The profile of students' problem-solving skill in physics across interest program in the secondary school

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Abstract. Problem-solving skills are important skills in physics. However, according to some researchers, the problem-solving skill of Indonesian students' problem in physics learning is categorized still low. The purpose of this study was to identify the profile of problem-solving skills of students who follow the across the interests program of physics. The subjects of the study were high school students of Social Sciences, grade X. The type of this research was descriptive research. The data which used to analyze the problem-solving skills were obtained through student questionnaires and the test results with impulse materials and collision. From the descriptive analysis results, the percentage of students' problem-solving skill based on the test was 52.93% and indicators respectively. These results indicated that students' problem-solving skill is categorized low.

1. Introduction
Is it a problem? The Big Indonesian Dictionary defines the word problem as something to be solved. For some people especially college students, physics is a problem. As evidence, many students are more interested in choosing IPS or social majors than IPA or science in order to avoid physics. In addition, many students are not interested in continuing lectures in physics and do not want to work in physics-related jobs or physics fields [1]. In fact, physics plays an important role in the development of the world, especially in the field of technology, and innovation in medicine [2]. Physics is closely related to human life. Physics is rich in its concepts, theories, and equations. Physics speak the language of mathematics in qualitative and quantitative calculations. In addition, dominant in physics is the nature of problem-solving, meaning almost all aspects of physics are concerned with problem-solving [3]. Physics needs to be solved through problem-solving because the problem solving of physics is a tradition that has been done by physicists, such as Newton who discovered his laws [4]. Thus, physics education should create students who are adept at problem-solving.

All science develops knowledge that directs students to be proficient at problem-solving. Problem-solving is the goal of modern education so that college students as individuals who can solve the problems encountered in everyday life [5]. Slavin (2011: 29) defines problem-solving as the application of knowledge and skills to achieve certain goals [6]. Gok and Silay (2008: 254) stated that problem-solving is the ability of students to use existing information or information obtained to determine what to do in a particular situation [7]. In this case, students must know what to do (know how to solve problems) in situations, students do not know how to solve the problem using existing
information. Thus, the educational process should enable students to use their knowledge in solving problem, referring to the effort required to achieve its goals or solutions.

Students' problem-solving ability in physics learning is still low due to internal and external factors. Based on research conducted by some researchers [8], the internal factors which cause low problem-solving skill were: 1) when students are given the opportunity to solve the physics problem, students often directly use the equation without doing problem analysis; 2) the students guess the formula to solve the problem; 3) the students memorize the settlement of the problem that has been resolved to solve a new problem; 4) lack of students' ability to remember appropriate equations; 5) students do not understand the basics of physics related to definitions, principles, laws in physics concepts; 6) they are weak in term of math skill to analyze physics problems; 7) students are confused to understand, remember, and convert units; 8) the students do not understand the problem given by the teacher; 9) students quickly give up when having trouble or difficulties in solving problems, there are also students who immediately give up when facing difficult physics problems.

The external factors of students' low skills are: 1) learning in the classroom that is still teacher centered; 2) the material of physics is taught by lecture, discussion, and assignment method; 3) lack of problem-solving practices during the classroom learning process; 4) lack of motivation and experience of physics teachers; 5) lack of exercises related to physics concepts; 6) lack of books and guidance on problem-solving materials in physics learning; and 7) lack of laboratory practice related to the concepts of physics studied. 6) they are weak in term of math skill to analyze physics problems; 7) students are confused to understand, remember, and convert units; 8) the students do not understand the problem given by the teacher; 9) students quickly give up when having trouble or difficulties in solving problems, there are also students who immediately give up when facing difficult physics problems. The external factors of students' low skills are: 1) learning in the classroom that is still teacher centered; 2) the material of physics is taught by lecture, discussion, and assignment method; 3) lack of problem-solving practices during the classroom learning process; 4) lack of motivation and experience of physics teachers; 5) lack of exercises related to physics concepts; 6) lack of books and guidance on problem-solving materials in physics learning; and 7) lack of laboratory practice related to the concepts of physics studied.

Based on the facts found above it is necessary to do a learning process that orientation on problem-solving so that students are accustomed to solving physics problems and problems-in life faced. The problem-solving process is a linear hierarchy process because each step of problem-solving is a continuation of the previous problem-solving step [5]. Troubleshooting requires defining, investigating, reviewing, and processing information about the problem you want to solve.

The most popular troubleshooting steps are the four Polya (1945: xvii) the step which is: recall (problem understanding), planning (strategy planning for problem-solving), implementation (implementing strategy), and evaluation (checking again) [9]. In addition, Heller, Keith, and Anderson (1991: 628-629) stated the problem-solving steps consisting of visualizing the program, describing its physics description, planning a solution, execute the plan, checking and evaluating [10]. Based on the steps proposed above, then the problem-solving steps in the lesson shown in Table 1.

Before the students followed the steps of problem-solving in the learning process, the research had done to see the profile of problem-solving skills of high school students who followed the across interests program of physics. The results of the study were further used as guidelines for developing the appropriate learning stages to improve problem-solving skill. In addition, the results of this study also used to select the indicator as a step of problem-solving that need to be trained more intensely by students during the problem-solving learning.
**Table 1.** The Steps of Problem-Solving and Its Indicators Adapted from The Problem-Solving Steps of Polya, Heller, Keith, and Anderson

| Steps                      | Indicators                                                                 | Code |
|----------------------------|---------------------------------------------------------------------------|------|
| Understanding the problem  | Identifying the known variables and converting the support units of problem-solving; | A1   |
|                            | Identifying the variables which are being asked;                          | A2   |
|                            | Visualizing the problem and/or identifying the supporting variables of problem-solving. | A3   |
| Planning the strategy      | Determining the theory and equation to solve the problem.                 | B1   |
| Implementing the strategy  | Using theory or equation to solve the problem asked.                      | C1   |
| Rechecking                 | Rechecking the truth of the answer;                                       | D1   |
|                            | Rechecking the appropriateness of theory/quantity/unit used.               | D2   |

Statements of physics, concept, theory, pictures, units, equation, and etc.

2. Method of Research

The type of this research was descriptive research. The subjects of this research were the students of class X, Social program 4, Senior High School or SMAN 1 Sambungmacan Sragen, semester 1, academic year 2016/2017. The research stage was done by observation of the learning process which done before starting the learning process. The students were asked to fill in questionnaire related to problem-solving skill. The instruments used in this research was a questionnaire of problem-solving skill and the test results with impulse and momentum materials and essay-based collision of 4 items.

The data were analysed using descriptive analysis by mean, the number of students' scores were categorized into the criteria shown in Table 2.

**Table 2.** The category of problem solving skill of students

| Interval Category | Category  |
|-------------------|-----------|
| $94.25 < X$       | Very high |
| $79.75 < X \leq 94.25$ | High    |
| $65.25 < X \leq 79.75$ | Enough  |
| $50.75 < X \leq 65.25$ | Law     |
| $X \leq 50.75$    | Very Low  |

Total of students' scores

Furthermore, students' scores were counted using this equation:

$$X = \frac{\text{Total student score per stage/indicator}}{\text{Maximum score per stage/indicator}} \times 100$$

3. Results and Discussion

In addition, to collect data through questionnaires and analysis of students' test results, researchers also observed the learning process of students for two hours of lessons. Some of the results of the observation in the learning process are: 1) students were not ready or not prepared to follow physics lessons; 2) the students forgot the physics concept which learned earlier; 3) the students' mathematical ability is weak; 4) students did not dare to ask the teacher about the problem or concept of physics that they understood; 5) students were still difficult to distinguish between the size and unit; and 6) students were still confused when converting units.

Based on the students' answers in the questionnaire, it was found that: 1) some students couldn't understand and solve problems because students pay attention and listen to teacher's explanations about the concepts of physics being studied; 2) some students assumed that gathering information is critical in solving problems so that students could find ideas to solve problems; 3) students usually plan and implement strategies to solve problems when students work together or discuss in groups. This is in line with the statement of Ikwanuddin, Jaedun, and Purwantoro (2010: 216) which stated
that problem-solving skills were excellent for being trained in groups because in groups the students can give their contribution [11].

Table 3. Summary of students' test analysis of problem-solving skills

| Step of problem-solving skills | Indicators | Category | %    |
|-------------------------------|------------|----------|------|
| Understanding the problem    | A1         | Enough   | 64.00|
|                              | A2         | Low      | 51.29|
|                              | A3         | Very low | 0.00 |
| Planning strategy            | B1         | High     | 73.49|
| Implementing strategy        | C1         | Enough   | 60.34|
| Recheking                    | D1         | Very low | 26.51|
|                              | D2         | Low      | 52.37|

Based on the analysis of students' test results on the collision materials momentum and impulse find some things such as 1) some students know and can write the amount or concept provided in the problem or problem; 2) most students can determine or know the exact equation to solve the problem; and 3) students can apply the equation to solve the problem. However, the average problem-solving skill of the students was analyzed based on the test results were categorized as “low” (52.93%). The highest percentage achieved by 73.49% students on the indicator determines the theory and/or equation to solve the problem. Meanwhile, the lowest percentage of problem-solving skill is 0.00% in the indicator to visualizing the problem and/or identifying the supporting variables of problem-solving.

3.1. The Profile of Students with “Very Low” Problem-Solving Skills

Student problem-solving skills that are categorized as very low are obtained on the result of student test analysis that is in understanding the problem skill, especially on indicators visualizing the problem and/or identifying the supporting variables of problem-solving. In addition, re-examination skills, especially on indicators re-examining the truth of answers are also categorized very low. This can be due to: first, the student's focus that always leads to known variables and the exact equations to solve the problem. As a result, many students do not find the right answer in problem-solving [12]. Visualizing and identifying the problem is very important in the troubleshooting process. The reason, when students know the right content in the problem, then students can plan appropriate steps to solve the problem [3]. Second, students assume the results already obtained are the correct answer. After getting the results from the calculation, students move directly to work on other questions, without paying attention to his work step from the beginning. As a result, many student calculations are wrong, although the equations used are correct. This is in line with Pardimin and Widodo's (2016: 394) study which states that students are only able to carry out problem-solving steps until implementing a plan to solve the problem. For students, checking back slows down troubleshooting time. This is why students' problem-solving skills have not been satisfactory [13]. According to Kurniawan, Handayanto, and Parro (2016: 108-109) students do not collect information and do not check the results of problem-solving, because students do not understand the underlying concept of problem-solving [14]. If students master the concept well, then the process of gathering information and re-examining problem-solving can be done well.

3.2. The Profile of Students with “Low” Problem-Solving Skills

Based on the results of the analysis of the data above, the problem-solving skill of low categorized students is at the stage of understanding the problem and checking again. Based on the answers from the student questionnaire, the low comprehension skills caused by the students did not pay attention to the initial explanation of the teacher, so that the students did not understand the problem posed by the teacher. Based on the test results, the problem-solving skills of the students are low at the stage of
understanding the problem especially on the indicators identifying the variables asked. While the skills to check back is also categorized low, especially on the skills to check the suitability of quantities and units.

The low student problem-solving skills can be caused by several things such as: first, the student does not prepare before doing the physics lesson, for example, re-reading the physics concept learned earlier. However, this is not done by the students, so the students have difficulty solving the problems posed by teachers. Habits of students who are not prepared, including not re-learning the concepts learned before, cause students difficulty in solving problems [15]. According to Selçuk, Çalışkan, and Erol (2008: 156-157), the troubleshooting process requires students to use previously learned knowledge to solve the problem. Thus, self-preparation in the form of reading and recalling physics concepts that have been studied, it is necessary to be done to help students in solving problems [5].

Secondly, the students do not understand the basics of physics related to definitions, principles, laws in the concept of physics. For example, students are still difficult to distinguish between the magnitude and the units. Other than that, students do not remember the exact equations to solve the problem. For example, students use the momentum equation to solve the perfect collision problem. If students are weak in the mastery of the concept of physics, resulting in low problem-solving skills [16]. Doctor et al (2015: 11) who examines the role of conceptual knowledge in problem-solving and its impact on students' finds that conceptual understanding is a "starting point" for problem-solving, helps students to differentiate some applicable principles to solve problems, and helps students set their mindset when dealing with problems [17].

Third, students do not understand the problem asked about the problem (Figure 1) and/or writing a false mark on a known variable, so students are confused when planning the problem-solving strategy. According Ikwanuddin, Jaedun, and Purwantoro (2010: 222) understand the problem of not just writing down what is known and asked with the correct notation. If the student is superficial in understanding the problem, resulting in failure to plan problem-solving strategies that impact on the failure of problem-solving [18].

**Figure 1.** Students did not identify or write the variables which are being asked.

**Figure 2.** Students still incorrectly convert units. For example, the conversion of units from gram (g) to kilogram (kg) should be divided by 1000, but students multiply by 1000 or divide by 100.

Fourth, students are still wrong and/or do not convert units when identifying problems (Figure 2), consequently, the result of problem-solving and unit writing is still wrong. According to Ogunleye (2009: 90), the unit plays an important role in the calculation of physical problems. If the unit and unit conversion are wrong, then many errors are experienced in the calculation of physical problems. Thus, students need to be taught about the use of the right units and how to convert units [3].
**Fifth**, students do not analyze the variables being questioned and directly use the equations without doing problem analysis. Students do not read or interpret the problem thoroughly so that students cannot identify the sign (which indicates direction) appropriately. For example, on the concept of impulse and collision other than numbers, the direction also has value or meaning in solving the problem. This is in line with the research of Pardimin and Widodo (2016: 394) which states that students do not write what is being asked what problems they are facing, so teachers are difficult to guess whether students understand the problem posed [11]. When students directly use the equation without analyzing or identifying the problem first, it can produce causal relationships that are not in accordance with the purpose of solving the problem to be solved [14]. In addition, problem-solving without prior analysis may lead to low problem-solving abilities [8].

### 3.3. The Profile of Students with “Enough” Problem-Solving Skills

Based on test results, students' skills in understanding the problem especially on indicators identifying the known variables and converting the support units of problem-solving and students' skills in implementing the strategy are also categorized as "sufficient". This can be due to a low student's mathematical ability. When analysed further, many students did not solve the problem that was categorized as difficult. The cause is a complex mathematical solution and the result is that students quickly give up to solve the problem. According to Brad (2011: 27-28), students quickly give up because students do not have many ways to solve the problem [18]. But according to Walsh, Howard & Bowe (2007: 9), students quickly give up because students are accustomed to using a strategic approach or equation [12]. Thus, when faced with complex problems, the approach does not apply to solve the problem.

### 3.4. The profile of students with "high" problem-solving skills.

Based on the test results, the students' skills in identifying the known variables and determining the theory and/or equations for solving the problem are categorized as "high". This shows that most students know the variables expressed in the problem. In addition, most students also know the exact equations in solving the proposed problem. According to Ogunleye (2009: 90), it is important for students to remember and know the exact equation because physics is never separated from the equation to solve the problem [3].

External factors causing low problem-solving skills are the time of physics lessons in the afternoon. This is in line with the results of Lestari research (2015: 116-123) which states that study time has a significant influence with students' mathematics learning outcomes and student learning outcomes have increased when lessons are held in the morning [19]. Mathematics and physics are hard and
difficult lessons. Study time in the morning can help students to concentrate more and focus on lessons. If the learning is done in the afternoon or afternoon, the concentration and focus of the students have decreased because the students have activities and thinking from the morning. So, students may be tired of thinking to solve the physics problem.

Based on data results and data analysis above, then the teacher needs to implement the learning by emphasizing the whole stages of problem-solving. Meanwhile, when the teacher trains students problem-solving skills in the form of quantitative questions, teachers need to train students to understand the variables asked, identify the variables of problem-solving support, convert the units precisely and thoroughly, and students are trained to re-examine the correctness of the problem either the final value and the units. In addition, teachers must also train students to understand the meaning of every word and sentence expressed in the matter, since the identification of the problem is not just limited to the values or quantities stated in the question.

4. Conclusions

Based on the results and discussion above, the problem-solving skill of Social Grade X student 4 SMAN 1 Sambungmacan is categorized still low. This is evidenced by the average percentage of problem-solving skills analysis of student test results (52.93%). When faced with the problem of quantitative problems, students are very skilled in implementing the strategy (73.49%). However, students are still less skilled at visualizing the problem and/or identify the variables of problem-solving support (0.00%) and re-examine the correctness of the problem (26.51%). The low student problem-solving skills are mostly due to internal factors of the students. Thus, students should continue to be trained to solve problems with the stages of problem-solving skills, especially on problem-solving skills understanding the problem and re-examination.

5. References

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Appendix
The problem used to test the students' problem-solving skills:

1. Right: A 15 gram bullet moved at a speed of 600 m/s. Calculate its collision or momentum!
   
   Left: A 40 gram bullet moved at 80 m/s. Calculate the momentum or its collision!

2. A car moved at a speed of 54 km/h. The mass of car was 2000 kg. Calculate the speed of a truck
   that has the same momentum/collision as the car, but its mass was 6000 kg.

3. The 0.1 kg of massive ball was thrown horizontally to the right at a speed of 20 m/s. Then, the ball
   was hit and moved at 60 m/s to the left. Calculate the value of the impulse.

4. Two balls (A and B) with the same mass, they moved closer to each other with velocity $V_A = 1$ m/s
   and $V_B = 2$ m/s. Ball A to the right, while the ball B to the left. As a result, both balls experienced a
   perfect tumble collision. What were the direction and the speed of ball A soon after the collision?