The Improvement of Students’ Problem-Solving Skills Through 5E Learning Model

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Abstract
This research aimed to describe the effect of the 5E learning model on students’ problem-solving skills in the topic of static fluid. The type of this research is pre-experimental study with One Group Pretest-Posttest Design. The population in this research was all eighth-grade students of SMP Torsina Singkawang. The sampling technique used in this study was purposive sampling with a total sample of 23 students. Because it is not normally distributed, the data were analyzed using non-parametric statistical test, which is Mc Nemar Test. From the calculation was obtained the value of χ² obtained > χ² critical or 15.059 > 3.841, then H₀ was rejected and H₁ accepted at the level of significance α = 0.05. So it can be concluded that the 5E learning model has a positive effect on students’ problem-solving skills in the topic of static fluid.

Keywords: 5E Learning Model, Problem-solving Skills, Static Fluid, Mc Nemar Test

1. Introduction
The purpose of physics learning in school is not just to encourage students to get satisfactory learning outcomes with learning completeness criteria that reach 100 percent. One way that can be done in physics learning to improve the quality of learning is to develop students’ abilities in solving physical problems through scientific processes using scientific methods (Rosdianto, 2017a; Taufik et al., 2010). The ability to provide new ideas and apply them in solving problems that include curiosity, the desire to ask questions, always want to find new experiences, can also be trained through creativity tests given to the students (Astawan & Mustika, 2013). This is consistent with physics characteristics that involve creative, imagination and discovery activities that can encourage students to develop divergent thinking (Hariawan et al, 2013; Trianggono, 2017). According to Eggen and Kauchac, curiosity and the desire to solve problems are the basis of students’ creative attitudes which show that students have the ability to create and work creatively (Sambada, 2012). From the statement above, it can be stated that students' ability to solve problems has implications with their learning outcomes in physics learning. For this reason, students' ability to recall previous topics needs to get more intense attention (Woods et al, 1997; Gertner & VanLehn, 2000).

The students’ ability to recall previous lessons relating to a problem, measured through recall lessons learned quickly, accuracy in creation, sharpness in distinguishing concepts, and accuracy in solving problems is very important to be taught to students (Rosdianto, 2017b; Jauhari & Suhaudi, 2010). According to Krulik and Rudnick, problem solving is an individual or group effort to find answers based on prior understanding in order to meet the demands of an unusual situation (Kariawan et al., 2015; Suardani et al., 2014). Heller et al. said that to improve the problem-solving abilities faced by students in physics learning can be done by providing strategies on how to solve these problems (Kariawan et al., 2015). Heller develops a problem-solving strategy that refers to five stages of problem solving including: 1) focus the problem, 2) describe the physics concepts, 3) plan the solution, 4) execute the plan, and 5) evaluate the solution. So, it can be concluded that problem solving can be interpreted as a process of eliminating existing problems that relate to physics concepts in solving problems (Aji et al., 2017; Azizah et al., 2015). Physics problem solving is a method of solving a number of problems related to physics (Unaifah & Suprapto, 2014), while the ability to solve problems in physics is the ability to use a method to solve a number
of problems in physics (Dewi et al., 2014; Hastuti et al., 2016). Thus, students’ ability to solve problems needs to be trained so that when faced with a problem, they can determine what steps need to be taken to solve the problem (Mayer, 1998; Dufresne, 1997). Innovative strategies and approaches from teachers are needed to facilitate students to improve their ability to solve problems (Kalelioglu & Gülbahtar, 2014; Bolton & Ross, 1997).

Some of the strategies applied by most teachers today do not seem to be able to facilitate students to be able to improve their problem-solving skills in physics learning (Mauke et al., 2013). Various learning activities are still dominated by teachers so that students are less active in the learning process (Sayyadi et al., 2016; Rosdianto et al., 2017; Venisari et al., 2015). So that the opportunity for students to improve their problem-solving skills is still low. Empowerment of problem-solving abilities is very important to be developed for students (Nurohman et al., 2014; Pratiwi et al., 2015). Problem solving skills can improve students’ verbal skills so that their understanding of physics concepts is getting better (Balci et al., 2006; Iklima et al., 2016). The strategy that can be applied is by implementing a learning process that is more student-centered. Students don’t just listen to the explanation from the teacher, but students are encouraged to discuss, expand their perspective, and more actively convey their opinions and arguments (Snyder & Snyder, 2008; Gok, 2010).

Most of the teachers actually have implemented multi-strategies in the learning process, but the method most often used is the lecturing and question and answer method (Lestari, 2015; Ratnaningdyah, 2017). This has an impact on students’ inability to express their opinions when they get problems from the teacher, and students’ problem-solving skills will be difficult to be developed (Jannah et al., 2015; Markawi, 2015). Based on this, students’ low ability to solve problems occurs in schools in Indonesia as a whole.

The low problem-solving skills also occur in SMP Torsina Singkawang. Based on the results of interviews conducted by researchers with science teachers at school, it is known that in learning activities, teachers do not only focus on student learning outcomes, teachers also try to improve students’ conceptual understanding. However, due to time constraints in learning activities, teachers’ efforts to improve students’ conceptual understanding are limited to the discussion of concepts. When faced with problems that occurs, students have difficulty in solving these problems. To support the interview data, the researchers then observed what the learning process was like in the classroom. Based on observations, it appears that students are confused when asked to solve problems related to the physics phenomena that occur around them. There is no further effort from the teacher to guide students in solving these problems due to limited time. From the results of observations, it can be concluded that efforts to improve students’ ability to solve problems are still not optimal. To support the observation results, the researcher provides a test to measure the level of students’ problem-solving skills. The test results show that only 10% of all SMP Torsina Singkawang students have sufficient levels of problem-solving skills. Furthermore, researchers conducted interviews with several students with relatively low problem-solving skills. The students stated that the physics concepts discussed in learning activities are only contextually. So that when they have difficulty in answering questions, they relate it to physics concepts that they understand contextually as well.

To overcome the students’ low skills in solving problems, a learning model is needed that can improve students’ problem-solving skills. One model that can be used is 5E learning model. The 5E learning model is a student-centered model that allows students to be more active in learning activities, so they can master the competencies that must be achieved (Acisli et al., 2011; Duran & Duran, 2004). The stages of the 5E learning model are: engagement, exploration, explanation, elaboration, and evaluation (Irhamna et al., 2017).

On the engagement stage, the teacher tries to arouse students’ interest and curiosity about the topic of the lesson: This activity is carried out by asking questions about factual processes in daily life (Reif et al, 1976). Thus, students will give a response or answer, then the student’s answer is used by the teacher to find out the students’ initial knowledge of the topic to be discussed (Bascones et al, 1985).

In the exploration stage, small groups of 2-4 students are formed, then they are given the opportunity to work together in small groups without teacher involvement directly. In this
group, students are encouraged to try alternative solutions (Schoenfeld, 1980), doing observations (Norman, 1988) and record observations record observations along with ideas or opinions that develop in the discussion (Borkowski et al, 1989). In this phase, the teacher acts as a facilitator (Mumford et al, 1996).

At the explanation stage, the teacher is required to encourage students to explain a concept with their own sentences, ask for evidence and clarification on students' explanations, and listen critically to each other's explanations between students. Activities in this phase aim to complete, perfect and develop concepts that have been obtained by students (Anderson, 1993). Students are required to explain the concepts learned in their own words (Larkin & Reif, 1979). In this phase, students are expected to find terms from concepts that have been learned (Hollingworth & McLoughlin, 2001).

In the elaboration stage, the teacher provides clarification on students' ideas which are still have misconceptions and gives students the opportunity to explaining the concepts in their positive structure by linking or developing concepts and skills that they acquired. This learning activity directs students to apply the concepts they have learned (Boggiano, 1993), to make connections between concepts and apply them to new situations through advanced practical activities that can strengthen and expand the concepts that have been learned (Gabel, 1984).

The final stage of the 5E learning model is evaluation. At this stage, the teacher can observe students' knowledge or understanding in applying new concepts (Udayani et al., 2014). Students are given questions to diagnose the implementation of learning activities and analyze the level of student understanding of the concepts obtained (Kazdin et al, 1992).

Like other learning models, the 5E learning model has its own advantages and disadvantages. The advantages of the 5E learning model are: 1) can increase learning motivation because students are actively involved in the learning process, 2) help develop students' scientific attitudes, and 3) learning activities become more meaningful (Wibowo, 2010). The disadvantages of the 5E learning model that must always be anticipated is: 1) learning effectiveness is low if the teacher does not understand the topic and learning steps, 2) demanding sincerity and creativity from the teacher in designing and implementing the learning process, and 3) requires more planned and organized classroom management (Wilder & Shuttleworth, 2005).

Researchers have anticipated to cover the disadvantages of the 5E learning model, so that this model can be applied effectively in learning. Anticipation efforts carried out by researchers in this study are as follows: 1) the researcher prepares himself in mastering the learning material and arranges structured learning steps, 2) researcher tries to be more creative in the learning process so that students do not feel bored and burdened with material that is a little complicated.

Through the implementation of 5E learning model, it's expected to have a significant effect on improving students' problem-solving skills. So, this model can be used as an alternative for teachers in physics learning at school.

2. Methods

The type of this research is pre-experimental study with One Group Pretest-Posttest Design. This type of research was chosen because students' problem solving abilities in the population were not uniform, so it was not possible to use quasi-experiment type. The population in this research were all eighth grade students of SMP Torsina Singkawang. The selection of all eighth grade students of Torsina Middle School as the population in this study was based on the results of the initial research which indicated that all students in the population had relatively low problem solving abilities. So that research can be carried out more effectively and efficiently, the researcher sets a research sample that is expected can represent the entire population. The sampling technique used in this study was purposive sampling with a total sample of 23 students, with the consideration that the level of their problem-solving skills is the lowest.
The variables in this research consist of independent and dependent variables. The independent variable in this study is 5E learning model, while the dependent variable is the students’ problem-solving skills after the 5E learning model is applied in learning activities. The test used is a description test to measure the level of students’ problem-solving skills. Data collection instruments used were pretest and posttest sheets. The number of questions given were 15 description questions for the pretest and posttest. Before use, the instrument is tested first to find out if the instrument were valid based on the assessment from three experts and reliable based on the results of the reliability test using the Cronbach Alpha, so it can be used in this research.

From the validity test, researcher revised the instrument based on suggestions and input from the validators, three revisions for the pretest instrument and four revisions for the posttest instrument. After the instrument is declared valid, the researcher then performs a reliability test by testing the instrument to students in other schools that have the same criteria as the school where the research will be conducted. From the results of the reliability test, it was found that the instrument reliability values were 0.78 and 0.77 with high category for the pretest and posttest respectively, so that the instrument is declared feasible to be used in research.

To see whether there is an improvement in problem solving skills, the data were analyzed using N-Gain as in equation 1,

\[ <g> = \frac{S_{posttest} - S_{pretest}}{S_{max} - S_{pretest}} \]  

where <g> is the normalized gain, \( S_{posttest} \) is the posttest average score, \( S_{pretest} \) is the average score of the pretest, and \( S_{max} \) is the possible maximum score. The N-Gain criteria obtained are shown in table 1.

<table>
<thead>
<tr>
<th>Gain Score</th>
<th>Criteria</th>
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<tbody>
<tr>
<td>( &lt;g&gt; \geq 0.7 )</td>
<td>High</td>
</tr>
<tr>
<td>( 0.3 \leq &lt;g&gt; &lt; 0.7 )</td>
<td>Fair</td>
</tr>
<tr>
<td>( &lt;g&gt; &lt; 0.3 )</td>
<td>Poor</td>
</tr>
</tbody>
</table>

To find out whether the research hypothesis is supported by the data obtained, the hypothesis must be tested. But before the normality test needs to be done to determine whether the obtained data is normally distributed or not. The normality test is carried out by using Chi-square test (Sugiyono, 2007) as in equation 2,

\[ \chi^2 = \sum_{i=1}^{k} \frac{(f_o - f_e)^2}{f_e} \]  

where \( f_o \) is the observation frequency and \( f_e \) is the expected frequency. The test criterion used at df = (k-3) with significance level \( \alpha = 0.05 \) is if \( \chi^2_{\text{obtained}} < \chi^2_{\text{critical}} \), then the data is normally distributed. If it is normally distributed, then the data obtained is analyzed using paired t-test (Sugiyono, 2007) with a pair of hypothesis as follows:

\( H_o \) : There is no effect of 5E learning model on students’ problem-solving skills in the topic of static fluid

\( H_a \) : There is an effect of 5E learning model on students’ problem-solving skills in the topic of static fluid.
The equation used was:

\[ t_{\text{obtained}} = \frac{x-y}{\sqrt{\frac{s_x^2}{n_x} + \frac{s_y^2}{n_y} - 2r\left(\frac{s_x}{\sqrt{n_x}}\right)\left(\frac{s_y}{\sqrt{n_y}}\right)}} \]  

(2)

with the test criterion: \( H_0 \) was accepted if \( t_{\text{obtained}} \leq t_{\text{critical}} \) at significance level \( \alpha = 0.05 \) and \( df = (n-1) \), as well as for other \( t \) values \( H_0 \) was rejected.

If the data is not normally distributed, then non-parametric statistical tests are used, which is Mc Nemar test (Sugiyono, 2007), with pairs of hypothesis as follows:

\( H_0 \) : There is no effect of 5E learning model on students’ problem-solving skills in the topic of static fluid

\( H_a \) : There is an effect of 5E learning model on students’ problem-solving skills in the topic of static fluid.

The equation used was:

\[ \chi^2 = \frac{(|A - D| - 1)^2}{A + D} \]  

(3)

with the test criterion: \( H_0 \) was accepted if \( \chi^2_{\text{obtained}} \leq \chi^2_{\text{critical}} \) at significance level \( \alpha = 0.05 \) and \( df = (n-1) \), as well as for other \( \chi^2 \) values \( H_0 \) was rejected.

3. Findings and Discussions

Data recapitulation from the results of the pretest and posttest can be seen in table 2.

<table>
<thead>
<tr>
<th>Table 2. Pretest and Posttest Results</th>
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<tbody>
<tr>
<td></td>
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<tr>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Average Score</td>
</tr>
<tr>
<td>Standard Deviation</td>
</tr>
<tr>
<td>Highest Score</td>
</tr>
<tr>
<td>Lowest Score</td>
</tr>
</tbody>
</table>

From table 2, although the maximum value between pretest and posttest is the same, but the average posttest score is much higher than the average pretest score. This shows that the students’ problem-solving skills increased after the treatment with 5E learning model. This means that the 5E learning model is effective for improving problem solving skills. This was proved by obtained N-Gain value by 0.43 with medium category.

Furthermore, statistical tests were conducted to strengthen the results of the N-Gain analysis. The first step in data analysis is to conduct a data normality test which aims to measure whether the data is normally distributed or not. If it is normally distributed, parametric statistical tests are used. However, if it is not normally distributed, non-parametric statistical tests are used. The summary of pretest and posttest data normality tests can be seen in tables 3 and 4.

<table>
<thead>
<tr>
<th>Table 3. Summary of Pretest Data Normality Test</th>
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<tbody>
<tr>
<td>( \chi^2_{\text{obtained}} ) from Pretest Score</td>
</tr>
<tr>
<td>------------------------------------------------</td>
</tr>
<tr>
<td>67.05</td>
</tr>
</tbody>
</table>
Table 4. Summary of posttest data normality test

<table>
<thead>
<tr>
<th>$\chi^2_{obtained}$ from Posttest Score</th>
<th>$\chi^2_{critical}$ from Posttest Score</th>
<th>Normality Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>135.45</td>
<td>7.815</td>
<td>Not Normal</td>
</tr>
</tbody>
</table>

From tables 3 and 4, it was found that the pretest and posttest scores of students were both not normally distributed. After ensuring that the data is not normally distributed, the statistical test used is the non-parametric statistical test, which is Mc Nemar test. From the calculation was obtained the value of $\chi^2_{obtained} > \chi^2_{critical}$ or $15.059 > 3.841$, then $H_0$ was rejected and $H_a$ accepted at the level of significance $\alpha = 0.05$.

The results showed that there was an effect of 5E learning model on students' problem-solving skills in the topic of Static Fluid at SMP Torsina Singkawang, proved by the average posttest score that is higher than the average pretest score. It is also proved by statistical tests to test the research hypothesis, obtained the value of $\chi^2_{obtained} > \chi^2_{critical}$ with significance level of 5%.

4. Conclusions

Students’ problem-solving skills were increased after 5E learning model was implemented. This can be seen from the average score of students’ learning outcomes after being treated which is higher than the average score of students’ learning outcomes before being treated.

There was an effect of 5E learning model on students' problem-solving skills in class VIII of SMP Torsina Singkawang in the topic of Static Fluids. This can be seen from the hypothesis test with the value of $\chi^2_{obtained} > \chi^2_{critical}$ with significance level of 5%.

References


