Using the media to support learning makes students master the material well because it can be visualized and interactive (Syaifulloh & Jatmiko, 2014).

Results of Interviews with Teachers

The teacher interviewed was one of the Physics teachers at Senior High School 1 Driyorejo, the teacher said that problem-solving skills were very important to be trained on students. This is because to solve a problem well, it requires good problem-solving skills as well. During teaching, the teacher has practiced problem-solving skills to solve various problems or lesson problems. In this case, the students also responded quite well to what was taught by the teacher. Besides teachers have also applied inquiry learning models, where students are more active than teachers. However, as long as the teacher implements the inquiry learning model in the learning process the syntax applied by the teacher is not the same as the inquiry syntax, sometimes other learning models are also inserted because according to him it is difficult to match the syntax of the inquiry model. During teaching the teacher has never done practical activities, because there are no laboratory facilities at the school. Sometimes the teacher brings practical tools that are available in school and the teacher can only demonstrate in front of the class because the number of available tools is not possible to be used by all students. So students can only observe what the teacher is doing. The teacher also does not introduce virtual laboratories such as PhET to students as an alternative solution to the absence of laboratory facilities in schools.

Discussion

From the results of student answers, it can be seen that there are still many students who are not right in solving problems, students in filling out answer sheets are not by the steps of problem-solving so that the results of problem-solving are also unsatisfactory. Therefore students' problem-solving skills need to be considered carefully because problem-solving skills are the core of a lesson. This is in line with the results of the study Sayyadi, Hidayat, & Muhardjito (2016) which says that problem-solving skills are the main point in all learning because by applying problem-solving skills, the best decision can be taken. If the problem-solving skills possessed by students are low then the best decision cannot be taken. Good problem-solving skills are certainly encouraged by the existence of other skills, namely good thinking skills. This is in line with the opinion Afifah, Masjkur, & Sutarman (2014) which says that students will find it easier to solve problems if they have the skills to analyze and describe the problem in detail. Describing the problem can be done with the troubleshooting steps A-C-C-E-S.

By using dynamic electric material, it can be known in advance the level of problem-solving students. Like the research conducted by Riantoni, Yuliati, Mufti, & Nehru (2017) that in electrical material with the sub-topic Kirchoff's Law about current and voltage is a prerequisite concept that students should understand in problem-solving. Some of the results of research conducted by researchers show that students do not understand this material, for example, students have difficulty in describing and interpreting from images or problems Kock, Taconis, & Bolhuis, (2014); Stetetzer, Kampen, & Shaffer (2013) they are confused with current, resistance and voltage in electricity (Kock et al., 2014; Smith & Kampen, 2011). When this material is not well understood, it is found that students' skills in solving problems are not optimal, several factors that cause students difficulty in understanding the material, such as inactive learning and not using a virtual laboratory (PhET) as a means of applying dynamic electrical material. Research conducted by Hardianti & Kuswanto (2017) suggests that appropriate learning so students are active in the classroom and make it easier for students to understand the material is an inquiry learning model where students get hands-on experience, by being directly involved students become more active in solving problems. By using the inquiry learning model students can find out the process of solving an indirect problem the result of a problem (Wenning, 2011).

The implementation of inquiry learning models can be supported by using PhET simulations because it can be used to explore students in the depth of the material and can be used to analyze the results of student problem solving (Ceberiol, Almudi, & Franco, 2016). Besides that usage of virtual laboratories (PhET) to support learning because not all Physics material can be explained and described in real terms, for example, dynamic electric material and the kinetic theory of gas. In PhET applications material that in the real world cannot be seen in real terms can be seen properly. That way students can understand the material better, with the use of PhET can reduce the risk of errors in delivering information from the teacher and the knowledge that students own. And the data obtained is also guaranteed creativity because the conditions in the PhET application are ideal, without being influenced by the environment. Students also become more creative because they can arrange their experiments and can experiment with their ideas so that students' problem-solving abilities will also increase (Asyhar, 2012; Azis & Yusuf, 2013; Daesang, K, & Woo-Hyung, 2013; Debowska et al., 2013; Hatimah, Zainuddin, & Mahardika, 2015; Khaerunnisak, 2018; Maesaroh, Sinon, & Yusuf, 2016; Mahanta & Sarma, 2012; Mahyuddin, Wati, & Misbah, 2017; Raihanah, Susilowati, & Salam, 2019; Yusuf & Widyaningsih, 2018).

Simulations in the PhET application are very accurate and can represent well the principles of Physics. PhET application is very appropriate to be used to support inquiry learning and problem-solving skills of students because this application provides a variety of physics problems so that students can use to do problem-solving activities and students can do practicums quickly and efficiently. Visually practicum in PhET application can be done anytime and does not have to be in the laboratory, students can also do practicum individually, the results of the practicum can be quickly obtained by students with a PhET simulation (Darrah, Humbert, Finstein, Simon, & Hopkins, 2014). The use of virtual laboratories (PhET) is safer than physical laboratories because when entering incorrect numbers a PhET application will not be damaged or error (Ceberiol et al., 2016; Zacharia & Jong, 2014). Ibrahim & Rebello (2012) from the results of his research found that after being given PhET-assisted inquiry learning some changes occur in students, especially strategies in problem-solving, problem-solving by students becomes more scientific and orderly.

Other researchers also conducted a study to investigate students' problem-solving skills by observing students in solving physics problems. Some findings show that the characteristics of an expert in solving problems are by describing information provided in the problem qualitatively and using other information in finding answers (Docktor et al., 2016; Docktor & Mestre, 2014; Hull, Kuo, Gupta, & Elby, 2013). Students in the beginner category immediately give answers that match the problem statement and mathematical skills. Students with categories who are experts by applying existing principles in solving physical problems in an organized manner. The results of students' answers show that there are still many students who do not solve physics problems properly because the school did not apply the inquiry learning model assisted by PhET simulations. The results of other studies also show that students do not use problem-solving strategies in solving a physical problem, students do not use existing physical principles. If a problem is felt to be complicated and different from usual students tend to use logic rather than using problem-solving strategies where students directly write the final results of a problem (Mason & Singh, 2016). Even though schools applying the PhET-assisted inquiry learning model can make it easier for students to solve physics problems properly.

CONCLUSION

Based on the results and analysis found that the problem-solving skills of students at Senior High School 1 Driyorejo are in the low and medium categories. Based on tests of problem-solving skills with the A-C-C-E-S strategy and questionnaires that have been carried out by all students indicate that problem-solving skills need to be trained by the teacher and students need to be trained in problem-solving skills and be able to apply in physics especially in Dynamic Electric material.

Students' skills in solving problems are still not maximal, it was found that students' skills in solving problems in the low category with a range of grades 0.00-0.99 were 14 students and students' skills in solving problems in the medium category with a range of grades 1.00-1.99 were 16 students. The lowest problem-solving skills criteria are in the C category (conceptualize the strategy) with an average value of 0.69.

For suggestions in research that is research can be done more than one class to know the overall level of problem-solving skills in a school. The material used to determine the level of problem-solving skills can use other material not only dynamic electricity.

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