Identification of physics problem-solving skills on senior high school students: An evaluation of e-learning during Covid-19 pandemic in Tuban

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Abstract. On the topic of work and energy, students learned the concepts of work and energy, the relationship between work and energy changes, the law of conservation energy, power, and its application in daily-life. This research aimed to identify and evaluate the achievement of physics problem-solving skills of senior high school students on work and energy topics in distance learning during the Covid-19 pandemic. The quantitative method used was pre-experiment with a one-shot case study design. The subjects were determined using the cluster sampling technique. The sample was 246 students of tenth-grade from three schools, namely in the city, middle, and suburb location in Tuban East Java Indonesia. The research results were analyzed by using descriptive quantitative. This research instrument used essay questions and teacher questionnaires. The Kruskal Wallis test showed that the mean of three schools differed significantly by 0.002<0.05. The overall students’ physics problem-solving skills on the topic of work and energy are classified as moderate. The fact of these findings suggests that students still have difficulty in useful description, physics approach, specific application of physics, mathematical procedures, and logical progression and consistent reasons. It is necessary to develop teaching materials that can train physics problem-solving skills.

1. Introduction
In the 21st century, science is experiencing very rapid development, of course, that must be followed by the field of education, so that students are required to have 21st-century skills. One of the skills of the 21st century is problem-solving skills [1,2,3,4]. In line with this, it is reviewed from Regulation of the Minister of Education and Culture No. 22 of 2016 related to the revised high school curriculum that also requires that physics learning be oriented towards 21st-century learning (Kemendikbud, 2016). So the goal of good physics learning is followed by trained 21st-century skills as well [5,6], one of which is physics problem-solving skills.

In learning physics, problem-solving skills are needed, because physics is a science that is widely applied in daily life [1,7,8,9,10,11,12]. Physics problem-solving skills are the cognitive ability of students to solve problems either in the form of problems given by teachers (well-defined) or real-world physics problems related to daily life (ill-defined) [13,14,15]. Physics problem-solving skills are needed to solve problems from one context to another [16,17,18]. In the process of using problem-solving skills, students are in a state of old knowledge and build new knowledge and understanding that students can finally make decisions to answer solutions [19,20,6,12]. So that, when students can solve physics problems, means they can build their cognitive knowledge well.
Problem-solving skills is a complex activity [21], because it involves various cognitive components for higher-order thinking [22], critical thinking and creative thinking [18,4], resolves issues related to physics [20], structural knowledge to process various knowledge [23], science process skills [24], and involves metacognitive skills such as setting goals, knowing how to use cognitive knowledge, assessing prior knowledge, assessing progress, and checking errors [25,26,27]. Based on the explanation above, physics problem-solving skills are very important and needed by senior high school students.

On the other hand, the Ministry of Education and Culture (Kemendikbud) issued Circular Letter number 4 of 2020 on the implementation of learning from home during the Covid-19 pandemic. The government states that learning activities must be conducted e-learning or online at all levels of education. Physics e-learning during the Covid-19 pandemic is different from ordinary face-to-face learning. Senior high school students studying physics do not come face-to-face with their teachers or friends. This e-learning state generally utilizes existing technologies such as school applications, zoom, g-meet, whatsapp-group, telegram, and others. This may have an effect on the achievement of physics learning goal in terms of training and improving the physics problem-solving skills of high school students. The achievement of physics problem-solving skills of high school students during the Covid-19 pandemic has not been identified, so it can not be said that the goal of physics learning is achieved well and able to train physics problem-solving skills.

In this regard, this research wants to identify and evaluate the achievement of physics problem-solving skills using steps [10]. Indicators of students are said to have physics problem-solving skills if they are able to use useful descriptions of physics information (useful description), use a physics approach (physics approach), using a specific application of physics (specific application of physics), using mathematical procedures (mathematical procedures) and progression of meaning and logical conclusion (logical progression).

In this case, researchers will identify the problem-solving skill of high school students on the topic of work and energy. This topic is a fundamental topic in physics, which is the material that high school students still to study in the emergency curriculum (certain conditions) during the Covid-19 pandemic. In this topic, many physical phenomena are related to daily life. It can be seen from the basic competencies of tenth-grade senior high school physics, students can analyze the concept of work and energy, relationships about work and energy changes, the law of conservation of energy, power, as well as its application in daily life. The minimum ability that students must have is to analyze so that physics problem-solving skills are very used to solve contextual problems related to daily life that are formed in the questions. Students solve problems using the equations of work, potential energy, kinetic energy, and the law of conservation of mechanical energy which is presented as follows [28]:

\[
W = \vec{F} \cdot d = \vec{F} \cos \theta \cdot d \tag{1}
\]

The equation of work (\(W\)) as a change in potential energy (\(PE\)) and kinetic energy (\(KE\)) is presented as follows [28]:

\[
W = \Delta EP \tag{2}
\]
\[
W = \Delta KE \tag{3}
\]

The equation for the law of conservation of mechanical energy (\(ME\)) is used as follows [28]:

\[
ME_i = ME_f \tag{4}
\]

Equation (4) can be formatted as [28]:

\[
PE_i + KE_f = PE_i + KE_f \tag{5}
\]

One example of a phenomenon in daily life related to the topic of work and energy is the use of waterfalls as a power plant. The amount of power generated (\(P\)) by the turbine is equal to the change in water potential energy (\(\Delta PE\)) of each unit of time (\(t\)), and the power is affected by the efficiency of the turbine (\(\eta\)). Students solve real-world problems to predict the amount of electrical power generated by turbines (\(P\)) driven using waterfalls using equations:

\[
P = \eta \frac{W}{t} = \eta \frac{\Delta PE}{t} \tag{6}
\]
Based on the above exposure, researchers aim to show the results of identification and evaluation of the achievement of physics problem-solving skills on the topic of work and energy for high school students during the covid 19 pandemics. Through the results of this study can be known how far each indicator reaches, as well as how far the difficulty of students in solving problems of 3 schools in Tuban district of East Java Indonesia in different places, namely in the city, middle, and suburb. The novelty of this research from previous research is to show the identification and evaluation of problem-solving skills of high school students on work and energy topics during the Covid-19 pandemic in Tuban district, East Java, Indonesia. This research is useful to plan and improve the quality of physics learning, especially to train and improve the physics problem-solving skills of high school students during distance learning in the covid-19 pandemic.

2. Method

The quantitative research method used was pre-experiment with a one-shot case study design. The research population is tenth grade students in the 2020/2021 high school academic year in Tuban district of East Java, Indonesia. The research subjects were determined by using the cluster sampling technique. The total sample was 246 senior high school students of tenth grade who have received topics about work and energy. This research was conducted at three schools in different locations, namely in the city (group A), middle (group B), and the suburb (group C) of Tuban district, East Java, Indonesia. Data collection techniques used physics questions given to students and response questionnaires given to physics teachers. The instruments used are 7 essay questions of work and energy topics with real-world problem approach in daily life. Each question contains five indicators of problem-solving [10] and learning indicators. The item validity result represents 9 valid items out of 14 items and reliable with Cronbach's Alpha of 0.85. The items have a difficult and moderate level. (2) The questionnaire consists of 12 questions given to the teacher via google-form, in which there are options in the form of never, rarely, often, always, and there is writing a descriptive statement. The teacher's questionnaire aimed to determine online physics learning activities during the Covid-19 pandemic in training physics problem-solving skills. The validation of the teacher questionnaire sheet was determined by the value of the Percentage of Agreement (PoA) from Borich [29] then categorized in the appropriate percentage. The result of the percentage of agreement given by the two validators is 97% so that the teacher questionnaire sheet was suitable for research with the very good category.

The results of the research were analyzed by using descriptive quantitative. The test results of the students were analyzed according to a rubric [10]. The analysis technique of the evaluation results and identification of physics problem-solving skill for each indicator used the percentages in Table 1, then categorized as very high, high, moderate, low, and very low [30].

Table 1. Interpretation of physics problem-solving skill level.

| Interval (%) | Category  |
|--------------|----------|
| 81-100       | Very high|
| 61-80        | High     |
| 41-60        | Moderate |
| 21-40        | Low      |
| 0-20         | Very low |

The average comparison of physics problem-solving skills from all three schools used a statistical test of Kruskal Wallis with SPSS applications. The analysis technique of teacher questionnaires was made in percentage form based on the teacher choosing never, rarely, often, or always from each questionnaire statement, then summarized descriptively [2].

3. Result and Discussion

The research results were the physics problem-solving skills test results of senior high school students and Kruskal Wallis statistical test and the results of the teacher questionnaire response. Table 2 shows the achievement of physics problem-solving skill tests of senior high school students from three schools in Tuban, East Java, Indonesia.
Table 2. Students’ physics problem-solving skills.

| Indicators of Physics Problem-Solving Skill | Average achievement score of students' physics problem-solving skill | Categories for the achievement of each indicator | Categories of students' overall physics problem-solving skills |
|--------------------------------------------|--------------------------------------------------------------------|-------------------------------------------------|---------------------------------------------------------------|
|                                            | Group A                | Group B               | Group C               | Very low | Low       | Moderate  | High     | Very high |
| Useful Description                          | 66%                   | 48%                   | 49%                   | Moderate |
| Physics Approach                            | 45%                   | 33.3%                 | 40%                   | Low      |
| Specific Application Of Physics             | 50%                   | 43%                   | 48%                   | Moderate |
| [students]                                 | 31                    | 92                    | 109                   | 14       |
| Mathematical Procedures                     | 50%                   | 33.3%                 | 37%                   | Low      |
| Logical Progression                         | 47%                   | 35%                   | 37%                   | Low      |

Research findings from overall of the achievement of physics problem-solving skills based on indicators in Table 2 are found as follows; (1) the useful description is 55.5%, (2) physics approach is 39.4%, (3) specific application of physics is 47%, (4) mathematical procedures are 38.3%, and (5) logical progression is 39.6%. Overall physics problem-solving skills of senior high school students was moderate category. The average comparison results from the three schools using the Kruskal Wallis test and Post-Hoc test are shown in Table 3 and Table 4.

Table 3. Kruskal Wallis statistical test results

| Data       |                |                |
|------------|----------------|----------------|
| Chi-Square | 12.661         |                |
| df         | 2              |                |
| Asymp. Sig.| 0.002          |                |

Table 4. Post-Hoc test results

| (I) Score | (J) Score | Mean Difference (I-J) | Std. Error | Sig. |
|-----------|-----------|-----------------------|------------|------|
| group A   | group B   | 7.95950               | 2.31831    | 0.002|
|           | group C   | -.89222               | 2.25357    | 0.917|
| group B   | group A   | -7.95950              | 2.31831    | 0.002|
|           | group C   | -8.85172              | 2.38694    | 0.001|
| group C   | group A   | .89222                | 2.25357    | 0.917|
|           | group B   | 8.85172               | 2.38694    | 0.001|

*. The mean difference is significant at the 0.05 level.

According to Table 3, Kruskal Wallis' test results stated that the average of the three schools differed significantly with Asymp 0.002<0.05. The post-hoc test is shown in Table 4, the average group B with C and group A with group B are different significant, while the average group A with C is no significant difference. The difference in the achievement of each indicator of the school in the city, middle, and suburb locations is based on the characteristics and background of different students, school infrastructure to support online learning activities, online learning media and methods, and the learning environment.
Based on Table 2, the fact findings from the identification and evaluation of the achievement of physics problem-solving skills of high school students on the topic of work and energy during e-learning can be explained as follows: (1) Most of the students at the writing step of useful description physics information reached 55.5% (moderate). The error could be seen when drawing a work graph and describing the forces acting on an object which are less precise. Students have not been able to fully present verbal forms into pictures, graphics, and symbols. (2) Writing the approach to concepts and principles of physics step reached 39.4% (low). Students are not complete in writing down what concepts were used and related to the problems in detail. This happened because they were not used to explaining the concepts of work and energy, relationships about work and energy changes, the law of conservation of energy in writing used in completing the question. The habit of students solving questions only to write down what is known, asked, and answered [31], this is what causes physics to appear mathematically only, the concepts and principles of physics are never directly explained in writing. (3) The specific application of the physics step reached 47% (moderate) and the mathematical procedure step reaches 38.3% (low). Students used specific applications such as mathematical equations used to solve problems, but there are some errors in the form of inaccuracy in completing the mathematical procedure related to the topic work and energy. Example: determines work through the slope, the minimum force used, work as change potential and kinetic energy, work done by aircraft brake force, the power generated by the turbine, and power generated by the water pump. (4) Then the logical progression step reached 39.6% (low), most students were not able to link logical and coherent conclusions from beginning to end contained in the real-world approach problem. Students have difficulty in relating useful information, statements of concepts and principles of physics, mathematical procedures, and logical and coherent conclusions.

In line with other research, most students solve problems by using plug and chug, without deep conceptual understanding [18,32]. They have difficulty in linking the meaning to the answers obtained from calculations [33]. Most students rely heavily on the teacher-derived formula, without making modifications to their understanding of previous knowledge for being applied to new problems [33]. Students have difficulty in identifying concepts in questions that contain real-world problems [31,34]. Physics problem-solving ability is low, this is due to the lack of effort to help develop thinking that leads them to actively solve a problem [33-37,23,24]. Based on Table 2, the overall physics problem-solving skills of high school students on topic work and energy in Tuban district of East Java Indonesia are moderate category. It can be said that learning during the Covid 19 pandemic has not been maximal in supporting and practicing physics problem-solving skills on topic work and energy. Physics learning goals have not been achieved to the maximum. In this regard, it is necessary to train physics problem-solving skills based on the Docktor step [10].

Table 5 presented a summary of the results of the response questionnaire given to physics teachers in 3 schools. Factors that influence the achievement of problem-solving skills are reviewed from the implementation of distance physics learning during the Covid 19 pandemic.

| Statement                                      | Never | Rarely | Often | Always |
|------------------------------------------------|-------|--------|-------|--------|
| Train physics problem-solving skills with real-world problem approaches in daily life. |       |        |       | 90%    |
| Applying and instructing physics problem-solving skills steps. |       | 5%     | 80%   | 15%    |
| Create e-modules to support physics problem-solving skills. | 50%   | 50%    |       |        |
| Practicum with a virtual laboratory. | 85%   |        | 15%   |        |

Table 5 shows most teachers trained physics problem-solving skills and provided examples of steps in problem-solving when studying physics, but the fact is based on Table 2, students' physics problem-solving skills on work and energy topics are moderate and low categories. This is due to factors that do not support training students' physics problem-solving skills, such as in Table 5 teachers who have never done practicum with virtual-laboratory and created e-modules. In addition, other factors can be viewed
from the description of the constraints written by the teachers during distance learning activities as follows teachers always use conventional methods and less varied learning methods, students are less active in e-learning and teachers have difficulty in conditioning students during meetings through school applications, WhatsApp-group, zoom, google-meet so that learning is not optimal.

Physics learning has not been achieved to the maximum because it has encountered some obstacles in the form of physical materials not fully understood by students, the lack of student center-oriented electronic learning media to support 21st-century skills, and learning facilities that are less supportive during the learning pandemic covid-19 [37,38,39,40,33]. Physics e-learning activities during the Covid-19 pandemic affect the learning goals to be achieved. Based on other literature, during the Covid-19 pandemic, teachers can develop teaching materials [41,42,37,38], use interesting learning models [43], and do a practicum with a virtual laboratory or laboratory at home [44,45,46]. Teaching materials that can build an understanding of the concepts and principles of physics, develop high-order thinking, and make students active are needed to support e-learning activities during the covid-19 pandemic [33,38,41,42,47].

Related to the research results of e-learning during the Covid 19 pandemic considering the skills of physics problem solving is very necessary for senior high school students, so alternative solutions teachers must be able to be creative and innovate to develop interesting teaching materials that can motivate students, train students’ problem-solving skills, and involves active, creative, and innovative students. Teachers can adjust their learning needs during distance physics learning which is adjusted to the characteristics and background of different students, school infrastructure to support online learning activities, the learning environment, and the conditions of each area.

4. Conclusion
The conclusion of this research, the overall students' physics problem-solving skills on the topic work and energy during the e-learning Covid-19 pandemic was a moderate category. Identification of the achievement of physics problem-solving skills based on the problem-solving indicators found as follows: (1) useful description is 55.5% (moderate), (2) physics approach is 39.4% (low), (3) specific application of physics is 47% (moderate), (4) mathematical procedures are 38.3% (low) and (5) logical progression is 39.6% (low). The Kruskal Wallis test showed that the average of the three schools in the city, middle, and suburb locations of Tuban district in East Java Indonesia significantly differed by 0.002<0.05. When students are solving work and energy problems, the fact of these findings suggests that students still have difficulty connecting concepts, mathematical procedures, and logical, coherent, and consistent reasons. During distance learning in Covid-19 pandemic, physics learning less use experiment learning with virtual laboratory, develop e-modules, and do not use varied and innovative methods. It is necessary to develop interesting teaching materials that can motivate students and train physics problem-solving skills. Recommendations for further research can identify the physics problem-solving skills of high school students on different physics topics.

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