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Problem-Solving Ability through Flipped-Problem Based Learning on Elasticity Materials for High School Student

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Abstract: This study aims to enhance problem-solving ability through Flipped-Problem Based Learning model on elasticity material for high school students. The type of research used is quantitative research with a one-group pretest-posttest design. The data collection technique uses Polya indicators, that is understanding the problem, devising a plan, carrying out the plan, and looking back. The assessment was carried out with help of the Minnesota Assessment of Problem Solving (MAPS) rubric. Data were analyzed using N-gain and Wilcoxon Signed Rank tests with an N-Gain score of 0.55 which was included in the medium category. The results of the Wilcoxon Signed Rank test showed a p-value of 0.00 with a significance of 0.05 which stated that there was a significant difference between students' problem-solving abilities after the Flipped-Problem Based Learning model was applied. The results showed that there was an increase in the problem-solving ability of students

Keywords: Elasticity, Flipped-problem based learning, MAPS rubric, Problem-solving ability, Polya Indicators

Kemampuan Pemecahan Masalah melalui Model *Flipped-Problem Based Learning* pada Materi Elastisitas untuk Peserta Didik Sekolah Menengah Atas

Abstrak: Penelitian ini bertujuan untuk meningkatkan kemampuan pemecahan masalah peserta didik melalui model *flipped-problem based learning* pada materi elastisitas untuk Sekolah Menengah Atas. Jenis penelitian yang digunakan adalah penelitian kuantitatif dengan desain *one-grup pretest-posttest*. Teknik pengambilan data menggunakan indikator Polya yaitu memahami masalah, merencanakan penyelesaian masalah, menyelesaikan masalah dan melakukan pengecekan kembali. Penilaian dilakukan dengan bantuan rubrik *Minnesota Assesment of Problem Solving* (MAPS). Data dianalisis dengan menggunakan uji N-gain dan *Wilcoxon Signed Rank*. dengan perolehan nilai N-Gain sebesar 0,55 yang termasuk dalam kategori sedang. Hasil pada uji *Wilcoxon Signed Rank* didapatkan hasil signifikansi p-value 0,00 dengan signifikansi 0,05 yang menyatakan bahwa terdapat perbedaan yang signifikan antara kemampuan pemecahan masalah peserta didik sebelum dan sesudah diterapkan model *flipped-problem based learning*. Hasil Penelitian menunjukkan bahwa terdapat peningkatan kemampuan pemecahan masalah peserta didik

Kata kunci: Elastisitas, *Flipped-problem based Learning*, Indikator Polya, Kemampuan Pemecahan Masalah, Rubrik MAPS

INTRODUCTION

In 21st-century learning, technological advances have changed the style of teaching and learning activities from passive learning to active learning and have produced students who were originally passive listeners to become active students, especially in science learning (Yanto et al., 2021). Several competencies or skills must be possessed by human resources in 21st-century learning, namely (1) Critical thinking and problem-

solving skills. (2) Creativity and Innovation skills (3) Technological literacy, the ability to utilize information and communication technology (4) Contextual Learning Skills (5) Information and Media literacy skills (Yanto, et al., 2021). The concept of learning in the 21st century is an aspect of student skills that must be focused on students so that it can be applied through a problem-solving process on physics material (Apriliasari et al., 2019).

Problem-solving skills are needed in learning physics because activities to solve problems can help students construct new knowledge in learning (Mukhopadhyay, 2013). Based on the results of observations when researchers carried out field practice activities, there were several obstacles in learning activities carried out online because of limited learning time and educators had to fulfill the material being taught so that the use of the model used during learning was conventional. This causes learning to be one-way and students only receive material and information. In addition, it causes students to be fixated on the material provided so that they do not explore further and students become less active during learning so students problem-solving abilities are low. The low problem-solving ability of students shows that students are still not able to understand the material and they lack thought development efforts that direct students to be active in solving a problem (Makrufi, 2016). The problem-solving ability of students is getting lower because the learning process is only done online with limited media and the teacher's ability to understand the media (Marhami et al., 2020).

Problem-solving ability is a human activity that combines previously acquired concepts and rules and is an ability that must be trained continuously. Therefore, it can be said that problem-solving skills are the main skills to develop students' abilities in planning problems in new ways and dealing with them using creative, systematic, and analytical strategies (Bahtiyar & Can, 2016). Stages of problem-solving skills include (a) understanding the problem (b) devising a plan (c) carrying out the plan, and (d) looking back (Polya, 2004). To overcome the problem of limited time during learning, the researcher used a Problem Based Learning (PBL) learning model combined with the flipped classroom model. Model Flipped classroom is a learning model that consists of three parts, namely interactive learning in groups in the classroom, individual computer-based learning outside the classroom, and evaluation (Lee et al., 2017). Model Flipped classroom is learning that can be done anytime and anywhere, not limited to classrooms, while PBL focuses students on solving problems. So if combining PBL with flipped classroom allows students to learn outside the classroom and solve problems in the classroom (Chis et al., 2018). The use of problem-based learning models combined with the flipped-classroom model is expected to meet the limited learning time carried out in schools, so that the use of this model can improve students' problem solving skills because in classroom learning students can focus only on the problems provided on worksheets and material deepening is carried out outside of class hours independently. this is in line with research by Arnata et al. (2020), improving students' problem-solving skills cannot be done in a short time so the use of flipped-problem-based is highly recommended to improve the quality of education in Indonesia. The use of flipped-problem based learning is expected to be a solution to the problem of the low problem-solving ability of students.

Flipped-problem based learning can be used as an alternative implementation of distance learning because the learning process is assisted by the availability of internet facilities. Applications can be used to access via a computer or smartphone, so learning becomes better. Then when learning in the classroom using a PBL model, students discuss the relationship between concepts and principles, collect various literacy sources,

use concepts and guidelines to discuss them in groups, and integrate their knowledge and abilities (Y.-H. Hu et al., 2018). Flipped classroom implemented into 3 stages, namely before learning, during learning, and after class learning (Long et al., 2016).

Students learn material independently outside the classroom from various sources such as videos. In the learning process, they are guided using platforms that are available and easy to use such as Google Classroom, and facilities for communication that can use smartphones in the WhatsApp application. During class learning, students learn to use the PBL model to develop students ability to answer problems. Students are formed in small groups to apply the latest abilities, ideas or concepts learned before class begins. After class, the teacher gives an evaluation in the form of multiple choice or essay using google forms, quizzes, or applications available on the internet. The use of the flipped-problem based learning model is expected to emphasize the skills and independence of students in using technology and find solutions to problems faced at the learning stage first (Ozdamli & Asiksoy, 2016). According to Monsang et al. (2021), problem-solving abilities of students have an important role to improve students' thinking skills and make learning science fun. This can motivate students to achieve more, by using scientific knowledge to solve problems that exist in the surrounding environment in everyday life. Learning that focuses on the real world and is related to the environment around students can develop students' problem-solving abilities (Ramadhani et al., 2021). Meanwhile, Retno et al., (2019), that problem-solving ability is a process in which individuals try to find a problem-solving effectively by involving cognitive strategies.

In solving problems, four important steps must be taken according to Polya (2004), namely understanding the problem, in this step involves understanding or conditions of the problem, selecting facts, and determining problem questions. Devising a plan, this step involves identifying appropriate problem-solving strategies to solve the problem. The strategy used must of course be related to the existing problems. Carrying out the plan, at this stage, the problem-solving is carried out in detail based on the settlement plan that has been formulated in general. Problem-solving is carried out systematically following the settlement plan. Looking back at all the steps that have been done, this step is done to check whether the results obtained are following the desired provisions.

Docktor et al. (2016), suggests that the steps for solving physics problems in the Minnesota Assessment of Problem Solving (MAPS) can be assessed from the *useful description*, and the ability of students to represent the information obtained on the problem correctly. *Physics approach*, the ability of students to choose appropriate physics concepts and principles to solve problems. *Specific application of physics*, the ability of students to apply concepts and principles of physics in special conditions that exist in the problem. *Mathematical procedures*, the ability to use mathematical procedures to obtain answers to questions. *Logical progression*, the ability of students to determine clear completion steps, stay focused on finding the desired answer, and produce the appropriate answer. The MAPS rubric is a rubric used to assess physics problem-solving skills developed by Jennifer L. Docktor, and several other researchers from America in 2016. The development of this rubric is based on the practicality needed for teachers to assess students' problem-solving abilities. The score for each category of the rubric ranges from 0 (lowest) to 5 (highest) with the addition of the "Not Applicable" for certain problem conditions and students, namely NA (problem) and NA (solver). NA (problem) is intended when certain categories of rubrics are not required to answer the questions. NA (solver) occurs when, based on the overall solution written by students, it can be seen that certain categories have been carried out by students but students do not write them on the answer sheet.

RESEARCH METHODS

Research uses quantitative methods because the data to be processed is related to values that can be calculated mathematically using statistical calculations (Fraenkel et al., 2012). Based on the research objectives to be achieved, the research design used is the one-group pretest-posttest design. The focus of the research is to determine the effect of flipped-problem based learning on improving students' problem-solving skills on the elasticity material. This research was conducted at SMAN 3 Samarinda in the academic year 2021/2022 in November 2021. The population in this study were class XI in SMAN 3 Samarinda. The sample in this study were students of class XI IPA 1 SMAN 3 Samarinda totaling 35 students.

The sampling technique used to determine the sample in this study is cluster random sampling, which is a technique in which the sample is taken based on a random class where students are seen as individuals who are members of the class (Ary et al., 2018). To meet the data needed in the study, the instrument used was a problem-solving ability test instrument. The test instrument used is a descriptive test. The test is given before learning (pre-test) and the after learning (post-test). validity of the pre-test and post-test will be tested using the Expert judgment method. In this method, three experts will be asked for their opinions on the instrument made by giving an assessment in the column of the validation sheet provided and writing down the revised items that must be corrected. This validity test is carried out to see and assess the suitability between each question indicator and each question given. After the questionnaires and questions have been corrected based on suggestions from experts, the instruments can also be given to students (Heryanto et al., 2019).

The data analysis technique used are the N-Gain Test and the non-parametric Wilcoxon Signed Rank Test. The N-Gain test is a test that can provide an overview of the increase in learning outcomes scores before and after the implementation of a method. The average problem-solving ability of students will be seen to increase using the formula (1) (Meltzer, 2012).

$$N - Gain = \frac{Posttest - Pretest}{Score\ Maximum - Pretest} \quad (1)$$

with N-Gain criteria in table 1 as follows (Hake, 1999).

Table 1. Criteria for obtaining N-Gain

Score N-Gain	Criteria
$N - Gain > 0,7$	High
$0,3 \leq N - Gain \leq 0,7$	Medium
$N - Gain < 0,3$	Low

Testing this hypothesis using the SPSS 24 computer program to determine whether or not there is a difference between the average value of students' problem-solving abilities before and after being given treatment. This analysis was performed by paired t-test. Before the t-test, normality and homogeneity tests were first performed. If the data obtained are not normally and homogeneously distributed, then the test performed is the Wilcoxon Signed Rank Test.

Analyze the score of each indicator of problem-solving ability to find out the difference in the scores obtained on each indicator during the pre-test and post-test using the average value of each indicator (Purnamasari et al., 2021). The average results of each indicator will be presented in the form of a bar graph. To determine the level of

problem-solving abilities of students can be seen through the scores obtained for each problem in the stages of the Polya model (Ninik et al., 2014). The value obtained to get the final score of the four questions at each stage is determined in table 2 as follows

Table 2. Level of Students' Problem-Solving Ability

Score	Criteria
$0 \leq SAL \leq 60$	Low
$60 < SAL \leq 75$	Medium
$75 < SAL \leq 100$	High

*SAL= Student Ability Level

RESULT AND DISCUSSION

Pre-test and post-test were used to analyze students' problem-solving abilities to determine whether there was an improvement between students' problem-solving abilities before and after the flipped-problem based learning applicated and to determine whether there was an effect of the flipped-problem based learning on students' problem-solving abilities in elasticity material. The instrument used in this research is a description of 4 questions. The question shows an overview of the problem-solving abilities of students in the elasticity material. The indicators used in this study are indicators of problem-solving abilities according to Polya and these indicators are assessed using the *MAPS* which consists of 5 categories.

The N-Gain provides an overview of improving students' problem-solving ability scores before and after the flipped-problem based learning model is applied. The results of these data are presented in table 1. The *N-Gain* taken from the average of the results of the pre-test and post-test, the significance is 0.55 which is included in the medium criteria. This increase is also in line with the research of X. Hu et al. (2019), results of the research shows that students who learn to use flipped-problem based learning have a higher problem-solving ability value than students who learn to use conventional methods.

Table 3. Average Results of Pre-test and Post-test

Average Pre-test	Average Post-test	N-Gain	Criteria
39.91	71.94	0.55	Medium

Based on the research data that has been analyzed, it can be seen that the data is homogeneous with sig. 0.824 and the normality test results from the pre-test and post-test indicate that the data is not normally distributed which have significance value of 0.012 and 0.000, so the wilcxon signed rank was conducted. The test of *Wilcoxon Signed Rank* test is a non-parametric test that is used to determine whether there is a significant difference between the two means of the pre-test and post-test in the same group. Hypothesis testing was carried out using the *Wilcoxon Signed Rank* because the pre-test and post-test did not requirements, homogeneous but not normal. The test results are obtained in table 4.

Table 4. Wilcoxon Signed Rank Test Results

Test Statistics ^a	
	Pre-test – Post-test
Z	-5.160 ^b
Asymp. Sig. (2-tailed)	0.000

Table 4 shows that the p -value obtained is 0.00 so it is less than the significance level of 0.05. It can be concluded that there is a significant difference between students' problem-solving abilities before and after the flipped-problem based learning to the elasticity material. There are 4 indicators of problem-solving ability assessed from the pre-test and post-test. The results of calculating the average score of each indicator are shown in the bar graph in figure 1 there is a varying increase. The assessment of each indicator has a maximum score of 5.00. Based on Figure 1, it can be concluded that there is an increase in each indicator after the Flipped-problem based learning is applied.

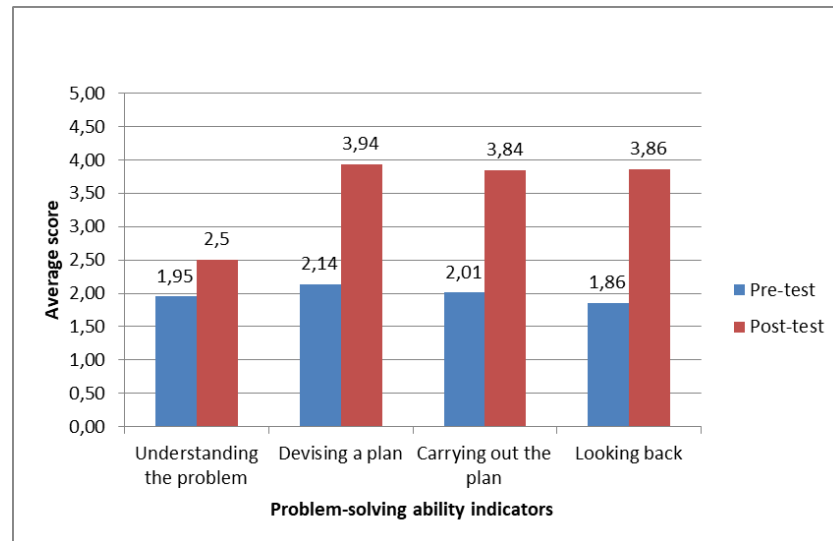


Figure 1. Graph of the improvement of each indicator of problem-solving ability

To see the level of problem-solving ability students can go through the scores obtained from each indicator at the stages of the Polya model which are categorized into low, medium, and high criteria. Based on the scores obtained by students before and after the *flipped-problem based learning* level of students' problem-solving abilities can be seen in the bar graphs in Figures 2 and 3 as follows.

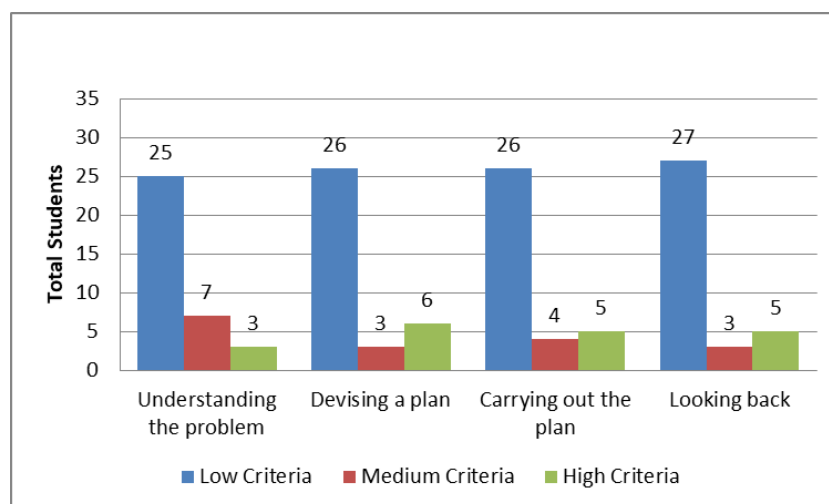


Figure 2. Problem-solving ability of students (Pre-test)

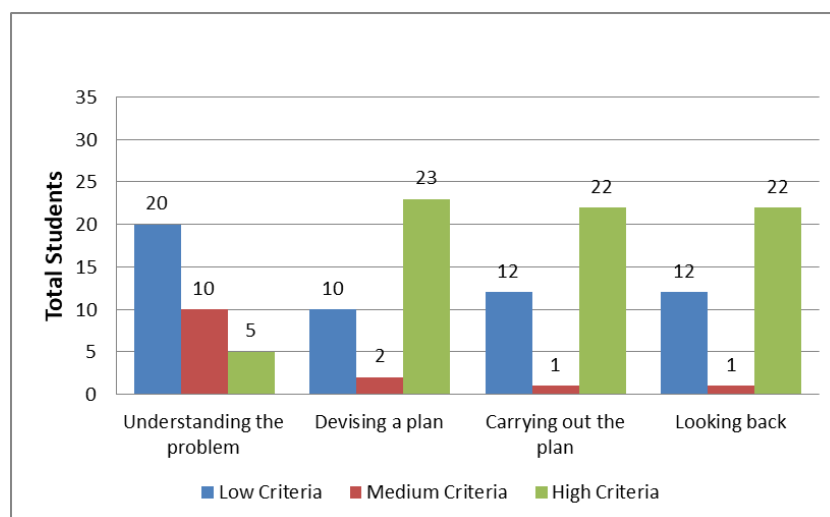


Figure 3. Problem-solving abilities of students (post-test)

The ability of students to understand problems is trained in flipped-problem based learning in the phase of organizing students to learn. In this phase, the teacher guides students to understand the problems contained in the worksheet. Together in groups, students can determine useful information obtained problems to formulate problems. At the stage of understanding the problem, there is a decrease in the number of students on the low criteria and there is an increase in the medium and high criteria. In Figure 3 it can be seen that the increase in the graph of understanding student problems is the lowest among other stages, this is because students do not write down what is known on the answer sheet, but actually students can understand the problem well because in Figure 1 the graph is at the stage of devising a plan looks like a good increase. This is included in the additional category contained in the MAPS rubric, it's NA (solver). NA (solver) on students can be seen based on the overall solution written by students on the answer sheet, students have done the stage of understanding the problem but students do not write it down on the answer sheet. This usually happens to students who have high problem-solving skills so they don't always write down the entire thought process on the answer sheet. In addition, it is because students do not know part of the assessment of problem-solving skills that they must write down all processes when they identify problems on the answer sheet. This is in line with Docktor et al. (2016), research that this often happens to experts who usually make decisions but do not write down all of their processes on answers. The results of this study are also relevant to Makrufi (2016), research which states that students have a low score of understanding the problem because most of the students are not able to describe the problem or describe it incorrectly and there is not even a description on the answer sheet. The ability of students to plan problem-solving is trained in flipped-problem based learning in the phase of devising a plan. In this phase, the teacher guides students in conducting group discussions to determine temporary solutions in the form of hypotheses and experimental steps that will be carried out to prove the proposed hypothesis. In the process of planning students' problems, it can be seen through the selection of concepts, formulas, or physics equations related to the given problem.

In Figure 1 the graph shows the average score of problem-solving abilities in the problem-planning stage is 2.14 after the application of the flipped-problem-based learning there is an increase to 3.94 which is the highest average score in the four indicators of students' problem-solving abilities. In this stage, there is a decrease in the

low criteria and medium criteria, while for the high category there is an increase. In the implementation of planning problem solving, most of the students can determine the formula that can be used to solve the problem correctly. These results are in line with the research of Faridah et al. (2021), that students' problem-solving abilities are in the high category, this indicates that students can plan problems using hypotheses or use the knowledge they already have to determine the most appropriate solution.

The ability of students to carry out the plan is trained in flipped-problem based learning in the phase of guiding individual and group experiences. In this phase, the teacher guides students in conducting experiments and in finding related sources to prove the hypothesis. In the stages of solving students' problems, it can be seen through the application of concepts or principles of physics. At the stage of the problem-solving Polya, it includes 2 indicators from the MAPS assessment rubric, its specific application of physics, and mathematical procedures. In addition to the application of concepts or principles of physics, the ability of students in the working process is also considered, as the skills of students in following appropriate and correct mathematical rules and procedures during problem-solving given in the form of questions. Based on Figure 1, the graph shows that at the stage of solving the problem, the students experienced an increase in the average score from 2.01 in the pre-test to 3.84 after the post-test. The low and medium categories experienced a decline, while in the high category there was an increase. This shows that after applying flipped-problem based learning students can solve problems well. These results are relevant to the research of Faridah et al. (2021), which shows that students can carry out the completion plan. This can be seen from the completion of the stages carried out by students completed coherently and completely.

The ability of students to look back is trained in flipped-problem-based learning in the phase of analyzing and evaluating the problem-solving process, where the teacher guides students in group discussions to provide feedback on the results obtained in other groups. In the stage of rechecking it can be seen through students checking the suitability of the answers in evaluating the steps for a coherent, and clear solution that is following the given problem. In the student answer sheet, this stage is seen through the overall steps of solving student problems in a clear, focused, and logically connected manner that can be seen through the students' answer sheets in making conclusions at the end of the answers. In Figure 1 the graph shows that at the stage of looking back the students experienced an increase from 1.86 to 3.86 in the post-test. Based on the picture, the last stage in the low category and medium category has decreased and the high category has increased. These data indicate that students have developed the ability to solve problems. This is almost similar to Ninik et al. (2014), research that students who did the re-examination stage were in the high category of 68.75% and the low category of 31.25%.

CONCLUSIONS AND RECOMMENDATIONS

Based on the research, it can be concluded that the improvement of students' problem-solving abilities after the application of the flipped-Problem Based Learning the elasticity material in the medium category with the significance of an N-Gain of 0.55 and the Wilcoxon Signed Rank obtained a significance value of 0.000. These results indicate that there is a significant difference between the problem-solving abilities of students before and after the flipped-problem-based learning model is applied, which affects the problem-solving abilities of students on the elasticity material. Problem-solving ability of students using flipped-problem-based learning can be improved if it is conducted their continuously and becomes a habit of students who have used it regularly skills with problems related to life around the students.

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