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Analysis of Students' Problem Solving Skills based on Heller's Indicator

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Abstract

Problem solving skills are a fundamental part of learning physics that must be owned by students in dealing with challenges and problems that involve critical, systematic thinking and being able to make the right decisions. In fact, these skills have not been optimally developed in students. The purpose of this study was to identify and analyze students' problem solving skills using the Heller indicator on the topic of fluid dynamics. The research method uses descriptive with a quantitative approach. The subjects were 36 students from one of Senior High School in Medan city Indonesia who were selected by probability sampling using the proportional stratified random sampling technique. The data collection instrument used a problem solving skills test of 10 questions. Based on research results, 50% students are in low problem solving skills and only 8% in high problem solving skills. Achievement of the lowest indicator that is on describe the problem in terms of physics, execute plan, and evaluate answer. The factors causing low level because students have not been able to understand the problem properly, students have difficulty changing problems in questions into simple sketches and are still confused in determining the physical quantities used to solve problem.

Keywords : Fluid Dynamics, Heller's Indicator, Problem Solving Skills

Introduction

Conceptual and Theoretical Framework

In facing the era of globalization which is marked by the rapid development of science and technology, it is necessary to have human resources who are reliable and capable of global competence. Quality human resources have thinking skills and are reliable, including critical, systematic, logical, creative thinking, being able to make the right decisions, and being able to solve problems in life with brilliant ideas. This is in accordance with Sani's view (2019) which states the importance of equipping students to have high creativity, flexibility in critical thinking, being able to make careful decisions and be proficient in solving existing problems.

Report of one of the international studies namely the PISA test (International Program for Student Assessment) held by the OECD (Organization for Economic Cooperation and Development). The results of PISA (2018) show that Indonesia is ranked 70 out of 78 countries with a science value of 396. Meanwhile, the results of the TIMSS (Trends in International Mathematics and Science Study) study show that Indonesian students are ranked 36 out of 49 countries in terms of carrying out a process. This is in line with the percentage of Indonesian students' science skills in the low category of 66.6% and the high category has not been studied (OECD, 2018). These results indicate that thinking skills of Indonesian students are still at the stage of low-level thinking skills. At higher level thinking skills, the emphasis is on skills that require reasoning, critical thinking, and creativity. These three components can be taught to students through problem solving activities (Kurniawan, 2015; Tanjung and Nasution, 2022).

Problem solving skills are one of the very important competencies that must be attached to all students (Greiff et al., 2013; Yanto, Festiyed & Enjoni, 2020). This problem-solving skill is part of a higher-order thinking process that requires students to be able to combine existing information with new information (Fanani, 2018; Saputra, 2016). Problem-solving

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skills-based learning is designed based on an active, student-oriented learning system, increasing curiosity and evaluation based on Higher Order Thinking Skills (HOTS) (Rapih and Sutaryadi, 2018; Boaler and Staples, 2008). Problem solving skills are seen as a fundamental part of learning physics. This is because through problem solving skills it is hoped that it can stimulate students to think about solving problems using appropriate principles and laws. The importance of having problem solving skills in students will increase new experiences in finding solutions to existing problems.

The application of problem solving should be applied in the learning process, that is because in the process of solving problems, students are not only required to hear, write and remember the concept of the lesson, but more than that students will be trained in active thinking, communicating, collecting and processing information, and concluded (Desliana et al., 2018). The capacity to solve complex problems is considered an important skill for every individual in today's technologically developing times (Martinez, 1998). The process of solving physics problems effectively guides students to be able to identify, make decisions and provide a flow of problem solving using logical thinking, literacy and high creativity (Hedge and Meera, 2012).

Students can be declared capable of solving problems if they are able to determine something that forms the basis of the problem to be solved, after that they must be able to determine effective and efficient steps so that the solution can be implemented immediately. Skills in problem solving are complex problem solving in which thinkers must be able to carry out analysis and synthesis which are high-order thinking skills (Widodo & Kadarwati, 2013).

Related Research

In physics lessons, students are said to have problem-solving skills if they are able to solve physics problems based on the stages of completion, including focusing on the problem, describing the problem in the context of physics, preparing a problem-solving plan, executing the problem-solving plan and evaluating the results obtained (Festiyed, Djamas & Pilendia, 2018). Solving physics problems systematically needs to be trained for all students so that understanding of the concept becomes more intact. In fact, what was found at school showed that students' physics problem-solving skills were still relatively low (Maulani et al., 2020). Students tend to have difficulty and are less able to solve problem-based questions (Sopian & Afriansyah, 2017).

This is in line with the results of research conducted by Khasanah (2015) that some students still experience difficulties in solving problems in word problems. When the teacher asks students to solve non-routine questions, students are less able to solve them. Non-routine questions are questions that require further thought to solve. In learning, the teacher never orients students to an everyday problem that is close to students' lives and does not pay attention to students' problem solving abilities (Tanjung and Dwiana, 2019; Tanjung et al., 2021). In a study conducted by Hariawan et al., 2014, it was shown that students' problem solving skill scores from the creative problem solving learning experimental class only reached 45% of the expected ideal score. This is also supported by the percentage of problem solving indexes for some students which are still below 75%, which also means that students' problem solving skills are still lacking (Nikat & Latifah, 2018).

The study of fluid dynamics is one of the studies of physics material whose application is often found in real life, but not all students can find examples of its application (Kusrini, 2020). Fluid Dynamics topic is also one of the most complex materials that requires an understanding of models, principles and basic laws such as Newton's laws and the conservation of energy (Young and Fredman, 2012). Based on the results of initial observations at one of senior high school in Medan, it was found that one of the physics materials that was quite difficult was dynamic fluid material. Through this material, students' physics problem-solving skills have never been measured or assessed, so researchers took dynamic fluid material because it would be suitable to be applied in a problem-solving skill-based test instrument.

Research questions of the study

Based on the background and problems described above, the research question is how the students' physics problem-solving skills based on Heller's indicators and students' difficulties in solving fluid dynamics problems. The results of this study can be an illustration for formulating appropriate learning in building and improving students' problem solving skills, especially on physics topics. If the problem given to the student is something that is well known, then the individual can solve the problem without using problem solving skills and the problem is not a problem for the student.

Research Methods

Research model

The type of research method used is descriptive method with a quantitative approach. Quantitative research doesnot focus on the depth of data that is important to record as much data as possible from a large population. Quantitative research uses instruments (data collection tools) that produce numerical data (numbers). Data analysis is done using statistical techniques to reduce and group data.

Participants

The subjects of this study were students at senior high school in Medan. The subjects were 36 students from one of Senior High School in Medan city Indonesia who were selected by probability sampling using the proportional stratified random sampling technique.

Data collection tools

The research was carried out by giving a problem solving skills test on dynamic fluid topics. The test is specifically designed to find out information about students' problem solving skills. The test is in the form of a description with a total of 10 questions. In this test the measurement instrument (assessment) uses a problem solving skills rubric adapted from the problem solving skills assessment rubric developed from the Robust Assessment Instrument For Student Problem Solving by Doctor and Heller (2009). For each item of question students are required to provide answers in the form of discussion or description based on the stages of completion following the indicators of problem solving skill flow according to Heller's theory, namely focus the problem, describe the problem in terms of physics, plan a solution, execute the plan, and evaluate the answers. As for Heller's problem solving steps, according to Figure 1.

Procedure

The procedure used in the study consisted of 3 stages: (1) the preparatory stage, compiling instruments or compiling questions for data collection, and developing questions according to Heller's problem solving indicators. (2) the implementation stage, testing the tests that have been developed, and (3) the evaluation stage.

Data on test results to measure students' problem-solving skills can be seen from the scores based on special grading rubric. The scores obtained are then calculated, then analyzed and converted into qualitative data to determine the percentage level of students' physics problem solving skills. The formula for the percentage of the final grade obtained by students is as follows:

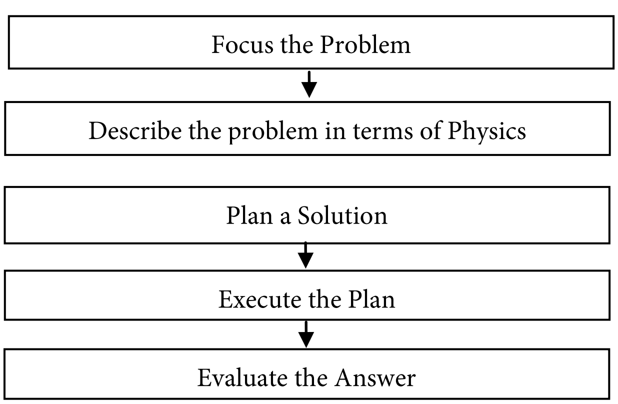

Fig. 1: Heller's problem solving steps

$$Percentage\ (P) = \frac{f}{N} \text{ x } 100$$

Description :

P = Percentage score
f = Total score obtained
P = Maximum total score

The calculated test result data is analyzed and converted into qualitative data to determine the level of students' physics problem-solving skills. The range for interpreting the results of the data obtained with the qualitative range is presented in Table 1.

Students are said to have good skills and are able to reach each stage of Heller's problem solving if students have been able to pass each indicator as shown in Table 1. Students are grouped based on problem solving skills per indicator. This is intended to see the ability and readiness of students in working on questions based on Heller's problem solving. In addition, it also describes the descriptors of achievement in solving problems. Student indicators can answer questions according to the problem-solving steps as shown in Table 2.

Results and Discussion

Results of Analysis of Students' Physics Problem Solving Skills

The problem solving skills data on dynamic fluid topics were obtained from test results using a problem solving skills test instrument. The results of the problem-solving skills test are then calculated based on 5 reference indicators in solving physics problems, including focusing on problems, describing problems in the context of physics, developing problem-solving plans and executing problem-solving plans. The results of students' physics problem-solving skills tests are presented in table 3.

Table 1: Leveling of Students' Physics Problem Solving Skills in Percentage

Achievement Percentage (AP)	Problem Solving Skills Level
$80 < AP \leq 100$	Very High
$60 < AP \leq 80$	High
$40 < AP \leq 60$	Middle
$20 < AP \leq 40$	Low
$0 < AP \leq 20$	Very Low

Table 2: Problem Solving Indicators based on Heller's Theory

No	*Indicator*	*Description*
1	Focus the Problem	Students are said to be able to focus on problems if they are able to analyze problems by clearly visualizing situations or events in the problem, including writing down what information is known and asked relevantly, giving each quantity and unit correctly and identifying physics approaches that might be useful to reach solutions such as basic principles what physics is used (eg: kinematics, Newton's law, conservation of energy).
2	Describe the problem in terms of Physics	Students are said to be capabledescribe the problem in the context of physics if you are able to describe the necessary diagrams/flows consistently with the right physics approach, identify the target quantities to be determined by the answers to these questions and assemble the appropriate equations to measure the physics principles and constraints identified in the physics approach will be applied.
3	Plan a Solution	Students are said to be able to devise a problem-solving plan if they are able to write down a plan for what will be done to solve the problem including making a chain of logical equations from the equations that have been identified in the previous step, starting from the target number to the known number and writing a description of the steps for solving the problem.
4	Execute the Plan	Students are said to be capableexecute the problem-solving plan if it is able to carry out the plans that have been made with reference to the plans that have been prepared before. Planning or carrying out plans that have been made as a follow-up step to focus on the problem.
5	Evaluate the Answer	Students are said to be capable evaluate the results obtained, if you are able to carry out an analysis and evaluation of the solving steps that have been carried out whether they are appropriate and effective, whether the solving steps are correct and can be applied to solving similar problems, or whether the solving steps require generalizations.

Table 3: Results of Physics Problem Solving Skills

Acquisition of Student Values	Number of Students	Percentage of Students	Skill Level
$60 < AP \leq 80$	3	8 %	High
$40 < AP \leq 60$	8	22 %	Middle
$20 < AP \leq 40$	18	50 %	Low
$0 < AP \leq 20$	7	20 %	Very Low

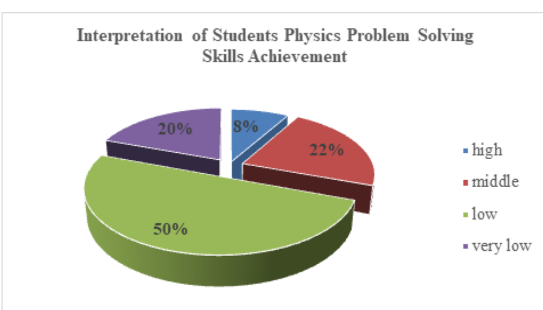

Figure 2: Interpretation of Achievement of Physics Problem Solving Skills

Based on the results of the test analysis, an interpretation of the results of the achievement of students' physics problem-solving skills can be presented, obtained from 36 students, shown in the pie chart in Figure 2.

The results of the analysis for each indicator at the stages of students' physics problem solving skills on the fluid dynamics topic are shown in table 4.

To see an informative comparison of percentages between one indicator and another, it can be seen in the line chart in Figure 3:

Achievement Analysis of Problem Solving Indicators

Indicator 1: Focus The Problem

The stage of focusing on the problem requires students to be able to identify and understand the problem carefully (Heller, 2010; Heller and Hungate, 1985; Afflerbach et al., 2015; Yee et al., 2015; Maulani et al., 2019). Based on the results of the analysis of the ten problems in the test instrument, it was found that students achieved this indicator at 54.86%.

Table 4: Percentage Results for Each Indicator of Physics Problem Solving Skills

Physics Problem Solving Skills Indicator	*Percentage Indicator*	*Skill Level*
Focus the Problem	54.86 %	Middle
Describe the problem in terms of Physics	34.79 %	Low
Plan a Solution	44.72 %	Middle
Execute the Plan	38.19 %	Low
Evaluate the Answer	37.78 %	Low

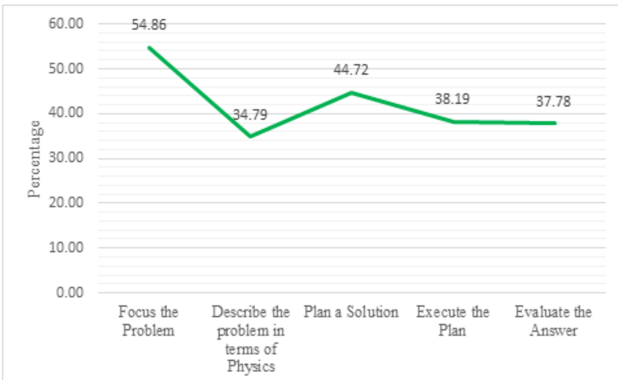

Fig. 3: Graph of Percentage Results for Each Indicator of Physics Problem Solving Skills

Based on the results of the analysis carried out, it was found that the achievement of this indicator requires students to understand the problem so that it is one of the easiest stages to do (N'am, 2012). The achievement of this indicator is based on the ability of students to provide information on what is known and asked relevantly, write down each quantity and unit correctly, present the information obtained and write down what conditions/requirements must be met.

Indicator 2: Describe the Problem in terms of Physics

The indicators describing problems in the context of physics require students to be able to describe the necessary diagrams/flows consistently with the right physics approach (Heller, 2010; Docktor and Heller, 2009; Puspitasari and Setyarsih, 2019; Al Maliki, 2016). Based on the results of the analysis of the ten problems in the test instrument, it was found that students could achieve this indicator with low criteria, which was equal to 34.79%.

The decrease in the percentage of indicators focusing on problems towards describing problems in the context of physics is caused by several factors, one of which is that students are less able to convert problems in questions into simple designs or sketches and the lack of awareness of students to relearn what they have learned, so that students difficulties in describing problems in the context of physics (Herman and Nurhayati, 2018). At this stage students are still not fully able to describe the necessary diagrams with a coordinate system that is consistent with the predetermined approach.

Indicator 3: *Plan a Solution*

Achievement of indicators in compiling a problem-solving plan requires students to be able to write down a plan for what will be done to solve the problem (Heller, 2010; Heller and Hungate, 1985; Wena, 2012; Ruseffendi, 1991; Maulani et al., 2019; Setyani et al., 2016). Based on the results of the analysis of the ten problems in the test instrument, it was found that students were able to plan problem solving by 44.72%.

This is because the achievement of the indicators for compiling this plan is measured based on the ability of students to write descriptions of the solution steps to be taken to determine the equations that have been determined in the previous step and to be able to look for possibilities that could occur or recall problems that have been solved before have similar characteristics/patterns with the problem to be solved. This achievement in this indicator because students can not describe problems in physics context correctly. The above results are confirmed by research by Maulani et al. (2019) states that students can plan the right strategy in determining equations to solve problems after students can describe problems in physics context.

Indicator 4: *Execute the Plan*

This indicator is achieved if students can carry out the strategies that have been made with perseverance and thoroughness to get the right solution (Heller, 2010; Heller and Hungate, 1985; N'am, 2012; Lismayani and Mahanal, 2017; Hidayat et al., 2017; Maulani et al., 2019; Agustini et al., 2015). Based on the results of the analysis of the ten problems in the test instrument, it was found that students could complete this stage in the low category at 38.19%. In achieving the indicators of executing the plan, students experience problems in checking and ensuring that each step is implemented and substituting known values into predetermined equations. In addition, students' skills in doing calculations at each step are still not accurate (Indah et al., 2022).

Indicator 5: Evaluate the Answer

The achievement of this indicator requires students to be able to re-examine the results of calculations and concepts of solving physics problems (Heller, 2010; Heller and Hungate, 1985; N'am, 2012; Maulani et al., 2019; Nurilyasari et al., 2018). Based on the results of the analysis of the ten problems in the test instrument, it was found that students could complete this stage low by 37.78%.

This indicator has not been optimally obtained because students experience problems in executing the planning at the previous stage which makes the final result of solving the problem not obtained, besides that most students also do not carry out inspections and evaluations of the steps taken to solve the problem, and have not fully ensured that the results problem solving solutions are complete, appropriate and reasonable. The results obtained were also confirmed by Rahmalia and Zahrotin's research (2021) which obtained the result that the re-examination/evaluation indicator (looking back) was included in the sufficient category.

Problem Solving Analysis Based on Question Items

Question 1**,** in item number one there is a problem of room temperature during winter which is often experienced by people who live in subtropical climates. Assuming that the density of air is constant and the space heater is square. Students are asked to help a family in designing the size of the heating channel which must be made by fulfilling several of the component requirements presented in the problem. Based on the results of the analysis of item number one, it was obtained that the results of the student completion process had almost fulfilled the stages of the solving process according to indicators of physics problem solving skills (Yuliana et al., 2019; Prastiwi and Nurita, 2018; Indah et al., 2022).

Students have been able to focus on the problem correctly. This is shown from the results of the answers given by students, where students can provide information that is known and asked about the questions completely and accurately (Ningsih and Syafi'i, 2018). At the stage of describing the problem in the context of physics, students experienced difficulties in describing the design sketch of the problem with the design of space heating ducts (Mufidaturosida, 2021). Students have also been able to plan problem solving well, but at the stage of executing the plans that have been prepared they experience problems because they require the ability to analyze and evaluate several equations for fluid flow discharge on the principle of continuity (Maulani et al., 2019). In addition, they also did not carry out a re-examination where this is important evidence in obtaining the right results (Asri et al., 2021; Ulfa, Roza & Maimunah, 2022; Herman and Nurhayati, 2018).

Question 2**,** in item number two there is a problem with the accumulation of bad fat in the capillaries of Mawar's mother which requires a CT-Scan, but it cannot be read by machine. So the doctor experienced problems in estimating the large number of capillary blood vessels in Mawar's body. Based on the results of the analysis of student problem solving in question number two, it was found that the stages of the student problem solving process were classified as sufficient in fulfilling the steps of the solving process using indicators of physics problem solving skills (Purnamasari et al., 2017; Hilyani et al., 2020; Setianingrum, 2016; Dali et al., 2018; Pratama et al., 2018). Some students have been able to carry out the stages of focusing on problems and describing problems in the context of physics, which can be seen from the results of students' answers in rewriting the problems contained in the questions (Maulani et al., 2019; Herman and Nurhayati, 2018).

The achievement of the indicators describes the problem in the context of physics, can be measured from the ability of students to apply equations to Dynamic Fluid and its application but are unable to analyze the discharge of blood flow in the aortic blood vessels with capillary blood vessels in determining the number of capillary blood vessels in Mawar's mother's body. However, the problem is that students still experience problems in following up on problem-solving plans to execute these problems (Asri et al., 2021). In item number two, students are still unable to connect the Continuity Equation to solve the problem in question. Students who get a good score indicate that students are able to describe a sketch diagram of the problems in the drainage system along with the physical quantities in it, however the resulting settlement results are not perfect because of the possibility of errors in calculations or errors in giving units in the final results obtained (Ulfa, Roza & Maimunah, 2022).

Question 3, in item number three there is a problem with the water channel system which is not smooth enough to reach the storage tank. So that a resident has difficulty in estimating the magnitude of the speed of water flowing in the water pipe, and in determining what solution to take, if you want the speed of water flowing at the mouth of the faucet to be 5 m/s. Based on the results of the analysis of problem solving skills in answer to question number three, there was an increase in students' ability to perform indicators of problem solving skills (Elisa et al., 2019). A number of students were also able to solve problems up to the stage of executing a problem solving plan. However, it does not require that there may still be students who are incomplete in writing down the units of each of the quantities that follow (Setianingrum, 2016).

In the indicator describing the problem in the context of physics, students have been able to describe the problem of the drainage system in the problem through a sketch diagram along with the physical quantities in it as well as determining the target variable and compiling the physics equations that will be applied (Misbah et al., 2017; Alfika and Mayasari, 2018). With several equations in fluid dynamics including the fluid flow discharge equation, the principle of continuity and Bernouli's law, students can develop a problem solving plan that will be implemented next. In executing the student's problem solving plan is still quite sufficient. This is because there are still many students who get a score of 1, where it is possible to enter the value incorrectly or there is an error in doing the calculation (Ningsih and Syafi'i, 2018). Students who get a score of 2 at this stage mean that they have mastered the indicators of problem solving skills well.

Question 4, in item number four shows the problems that residents experience when pumping flood water, namely the specification of the power of the water pump that is not listed on the packaging or pump label. Assuming the acceleration of gravity of the earth is 10 m/s^2 and the size ratio of 1 inc is 0.025 m. Students are asked to help these residents in estimating how the power/power of the pump is every second in pumping the water. Based on the analysis of item number four, it was found that students had difficulty completing the indicators completely and re-checking the steps that had been carried out (Setianingrum, 2016; Dali et al., 2018). Students who are able to achieve indicators of focusing on problems already know the problems to be solved but are still unable to analyze what steps must be taken (Maulani et al., 2019; Misbah et al., 2017).

Students who reach the indicator of describing problems in the context of physics are able to describe the problems of the water pumping system in the problem through sketch diagrams along with the physical quantities in them (Herman and Nurhayati, 2018). At the stage of planning problem solving students are classified as in a good category, shown by the results of student answers that are appropriate and appropriate in describing the steps that must be taken in solving problems in the water pumping system (Argarini, 2018; Setyani et al., 2016). However, at the stage of executing the plans that have been prepared, students still experience problems in carrying out the analysis by combining several continuity equations to obtain the power equation for the water pump, inaccuracies in workmanship which resulted in inaccurate answers and errors in calculating or entering values into the continuity equation (Asri et al., 2021; Nurilyasari et al., 2018). In addition, students still experience difficulties in concluding the final results obtained and do not write down the units of the final results obtained (Astutiani et al., 2019; Yuliana et al., 2019).

Question 5, in item number five shows the problem of error rate in military equipment that is quite large, such as torpedoes, so that it requires regular development and testing. Assuming the density of water is 1000 kg/m^3, students are asked to estimate how fast the water should flow in the non-narrow section of the pipe due to the torpedo model and determine how the pressure difference is between the narrow and non-narrow pipe sections. Based on the results of the analysis of student problem solving in question number five, it was found that the stages of the student problem solving process were classified as sufficient in fulfilling the steps of the solving process using indicators of physics problem solving skills (Purnamasari et al., 2017; Dali et al., 2018; Hilyani et al., 2020; Setianingrum, 2016). At the stage of focusing on the problem, students have been able to provide information that is known and asked about the questions completely and precisely (Maulani et al., 2019; Ningsih and Syafi'i, 2018).

Indicators of focusing on problems can be achieved if students already understand the problems in the questions and formulate problems correctly and precisely. At the stage of describing the problem in the context of physics, there are still problems in drawing a diagram of testing a torpedo in a water flow system into a simple solution sketch and determining the target variables and compiling the physics equations that will be applied (Asri et al., 2021; Puspitasari and Setyarsih, 2019). This is caused by several factors, one of which is that students' reasoning abilities on physics problems are still low and they do not understand the basic concepts of the continuity equation and Bernouli's law (Khotimah and Purwandari, 2018). From the results of working on the problems on the questions, students had difficulty carrying out the third, fourth and fifth completion stages. This can be seen from the results of student answers which are still not quite right and there are still students who empty their answer sheets at this stage of completion (Pratama and Sakdiyah, 2020). The results of the student answer sheets show that most students do not want to continue solving because they are still constrained in analyzing and evaluating several formula equations in fluid dynamics and suspecting that the stages in the problem require a long time to work on.

Question 6, in item number six shows that the problem of lift force on the aircraft is not optimal, it is caused not only by the design of the cross-section of the aircraft's wings that are not correct, but also because the aircraft engineer does not take into account the ideal weight that the aircraft must have. In item number six, the average student skill in applying the stages of problem solving is in the sufficient category (Hilyani et al., 2020; Pratama et al., 2018; Setianingrum, 2016). Based on the results of the analysis of the five indicators of problem solving skills, most students have achieved the indicator of focusing on problems. This first indicator shows that students are able to understand and find information in questions carefully and well (Hidayatulloh et al., 2020; Setianingrum, 2016). The problem-focusing indicator has the highest percentage of achievement, when compared to other indicators. These results also show that the indicator of focusing on problems is an indicator that students can master in solving student problems (Fatmawati and Murtafiah, 2018).

In the indicator describing the problem in the context of physics, students have not been fully able to describe the problem on the cross-section of an airplane wing with the magnitudes of the forces acting on it through a simple sketch design, besides that students are still confused in determining what physics equations will be used in solving problems (Misbah et al., 2017; Herman and Nurhayati, 2018). The results of the analysis on the indicators of compiling a problem-solving plan show that some students have difficulty relating the existing information to the completion plan in analyzing the ideal weight of the aircraft. Another factor is the inaccuracy of students in reading the questions because the problem-solving skill-based test instrument makes students less thorough, so that problem planning is made, also becomes less optimal and even illogical. The indicator of executing the problem solving plan in the number of questions is also still relatively low, indicating that students still have difficulty implementing Bernouli's law concept on the cross section of an airplane wing. This difficulty is caused by the planning of problem solving which is sometimes illogical and deviates from Bernouli's concept, so that when students are at the stage of implementing alternative problem solving, student answers become inappropriate (Yanti et al., 2016; Hidayatulloh et al., 2020).

Question 7**,** in item number seven shows a problem that requires students to be able to estimate how broad the cross-section of the Mendungkila river is and how large the discharge of water flowing in the Pantan and Mendungkila rivers is based on the problems given in the questions. The results of the item analysis for number seven show that the average student skill in applying the stages of problem solving is in the good category (Indah et al., 2022; Yuliana et al., 2019; Prastiwi and Nurita, 2018). Based on the results of the test trials that have been carried out by students, it shows that the achievement of indicators that focus on problems is in the good category. Students have been able to identify known information from the questions given and correctly write down what is asked from the questions given (Debora and Hakim, 2020; Setianingrum, 2016)

In the indicators describing problems in the context of physics, students are already in the good category. The achievement of indicators describing problems in the context of physics can be seen from the ability of students to compile and apply the fluid flow discharge equations along with the continuity principle equations. In addition, students can also describe the problem diagram on the cross-section of the river in the problem into a simple solution sketch and can determine the target variable correctly (Indrawati and Darmadi, 2021; Setianingrum, 2016). Then on the indicator of compiling a problem-solving plan, students are able to write down a description of the steps used because students in question number seven already understand what steps must be taken to solve problems in the river flow (Asri et al., 2021). On the indicator of executing a problem-solving plan, students are able to carry out the completion steps according to a predetermined plan. Students are able to draw up a problem-solving plan properly, so as to bring students consistent in solving problems and performing physics calculation operations using several equations on fluid flow discharge along with the principle of continuity. However, on indicators evaluating the results obtained, students did not re-check answers that had been completed properly. Even though the final results obtained are correct, because students consider this stage trivial (Gunada and Roswiani, 2019; Yanti et al., 2016; Hidayatulloh et al., 2020).

Question 8**,** in item number eight there is a problem regarding a trial carried out on one of the aircraft wing designs, but the result causes the wing to tilt and not lift perfectly. This is due to differences in air pressure that do not match the shape of the wings. In order for the aircraft wing to be able to maintain its balance and be able to produce a large lift, students are asked to choose one of the three aircraft design designs made by the engineer and to influence the design of the chosen shape of the aircraft wing in producing lift on the aircraft. Based on the results of the analysis of problem solving skills in the answer to question number eight, there was an increase in students' achievement of physics problem solving indicators. A number of students were able to solve the problems presented in the questions up to the stage of executing the problem solving plan. In the indicator of focusing on problems, the results at this stage show that students are able to express what is known and can express what is asked of the problems in the wing design clearly and precisely (Hati et al., 2018; Mawaddah and Anisah, 2015).

In the indicator describing the problem in the context of physics, students have not been fully able to describe the problem on the cross-section of an airplane wing with the magnitudes of the forces acting on it through a simple sketch design, besides that students are still confused in determining what physics equations will be used in solving problem (Indah et al., 2022; Ningsih and Syafi'i, 2018). Based on the results of the analysis at the stage of compiling a problem-solving plan at number eight it was obtained, students belonged to the good category (Maulani et al., 2019). This can be seen from the students' answers in writing and describing the settlement plan in solving problems in aircraft wing design. In addition, students are also right in directing problems to solving procedures that will be used to solve problems precisely and clearly. However, the indicators of executing planning, solving problems and evaluating the results obtained are still in the sufficient category.

One of the factors that causes it is because students still feel confused in executing Bernouli's equations on airplane wings. Even in the process of carrying out problem solving, students still admit that they are always not careful in doing calculations (Sari et al., 2020). This can be seen in the indicators in evaluating the results obtained, which show that students rarely check and look back at the answers students have worked on, thus these students are still confused in knowing whether the completion steps that have been taken are correct or not (Haryati et al. al., 2021).

Question 9**,** in item number nine shows problems in the process of preventing malaria through fogging which requires the use of quite large tools, so that it also requires a large amount of energy to operate. A mosquito repellent manufacturer has an initiative in developing an innovative mosquito repellent sprayer that is effective and easy for all people to use. However, the producer had a number of problems that arose in his mind related to the working process of the mosquito sprayer that would be applied. Based on these problems, students were asked to help the producer in solving a number of problems that arose in his mind so that the mosquito sprayer could be used optimally and effectively. Based on the results of the analysis of item number nine, students in applying the stages of problem solving are classified as sufficient (Hilyani et al., 2020; Setianingrum, 2016; Dali et al., 2018; Pratama et al., 2018) . Based on the results of the analysis of the five indicators of the stages of problem solving skills, it was found that most of the students had achieved the indicator of focusing on problems.

This is shown from the results of the answers given by students, where students can provide information that is known and asked about the questions completely and accurately (Aji and Mahmudi, 2018; Yanti et al., 2016). At the stage of describing the problem in the context of physics, students have not been fully able to describe the problems in designing mosquito coil sprayers with dynamic fluid quantities working in them through a simple sketch design, besides that students are still confused in determining what physics equations will be used in problem solving (Susiana et al., 2017; Puspitasari and Setyarsih, 2019). At the stage of compiling a problem-solving plan, students are still not precise in determining problem-solving steps (Hilyani et al., 2020; Setianingrum, 2016; Dali et al., 2018). This can be seen from the students' answers in preparing plans to solve problems in the design of mosquito repellent sprayers, so that it is very influential at the stage of executing the problem solving plan which results in solving the problem not being answered by students. This can be seen from the students' answers, most of which provide inaccurate or partial completion conclusions (Azizah et al., 2015; Laksmiari et al., 2019).

Question 10**,** the problem in point number ten concerns a leak in the water storage tank at its base which causes water to gush out. Assuming that the gushing water travels the furthest distance from the tank hole, based on this problem, students are asked to estimate the initial height of the water in the tank. Based on the results of the analysis of student problem solving in question number ten, it was found that the stages of the student problem solving process were classified as sufficient in fulfilling the steps of the solving process using indicators of physics problem solving skills. The results of the student description in number ten seem to be able to focus on the problem, which can be seen from the students being able to understand and find information on the leaking tank problem carefully and well (Widiningtyas and Sudarti, 2018; Yanti et al., 2016).

At the stage of describing the problem in context of physics, students are not fully able to describe the problem in a water storage tank that has a hole at the bottom which causes water to gush out. In addition, students are also still confused about showing dynamic fluid quantities in problems through a simple sketch design (Susiana et al., 2017; Asri et al., 2021). In addition, students are still confused in formulating the toricceli theorem equations and analyzing them based on the equations of motion of objects in free fall. This is due to students' reasoning and analytical skills regarding physics problems are still relatively low (Anjani et al., 2020; Tanjung and Bakar, 2019; Tanjung and Nasution, 2022). This is confirmed from the description of the stages of preparing a problem solving plan, where students have not been able to answer questions correctly so that it can be said students are still not able to plan in solving problems with leaking tanks. This also has an impact on the execution of problem-solving plans which results in errors in obtaining the correct results and students also still experience problems in re-checking the answers obtained correctly and correctly (Haryati et al., 2021; Fatmawati and Murtafiah, 2018; Hidayatulloh et al. al., 2020; Indrawati and Darmadi, 2021).

The research findings that have been obtained indicate that a problem-solving skill-based test instrument can measure and assess students' physics problem-solving skills (Hidayat et al., 2017). This provides an indication that using a problem-solving skill-based test instrument can familiarize students with improving their thinking skills to solve physics problems, so that educators can further evaluate the advantages and disadvantages of the learning carried out (Kesuma and Setyarsih, 2021). Product problem-solving skills-based test instruments that have been developed include measurement tools that can improve students' higher-order thinking skills.

The Achievement of student scores in working on problem-solving skills-based test instruments is due to the fact that most of the test instruments that have been used by educators/teachers for student assignments tend to fall into the LOT and HOT category test instruments which fulfill the thinking criteria according to Bloom's taxonomy while for test instruments that measuring high-order thinking skills based on students' physics problem solving is still rarely applied (Rusdianto, 2020; Widana, 2017; Rahayu et al., 2018). In addition, the questions used are still focused on conceptual knowledge and are at the cognitive level of understanding to analysis only. Another factor is because the form of the questions used at school is very different from the test instrument that I developed. This is because they feel that working on the test instrument product will not affect their scores in physics subjects (Hidayatulloh et al., 2020; Setianingrum, 2016).

In addition, the findings based on research data obtained that students in providing solutions according to Heller's problem solving indicators did not rule out the possibility of missing some or several stages in problem solving (Debora and Hakim, 2020). Based on analysis of student answers on problem-solving skills-based test instruments, it was found that on average students usually do focus on the problem stage well. That's because on this indicator students have been able to understand the problem well. In addition, at this stage students are only required to provide information about what problems are presented in the questions along with information that is the focus of the problems asked in the questions (Hidayatulloh et al., 2020; Setianingrum, 2016). In the indicators describing problems in the context of physics, it was found that on average, some students skipped this stage and continued at the stage of preparing a problem-solving plan. This is because students experience difficulties in changing the problem in the problem into a simple sketch design form (Susiana et al., 2017; Asri et al., 2021).

In the indicators of compiling a problem-solving plan, on average, some students don't miss it because at this stage students are required to only outline the steps for solving the problem. This is in accordance with the results of interviews with students who stated that in working on the third stage, namely compiling a problem-solving plan, it took quite a short time when compared to when working on the second stage, namely describing the problem in the context of physics. The students' views were also confirmed based on the statements of Pramada and Hajerina (2020) which argued that students were more likely to work on problems that tended to require a relatively short amount of time.

In addition, there are also students who do non-sequential problem solving according to the implementation indicators. One of the reasons is because they think that the final result of the answers that are done is the most important thing (Nurul, 2022). So they feel that executing problem solving without understanding and planning is enough to prove that they are capable of solving problems. Even though this is a mistake, which is based on the view according to Nakin (2003) which states that problem solving is a thinking process that involves the use of certain stages (heuristics), which are referred to as models or clear problem-solving steps to find a solution to a problem. In this case students can be said to be skilled in solving problems if students are able to solve physics problems that are presented based on each stage in solving physics problems (Heller, 2010; Andriani, 2016). Therefore, if students only contain part or half of each stage of solving physics problems, it can be concluded that students are not fully skilled in solving physics problems.

These problems also make students only work on stages that require brief descriptions of answers such as in the final stage of evaluating the results obtained. This case occurred because students copied the results of the stages from other students so that they were not in sync with the results at the previous stage which were still fully in the middle of completion (Andiwatir and Khakim, 2019). Besides that, another cause is that students know that each stage in problem solving is given a score even though the description of the stages given is wrong. Departing from these factors, students choose to provide descriptions of answers at stages that require less time, such as at this final stage (Pratama et al., 2017).

Conclusion

Based on research results, 50% students are in low problem solving skills and only 8% in high problem solving skills. Achievement of the lowest indicator that is on describe the problem in terms of physics, execute plan, and evaluate answer. The factors causing low level because students have not been able to understand the problem properly, students have difficulty changing problems in questions into simple sketches and are still confused in determining the physical quantities and content used to solve problem, besides that students have not been able to finish the steps of solving the problem correctly, structured, and finally students are not fully skilled in executing physics problems because students only memorize formulas and equations mathematically without understanding concept of fluid dynamics and having difficulty connecting quantitative equations on the topic of fluid dynamics with other topics that will be applied in problem solving.

Recommendation

The recommendation of this research is that physics teachers can apply the learning model to improve creative thinking and problem solving skills. In addition, it can increase understanding in the integration of science and pedagogy. The results of this study can be used as a reference for teachers in developing contextual physics learning.

References

Abdullah, S. R. (2019). Strategi belajar mengajar. Depok: PT Raja Grafindo Persada.

Agustini, D., Subagia, I wayan, & Suardana, I. (2015). Pengaruh Model Pembelajaran Sains Teknologi Pelajaran IPA di Mts Negeri Patas. Jurnal Media Pendidikan Matematika. 3(2): 100–108.

Aji, R.E.W., & Mahmudi, A. (2018). Efektifitas pembelajaran matematika dengan strategi problem solving untuk meningkatkan kemampuan pemecahan masalah matematis siswa Kelas VIII SMP. Jurnal Pendidikan Matematika. 7(3): 46-54.

Al Maliki, I. M. (2016). Identifikasi Kemampuan Pemecahan Masalah Siswa Kelas X Sman 9 Malang Pada Topik Suhu Dan Kalor. JURNAL PEMBELAJARAN FISIKA, 4(5), 801-807.

Andiwatir, A., Khakim, A. (2019). Analisis Perilaku Menyontek dan Rancangan Perubahannya pada Siswa SMP (Analysis of Cheating Behavior and Change Design in Junior High School Students). Jurnal Psikologi Ilmiah. 11(2): 88-97.

Andriani, N. L. Y., & Darsikin, D. (2016). Analisis kesulitan siswa dalam menyelesaikan soal gerak lurus. JPFT (Jurnal Pendidikan Fisika Tadulako Online), 4(3), 36-41.

Anjani, F., Supeno, S., & Subiki, S. (2020). Kemampuan Penalaran Ilmiah Siswa SMA Dalam Pembelajaran Fisika Menggunakan Model Inkuiri Terbimbing Disertai Diagram Berpikir Multidimensi. Lantanida Journal. 8(1): 13-28.

Argarini, D.F. (2018). Analisis Pemecahan Masalah Berbasis Polya pada Topik Perkalian Vektor Ditinjau dari Gaya Belajar. Jurnal Matematika dan Pembelajaran. 6(1): 91-99.

Arief, M. K., Handayani, L., & Dwijananti, P. (2012). Identifikasi kesulitan belajar fisika pada siswa RSBI: Studi kasus di RSMABI se Kota Semarang. UPEJ Unnes Physics Education Journal, 1(2).

Asri, D., Silitonga, H. M., Arsyid, S. B. (2021). Deskripsi Kemampuan Pemecahan Masalah Pada Topik Momentum Dan Impuls Siswa di SMA Negeri 3 Pontianak. Jurnal Pendidikan dan Pembelajaran. 10(12): 1-10.

Astutiani, R. (2019). Kemampuan pemecahan masalah matematika dalam menyelesaikan soal cerita berdasarkan langkah Polya. In Prosiding Seminar Nasional Pascasarjana (PROSNAMPAS) (Vol. 2, No. 1, pp. 297-303).

Azizah, R., Yuliati, L., & Latifah, E. (2015). Kesulitan pemecahan masalah fisika pada siswa SMA. Jurnal penelitian fisika dan aplikasinya (JPFA), 5(2), 44-50.

Boaler, J., & Staples, M. (2008). Creating mathematical futures through an equitable teaching approach: The case of Railside school. Teacher College Record, 110(3) : 608-645.

Charles,R., Laster, F., dan O'Daffer, P. (1994). How to Evaluate Progress in Problem Solving. National Council of Teacher of Mathematics.

Debora, M.B.B., Hakim, A. (2020). Analisis Kemampuan Pemecahan Masalah Matematika melalui Metode Practice Rehearsal Pairspada Siswa SMA Al-Hidayah. Jurnal ilmiah fakultas keguruan dan ilmu pendidikan. 6(1): 74-78.

Debora, M.B.B., Hakim, A. (2020). Kemampuan Pemecahan Masalah Fisika Pada Topik Usaha dan Daya Berdasarkan Langkah-Langkah Heller. Jurnal Pendidikan Fisika. 9(2): 8-12.

Desliana, M. (2018). Kemampuan Pemecahan Masalah Siswa Kelas X SMAN 4 Tanjungpinang Berdasarkan Gaya Belajar Model David Kolb. Skripsi Pendidikan Biologi. Universitas Maritim Raja Ali Haji. Tanjung Pinang

Docktor, J., & Heller, K. (2009, April). Robust assessment instrument for student problem solving. In Proceedings of the NARST 2009 Annual Meeting, Garden Grove, CA (Vol. 1, No. 1, pp. 1-19).

Doctor, J & Heller. (2009) Robust Assessment Instrument for Student Problem Solving. Proceedings of the NARST 2009 Annual Meeting, Minnesota University.

DR, D. A., & Zahrotin, A. (2021, December). Analisis Kemampuan Pemecahan Masalah Fisika pada Materi Gerak Parabola SMA. In PISCES: Proceeding of Integrative Science Education Seminar (Vol. 1, No. 1, pp. 575-580).

Elisa, E., Mardiyah, A., & Rambe, A. (2019). Peningkatan Kemampuan Pemecahan Masalah Fisika Siswa Menggunakan Metode Praktikum Di Kelas X MAN Sipirok. PeTeKa, 2(1), 9-13.

Fatmawati, F., & Murtafiah, M. (2018). Deskripsi kemampuan pemecahan masalah peserta didik kelas XI SMA Negeri 1 Majene. Saintifik, 4(1), 63-73.

Festiyed, F., Djamas, D., & Pilendia, D. (2018). Implementation Authentic Task to Enhance Problem Solving and Self-Management for Physics College Students.

Greiff, S., & Funke, J. (2009). Measuring complex problem solving: The MicroDYN approach.In F. Scheuermann & J. Björnsson (Eds.), The transition to computer-based assessment: New approaches to skills assessment and implications for large-scale testing (pp.157–163). Ispara, Italy: European Commission.

Gunada, I.W., Roswiani, Y. (2019). Analisis Tingkat Kemampuan Pemecahan Masalah Topik Fluida Statis Melalui Model Pembelajaran Problem Solving. Jurnal Pendidikan Fisika. 14(1): 1-10.

Hegde, B., & Meera, B. N. (2012). How do they solve it? An insight into the learner's approach to the mechanism of physics problem solving. Physical Review Special Topics-Physics Education Research, 8(1), 010109.

Heller, K & Heller, P. (2010). Cooperative Problem Solving in Physics A User's Manual. US : Department of Education.

Herman, N. M., & Nurhayati, N. Analisis Kemampuan Memecahkan Masalah Fisika melalui Kegiatan Praktikum pada Peserta Didik Kelas XI IPA SMA Negeri 10 Makassar. Jurnal Sains dan Pendidikan Fisika, 14(1), 319142.

Hidayat, S.R., Setyadin, A.H., Hermawan, H., Kaniawati, I., Suhendi, E., Siahaan, P., & Samsudin, A. (2017). Pengembangan instrumen tes keterampilan pemecahan masalah pada topik getaran, gelombang, dan bunyi. Jurnal Penelitian & Pengembangan Pendidikan Fisika. 3(2): 157–166.

Hidayatulloh, R., Suyono, S., & Azizah, U. (2020). Analisis keterampilan pemecahan masalah siswa sma pada topik laju reaksi. JPPS (Jurnal Penelitian Pendidikan Sains), 10(1), 1899-1909.

Hilyani, N. H., Pitriani, P., & Malalina, M. (2020). Analisis Kemampuan Pemecahan Masalah Matematis Pada Siswa Kelas Vii Smp Negeri 57 Palembang Materi Aritmatika Sosial. Sigma: Jurnal Pendidikan Matematika, 12(2), 125-132.

Indah, N., Sukariasih, L., Erniwati. (2022). Analisis Kemampuan Pemecahan Masalah Fisika Siswa Pada Topik Hukum II Newton Di SMK Negeri 02 Bombana. Jurnal Penelitian Pendidikan Fisika. 7(2) : 78-83.

Indrawati, A., Darmadi, W.I. (2021). Kemampuan Pemecahan Masalah Fisika Pada Topik Usaha dan Daya Berdasarkan Langkah-Langkah Heller. Jurnal Pendidikan Fisika Tadulako. 9(2): 8-12.

Khotimah, D.H., Purwandari. (2018). Profil kemampuan penalaran pada pembelajaran fisika siswa SMK Kabupaten Madiun. Seminar Nasional Quantum : 450-453.

Martinez, M. E. (1998). What is problem solving?. The Phi Delta Kappan, 79(8), 605-609.

Maulani, N., Linuwih, S., & Sulhadi, S. (2020). Analisis Kemampuan Pemecahan Masalah Fisika Dalam Asesmen Higher Order Thinking. In Prosiding Seminar Nasional Pascasarjana (PROSNAMPAS) (Vol. 3, No. 1, pp. 590-597).

Maulani, N., & Subali, B. (2019). Analisis kemampuan rekonstruksi problem solving siswa melalui asesmen higher order thinking (HOT) siswa SMA. UPEJ Unnes Physics Education Journal, 8(3), 319-332.

Maulani, N., Linuwih, S., & Sulhadi, S. (2020). Analisis Kemampuan Pemecahan Masalah Fisika Dalam Asesmen Higher Order Thinking. In Prosiding Seminar Nasional Pascasarjana (PROSNAMPAS) (Vol. 3, No. 1, pp. 590-597).

Mawaddah, S., & Anisah, H. (2015). Kemampuan pemecahan masalah matematis siswa pada pembelajaran matematika dengan menggunakan model pembelajaran generatif (generative learning) di SMP. EDU-MAT: Jurnal Pendidikan Matematika, 3(2).

Misbah, Hafizah, E., & An'nur, S. (2017). Analisis Kemampuan Pemecahan Masalah Mahasiswa Pada Topik Suhu dan Kalor. Prosiding Seminar Nasional Pendidikan IPA: 22-26.

Mufidaturosida, Naila. (2018). Analisis kemampuan Pemecahan Masalah Siswa Berdasarkan Teori Heller Pada Topik Fluida Dinamis di SMA IT Alquraniyyah Kota Tangerang Selatan. Skripsi. Jakarta: Universitas Islam Negeri Syarif Hidayatullah.

Ningsih, R. S., Azhar, A., & Syafi'i, M. (2018). Analisis Kemampuan Pemecahan Masalah Fisika Siswa Kelas X Sma Pada Materi Kinematika Gerak Lurus Di Sma Negeri Plus Provinsi Riau. Jurnal Online Mahasiswa (JOM) Bidang Keguruan dan Ilmu Pendidikan, 5(1), 395-406.

Nurilyasari, D. F., Zainuddin, A., & Hariyanto, P. A. (2018). Analisis keterampilan pemecahan masalah pada mahasiswa pendidikan fisika Universitas Negeri Surabaya materi dinamika gerak partikel. Jurnal Riset Pendidikan Fisika, 3(1), 15-21.

Nurul, D. (2022). Analisis Kesulitan Kemampuan Pemecahan Masalah Pada Pesera Didik Dalam Pembelajaran Fisika. Jurnal Inovasi dan Teknologi Pendidikan. 1(1): 20-30.

Prastiwi, M. D., & Nurita, T. (2018). Kemampuan pemecahan masalah pada siswa kelas VII SMP. Pensa E-Jurnal: Pendidikan Sains, 6(02).

Pratama, N. D. S., & Sakdiyah, H. (2020). Analisis Kesulitan Siswa dalam Memecahkan Masalah Fisika pada Masa Pandemi COVID-19. In Seminar Nasional Fisika (Vol. 1, No. 1, pp. 63-70).

Pratama, N. D. S., Suyudi, A., Sakdiah, H., & Bahar, F. (2017). Analisis kesulitan siswa dalam memecahkan masalah fisika materi usaha dan energi. Jurnal Riset Pendidikan Fisika, 2(2).

Purnamasari, I., Yuliati, L., & Diantoro, M. (2017). Analisis kemampuan pemecahan masalah fisika pada materi fluida statis. In Seminar Nasional Pendidikan IPA 2017 (Vol. 2).

Puspitasari, N., & Setyarsih, W. (2019). Identifikasi kemampuan pemecahan masalah fisika peserta didik SMA menggunakan model pembelajaran cooperative problem solving. In Prosiding Seminar Nasional Fisika (SNF) (Vol. 3, pp. 119-126).

Rapih, S., & Sytardi. (2018). Perspektif Guru Sekolah Dasar Terhadap Higher Order Thinking Skills Pemahaman, Penerapan, dan Hambatan. Premier Education: Jurnal Pendidikan Dasar dan Pembelajaran. 8 (1) : 78-87.

Rosdiana & Misu, L. (2013). Pengembangan teori pembelajaran perilaku dalam Kaitannya dengan kemampuan pemecahan masalah Matematik siswa di SMA. In Prosiding Seminar Nasional Matematika dan Pendidikan Matematika FMIPA UNY.

Saad, N. Ghani, S & Rajendran N.S. (2005). The Sources of Pedagogical Content Knowledge (PCK) Used by Mathematics Teacher During Instructions: A Case Study. Departement of Mathematics. Universiti Pendidikan Sultan Idris.

Sani, R. A. (2019). Cara membuat soal HOTS. Tangerang: Tira Smart.

Saputra, Hatta. (2016). Pengembangan Mutu Pendidikan Menuju Era Global: Penguatan Mutu Pembelajaran dengan Penerapan HOTS (High Order Thinking Skills). Bandung: SMILE's Publishing.

Sari, D. I., Rejekiningsih, T., & Muchtarom, M. (2020, February). The concept of human literacy as civics education strategy to reinforce students' character in the era of disruption. In 3rd International Conference on Learning Innovation and Quality Education (ICLIQE 2019) (pp. 1132-1141). Atlantis Press.

Setianingrum, L. (2016). Analisis Kemampuan Pemecahan Masalah Fisika Siswa SMK. In SEMINAR NASIONAL JURUSAN FISIKA FMIPA UM 2016 ISBN 978-602-71279-1 (Vol. 9).

Sukmadinata & As'ari. (2006). Pengembangan Kurikulum Berbasis Kompetensi. PT. Universitas Pendidikan Indonesia.

Susiana, N., Yuliati, L., & Latifah, E. (2017). Analisis pembelajaran berdasarkan profil kemampuan pemecahan masalah fisika siswa kelas x sma. Research Report.

Tanjung, Y. I., & Bakar, A. (2019). Development of Physical Test Instruments Based on the Conceptual Knowledge Dimension of the Revision Bloom Taxonomy. Jurnal Pendidikan Fisika, 8(2), 141-148.

Tanjung, Y. I., Wulandari, D., Bakar, A., & Ramadhani, I. (2021, March). The Development of Online Physics Test System at SMA CT Foundation Medan. In Journal of Physics: Conference Series (Vol. 1819, No. 1, p. 012054). IOP Publishing.

Tanjung, Y. I., & Dwiana, Y. A. (2019). Pengembangan instrumen tes berbasis critical thinking skill pada materi gerak lurus. INPAFI (Inovasi Pembelajaran Fisika), 7(4).

Tanjung, Y. I., & Nasution, I. R. (2022). The Development of Creative Thinking Test Instruments with Torrance Indicators on Direct Current Electricity Materials. Jurnal Pendidikan Fisika Indonesia, 18(2), 134-143.

Ulfa, Y. L., Roza, Y., & Maimunah, M. (2022). Kemampuan Pemecahan Masalah Matematis Siswa SMA pada Materi Jarak pada Bangun Ruang. Mosharafa: Jurnal Pendidikan Matematika, 11(3), 415-424.

Utami, N. E. B. (2018). Layanan Guru Kelas Bagi Siswa Slow Learner Di Sekolah Inklusi (SD N Bangunrejo 2 Yogyakarta). Al-Bidayah: jurnal pendidikan dasar Islam, 10(2), 271-290.

Widiningtyas, A., & Sudarti, S. (2018). Analisis Kemampuan Menyelesaikan Masalah pada Materi Rangkaian Arus Searah Berdasarkan Polya pada Siswa Kelas XII IPA 4 SMA Negeri 4 Jember. FKIP e-PROCEEDING, 3(1), 268-272.

Windari, F., Dwina, F., & Suherman. (2014). Meningkatkan Kemampuan Pemecahan Masalah Matematika Siswa Kelas VIII SMPN 8 Padang Tahun Pelajaran 2013/2014 dengan Menggunakan Strategi Pembelajaran Inkuiri. Jurnal Pendidikan Matematika. 3(2): 25-28.

Yanti, N.R., Suharto, B., & Syahmani. (2016). Implementasi model problem based learning berbantuan tes superitem terhadap kemampuan pemecahan masalah topik kelarutan dan hasil kali kelarutan. Quantum, Jurnal Inovasi Pendidikan Sains. 7(2): 147–155.

Yanto, F., Festiyed, F., & Enjoni, E. (2021). Problem Based Learning Model For Increasing Problem Solving Skills In Physics Learning. JIPF (Jurnal Ilmu Pendidikan Fisika), 6(1), 53-65.

Yuliana, A. S., Parno, & Taufiq, A. (2019). Analisis Kemampuan Pemecahan Masalah Siswa Berdasarkan Rubrik yang Dikembangkan Docktor pada Topik Suhu dan Kalor. Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan. 4(4): 524–530.

Yuliana, Y., Rahayu, R. R., & Firmansah, F. (2022). Kesalahan Siswa dalam Pemecahan Masalah Matematika pada Teorema Pythagoras. Edukatif: Jurnal Ilmu Pendidikan, 4(4), 5532-5543.