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Analysis of Physics Problem-Solving Strategy on Elasticity and Hooke's Law Concepts

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ABSTRACT

Problem solving strategies are needed by students to master physics concepts. Students who are skilled at solving problems can apply physics concepts in the real world. This research aims to analyze students' abilities in solving problems on the concept of elasticity and Hooke's Law. The research method used is a quantitative method. The steps in this research include: determining the topic, finding instruments, collecting data, analyzing data, and interpreting data. This research was distributed to 64 (31.25% male: 68.75% female) high school students. The research instrument is 5 essay questions on elasticity and Hooke's law. The data collection technique is purposive sampling with the criteria that students have studied elasticity material and Hooke's Law and students are taught by the same teacher. Assessment indicators are understanding the problem, writing the problem in terms, planning a solution, solving the problem according to plan, and interpreting and evaluating the solution. Mastery of physics problem solving strategies by high school students has not been achieved optimally. Students were also able to understand the problem with a percentage of 61.6%. The percentages of plan a solution, execute the plan, and evaluate the solution indicators are 49.1%, 45.7%, and 44.3% respectively. Students are skilled in explaining problems in the form of physics terms. It is hoped that future research will be able to develop media that can improve students' abilities in solving physics problems.

Keywords: *Problem-Solving Strategy; Elasticity and Hooke's Law; Physics Learning*

I. INTRODUCTION

Problem-solving has long been used in physics education to increase student learning. In general, the problem employed have been divided into two major categories: well-structured problems and real-world situations [1]–[3]. While well-structured physics problems are common in the physics curriculum, physics education research (PER) experts have recently shown that they have minimal influence on students' conceptual growth and cooperation chances [4], [5]. Consistent engagement with well-structured physics issues promotes shallow problem-solving procedures that dissuade students from pondering on physics concepts and principles, limiting their conceptual progress [4]. Students who work on well-structured issues have low degrees of positive interdependence, which drives individual performance rather than joint performance [4], [6]. PER academics, on the other hand, have discovered that incorporating real-world situations in the classroom might possibly provide opportunity for students to participate in problem-solving abilities, as well as promote conceptual growth and decision-making [4]. The learning possibilities provided by real-world situations are critical for the PER sector, which must quickly adapt to the fast-paced and ever-changing professional obligations that their students will face after graduation.

Problem solving is becoming an essential part of education all across the world [7]. It is seen as an essential component of learning physics, and research has been conducted to improve physics teaching and learning. In many countries, problem solving is a main topic of Physics Education Research (PER) [7], [8]. Even

though problem solving has gained widespread recognition and is employed in the teaching and learning of physics, students confront challenges in solving problems and comprehending numerical results[9]. In general, physics educators feel that problem-solving leads to comprehension of physics and that it is a reliable approach to demonstrate such understanding for evaluation reasons [7]. Students, on the other hand, are frequently unable to comprehend or explain the significance of their own algebraic answers to problems [7], [10]. Therefore, students need effective strategies to solve problems.

A problem-solving strategy is a process carried out by someone to find a solution to a problem. Problem solving in physics learning to increase activeness during the learning process [11]. According to Heller and Heller [12] there are five problem solving strategies in physics, namely comprehend the problem, represent the problem in formal terms, plan a solution, execute the plan, and interpret and evaluate the solution. First, students understand the problem by writing words or scribbling pictures [12], [13]. Second, students connect problems with physics concepts in terms of physical symbols and principles [12], [13]. Third, students plan the solution that will be used in the form of an equation [12]. Fourth, students determine the correct equation and solve the mathematical problem [12]. Fifth, students evaluate and convince themselves that the solution is appropriate [12]. This problem-solving strategy is effective for finding solutions based on students' understanding of physics [14]. Students who are successful in learning, especially skilled in solving physics problems, have the opportunity to apply their scientific knowledge [15].

This research focuses on student problem solving strategies. Students' abilities in solving physics problems need to be analyzed to determine strategies that can improve these abilities. Several studies have found that students' ability to solve physics problems is still low, especially at the stages of determining plans, implementing plans, and evaluating solutions. In Hasan et al's research [16], students' ability to focus on problems (72.50%), describe problems (14.66%), plan solutions (64.50%), implement plans (54.75%), and evaluate solutions (56.50%). The main obstacle for students is their ability to describe problems using a physics approach. This obstacle may be caused by students not being able to determine the equations/formulas that must be used to solve certain problems [17]. The aim of this research is to analyze students' physics problem solving strategies in solving problems on the concept of elasticity and Hooke's Law. The organization of this article is as follows: the research technique is detailed in the second section, the study results and discussion are provided individually, and the final section is the conclusion, which includes comments and recommendations for future research.

II. METHOD

This research uses quantitative descriptive research methods with the aim of describing the state of a particular variable. Most quantitative research collects data in the form of numbers starting from data interpretation to presentation [18]. Quantitative descriptive research in this study aims to see, review, and describe with numbers the object being studied, as well as drawing conclusions about the object according to the phenomena that emerged during the research conducted by Ade [19]. The steps in this research include: determining the topic, finding instruments, collecting data, analyzing data, and interpreting data.

This research was distributed to one of senior high school in west java. The data collection technique is purposive sampling with the criteria that students have studied elasticity material and Hooke's Law and students are taught by the same teacher. A total of 64 students (31.25% male: 68.75% female) were involved in this research from two science classes. Both classes are taught using the old curriculum, namely the 2013 curriculum.

This research uses an instrument developed by Putri [20] in her thesis research. The physics content tested is elasticity and Hooke's Law. The instrument is in the form of 5 essay questions. The assessment indicators are based on the Heller and Heller [12] framework namely understanding the problem, writing the problem in the form of terms, planning a solution, solving the problem according to plan, and interpreting and evaluating the solution. Indicators are written in the form of questions that guide students in answering questions. Each indicator is given a score of 4 so the total score for one question is 20. Students are given 80 minutes to work on the question.

Student answers are collected and assessed based on problem solving indicators. In this research, scores are calculated based on the value obtained for each problem-solving indicator, not based on the individual's maximum score. This aims to reveal students' overall level of achievement in solving physics problems. The data calculation method is as follows [16]:

$$P_i = \frac{x}{X} \times 100\%$$

Description:
P_i = percentage per indicator (%)
x = student score per indicator
X = maximum score per indicator

The technique for drawing conclusions is based on the scores obtained in the calculations. The score categories with the percentage of each indicator are 0%-30.99% (very poor), 40%-54.99 (poor), 55%-69.99 (fair), 70%-84.99% (good), 85%-100% (very good)[16].

III. RESULTS AND DISCUSSION

Results

Problem solving strategies in physics learning are really needed by students. The advantage of students who are used to solving problems is that they can apply their scientific knowledge in everyday life. The problem-solving strategy developed by Heller and Heller consists of five, namely comprehend the problem, represent the problem in formal terms, plan a solution, execute the plan, and interpret and evaluate the solution [12]. The distribution of questions given is two three questions on the concept of elasticity and two questions related to Hooke's Law. Students' abilities in solving problems can be seen in Figure 1. Based on the results of the analysis, questions related to elasticity are easier for students to solve than Hooke's Law questions.

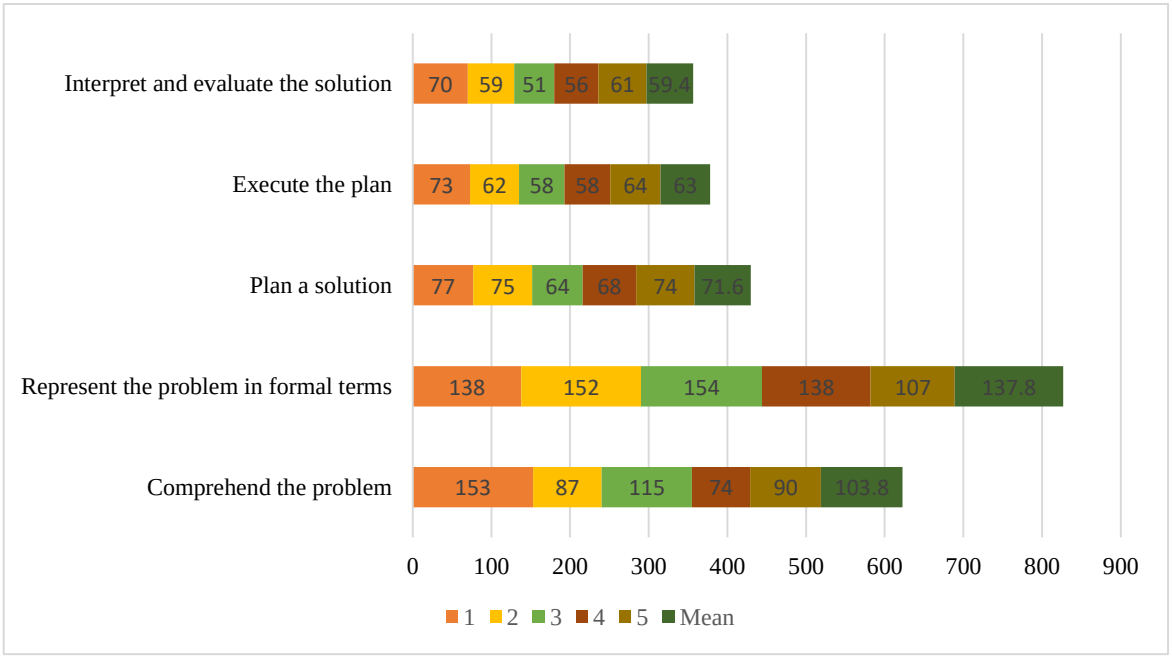


Fig. 1. Problem-Solving Strategies Score

Based on Figure 1, the range of values for each indicator is quite diverse. Students' ability to understand problems was obtained on average 103.8 from five questions. Question number 1 is classified as the easiest problem for students to understand with a total score of 153. Students' ability to explain the problem again in terms of terms is good with an average of 137.8 from five questions. Generally, students are able to explain the problem again by writing down what they know and asking about the problem given. The average ability of students in planning solutions, executing the plan, and interpreting and evaluating the solution is 71.6, 63.0, and 59.4. This shows that these three indicators have not been mastered by students in solving physics problems.

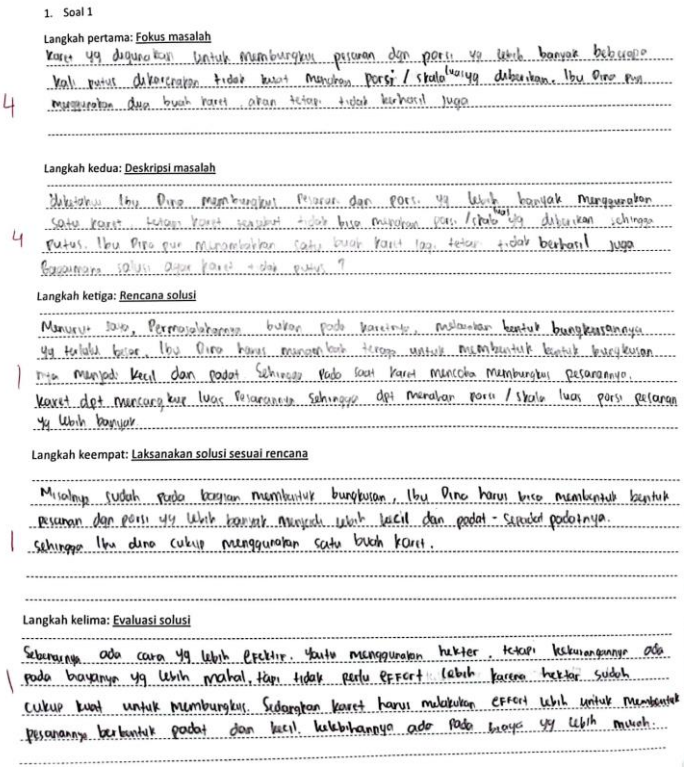
Table 1. Analysis of Student Problem-Solving Strategies Per Indicator

No	Indicator	Percentage	Category
1	Comprehend the problem	61.6%	Enough
2	Represent the problem in formal terms	74.9%	Good
3	Plan a solution	49.1%	Less
4	Execute the plan	45.7%	Less
5	Interpret and evaluate the solution	44.3%	Less

The results of the analysis of student problem solving indicators can be seen in Table 2. This data is in line with Figure 1, where the students' ability to explain problems in terms of terms is good overall. Students were also able to understand the problem with a percentage of 61.6%. The percentages of plan a solution, execute the plan, and evaluate the solution indicators are 49.1%, 45.7%, and 44.3% respectively. This shows that the plan a solution, execute the plan, and evaluate the solution indicators have not been achieved. Therefore, students need to get used to working on questions with real world contexts.

Discussion

Problem solving is one of the 21st century skills that students really need for their future. In physics learning, problem solving strategies are needed by students to find solutions to the problems given. Students who are skilled at solving physics problems tend to show good learning outcomes. In this research, the tools for measuring problem solving abilities based on the concept of elasticity and Hooke's Law are essay questions. The physics problem solving indicators used are comprehend the problem, represent the problem in formal terms, plan a solution, execute the plan, and interpret and evaluate the solution. These indicators show the systematic process carried out by students to find solutions to the problems given. Students who are skilled in solving problems can be seen from the students' skills in making logical decisions [21].


1. Soal 1

Langkah pertama: Fokus masalah

Karet yg digunakan untuk membungkus pecahan dan porsi yg lebih banyak beberapa kali putus dikarenakan tidak kuat menahan porsi / skala yg dibutuhkan. Ibu Pira pun menggunakan dua buah karet akan tetapi tidak berhasil juga

4

Langkah kedua: Deskripsi masalah

Diketahui Ibu Pira membungkus pecahan dan porsi yg lebih banyak menggunakan satu karet tetapi karet tersebut tidak bisa menahan porsi / skala yg dibutuhkan sehingga putus. Ibu Pira pun menggunakan satu buah karet lagi tetapi tidak berhasil juga

4

Langkah ketiga: Rencana solusi

Menurut saya, Permasalahannya terlalu pada karetnya, solusinya bentuk bungkusannya yg terlalu besar. Ibu Dira harus menggunakan trik agar untuk membentuk bentuk bungkusan nya menjadi kecil dan padat sehingga pada saat karet mencoba membungkus pecahannya. karet dpt mencengkeram luas pecahannya sehingga dpt menahan porsi / skala luas porsi pecahan yg lebih banyak

1

Langkah keempat: Laksanakan solusi sesuai rencana

Misalnya sudah pada bagian membentuk bungkusan, Ibu Dira harus bisa membentuk bentuk pecahan dan porsi yg lebih banyak menjadi lebih kecil dan padat - seperti padatnya. Sehingga Ibu dira cukup menggunakan satu buah karet.

1

Langkah kelima: Evaluasi solusi

Sebenarnya ada cara yg lebih efektif. Yaitu menggunakan hekter, tetapi kekurangannya ada pada banyaknya yg lebih mahal. Tapi tidak perlu effort lebih karena hekter sudah cukup kuat untuk membungkus. Sedangkan karet harus melakukan effort lebih untuk membentuk pecahannya berbentuk padat dan kecil kelebihannya ada pada biaya yg lebih murah.

1

Fig. 2. One of student's answer sheet for problem 1

Figure 2 is one of the students' answers to question number 1. Step 1, problem focus, students explain perfectly the problem given. Step 2, describe the problem in formal terms, students also explain well the

evidence is that students write known and questions. Step 3, plan the solution, the student's answer was incorrect because he did not write down the physics approach at all. Step 4, execute the plan, because the plan is not right, the solution the students work on is also not right. The final step, evaluate the answer, as well as the evaluation given is incorrect even though the student has explained in detail and at length. So, it can be concluded that most students are still having problems planning solutions, executing plans, and evaluating answers.

Students generally have not mastered problem solving strategies completely. Apparently, students were able to understand the problem and explain it in terms. However, there are still many students who are hampered by the steps to determine a solution, execute the plan, and evaluate the solution. This is in line with the research results of Apriyani et al. (2019) [22], 94.91% of students were able to focus on the problem, 87.73% of students were able to explain the problem, 80.08% of students were able to plan a solution, 61.11% of students were able to complete the solution according to plan, and 51.85% of students able to evaluate solutions. Students are skilled in understanding problems and explaining these problems. The students' N-Gain scores from each problem-solving indicator were 0.83 (visualizing the problem), 0.80 (describing the problem), 0.64 (planning the solution), 0.58 (executing the plan), and 0.72 (evaluating the solution) [23]. It can be concluded that students are skilled in understanding problems and describing problems in the form of terms.

Problem solving strategies that students have not yet achieved are planning solutions, executing plans, and evaluating. The stage of planning a solution becomes an obstacle for students. At this stage, the step that needs to be taken is to explain the physical description relating to the problem given in the form of the equation [12]. This is because many students do not understand the basic concepts of physics, mathematical calculations, and are not active in learning [24]. Other contributing factors are the unavailability of physics laboratories [24], not being used to solving physics problems [25], and not being motivated to study physics [26]. Students' strategies in executing plans were also found to be low. This strategy is related to mathematical equations and calculations. The low ability of students at this stage may be because students do not fully understand the concept of physics and are not careful in determining units [27].

IV. CONCLUSION

Mastery of physics problem solving strategies by high school students has not been achieved optimally. Students were also able to understand the problem with a percentage of 61.6%. The percentages of plan a solution, execute the plan, and evaluate the solution indicators are 49.1%, 45.7%, and 44.3% respectively. Students are skilled in explaining problems in the form of physics terms. However, students still have difficulty planning the right solution, implementing the plans made, and evaluating solutions. These student difficulties are also findings from previous studies. Questions related to elasticity are easier for students to do than Hooke's Law questions.

Students' obstacles in solving physics problems are a concern for teachers and researchers. Students need the right media to improve their problem-solving abilities. This media can be in the form of visual tools, worksheet, videos, books, and so on which are able to facilitate students with different learning styles. Future researchers can work together with teachers in developing effective models, approaches and learning media to improve students' problem solving skills. The weakness of this research is that the student answer sheets analyzed were only taken from five students who represented their respective learning styles.

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