STEM-CP (Sains, Technology, Engineering Mathematics-Contextual Problem) Based Physics Module to Increase Student Literacy Skills at Vocational High School

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ABSTRACT

Materials in physics learning at school are considered difficult to understand, especially in the concept of fluids. Students also frequently had misconceptions. Contextual issues are required to overcome this problem. STEM-CP (science, technology, engineering, mathematics-contextual problem) is seen to help students understand the concept of fluid through contextual issues. This study aimed to develop a module based on STEM-CP (Science, Technology, Engineering, Mathematics-Contextual Problem) in physics designed for a vocational school. This research used Quasi-Pretest-Posttest Experiment without control class study obtained the data by using observation and testing of vocational schools in Jember. The study involved 35 students of SMK grade X. The data collected from the pretest and posttest using an open question correspond to the indicator of scientific literacy. The results showed an average of scientific literacy of students using STEM-CP based modules are in both categories in the cognitive domain and a very good product on the cognitive process.

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INTRODUCTION

The fluid is considered one of the physics materials that difficult to comprehend [1]. Students also had misconceptions. For example, when an object is inserted into a container filled with water, the mass of the object will affect the magnitude and direction of the buoyant force [2]. The size of the pumice force should be the same as the volume of the object. There are many phenomena or problems in life that can be studied and solved using a fluid concept. The fact student still have difficulties in linking concepts with contextual problems. At present we are in the 21st century which
is a century of rapid technological development in various countries. The development and change of the learning system along with the development of science and technology in the Industrial Revolution 4.0 era is the task and role of educators. STEM learning help students to solve problems and to conclude previous learning by applying it through science, technology, engineering, and mathematics [3]. However, STEM usually only generally applicable, so that the use of the STEM approach is not enough. It needs to increase the relevant contextual issues so that students do not encounter misconceptions. Johnson says that a contextual approach is a system that stimulates the brain to develop patterns that embody meaning [4]. The problem of contextual learning is a problem in everyday life and is shown to help to understand the concept of it. STEM education has greatly contributed in helping learning in the 21st century [5].

STEM-CP stands for Science, Technology, Mathematics, Contextual problems, and Engineering. Science in the STEM-Cp load stage picture of the failure by a discussion of science by students, facilitated or independently. Technology load stages of their discussion of the application of material science discussed in the technology. Mathematics load stages discussion material science mathematically. Contextual problem loading stages discussion of issues and technologies that exist in the environment or known to the students' related discussion of material science. Engineering load stages the discussion of science in technology that may be produce the community needs related to the implementation of the subject matter of science. Learning with contextual problems is a learning concept that helps teachers to link subject matter with the real world of students and motivate students to make connections between knowledge that is facilitated by its application in daily life as family members, communities, and workers.

Based on the measurement results of the last scientific literacy PISA in 2009 published by the OECD (Organization for Economic Cooperation and Development), it showed that the level of scientific literacy of students Indonesia is still low. Some Indonesian students become champions in the science Olympics, but these achievements do not guarantee the country regarded as a high science literacy country. In this case, it requires a module that trains students' science literacy. The level of reading literacy, mathematics, and science learners around the world can be seen from three international studies that are believed to be the instrument to test the global competence. Factors that significantly affect the ability of science are reading, math skills, and educational facilities [6]. Scientific literacy is one the main skills studentsmust master to achieve scientific education goals [7]. Scientific literacy is a person's ability to use scientific knowledge and processes and apply scientific knowledge to provide solutions to changes that occur due to human interaction with nature. Science-literate students are able to apply concepts or facts obtained in classroom learning to solve natural phenomena that occur in everyday life. STEM-CP is also expected to fulfill the demands of society, especially in the field of life skills that are essential to the provision of future students. However, recently Physics in vocational modules that are operationally using an approach that trains STEM-CP scientific literacy of students is limited. Research is needed using a physics module based on STEM-CP to improve students' scientific literacy.
METHODOLOGY
This research focused on the students of grade X of vocational school (SMK) in Jember. The main instrument in this study was a set of indicators of scientific literacy. The research problems are divided into two parts. Part I contains cognitive products that include several sub-indicators such as the use of effective literature, the identification of scientific arguments, the evaluation of scientific information utility, reading and interpreting the data using statistics, solving a problem using a quantitative ability, presenting the conclusions, predictions based on quantitative data. The second part contains the cognitive process that includes sub-indicators, such as understanding the element of research design and how it will impact scientific discoveries, creating graphs to represent data.

The data were analyzed using qualitative analysis. The data was converted to a scale of 100 and were grouped into several categories and explained further with a description of the student’s science literacy skills. The categories are based on [8] and described as follow:

<table>
<thead>
<tr>
<th>Interval</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>85-100</td>
<td>Very Good</td>
</tr>
<tr>
<td>70-84</td>
<td>Good</td>
</tr>
<tr>
<td>55-69</td>
<td>Enough</td>
</tr>
<tr>
<td>50-54</td>
<td>Less</td>
</tr>
<tr>
<td>0-49</td>
<td>Very Less</td>
</tr>
</tbody>
</table>

Source: Sudijono, 2006 [7]

RESULT AND DISCUSSION
The module is a self-learning package that includes a series of learning experiences systematically planned and designed to help students achieve learning objectives. The module is one of the right steps to improve the quality of learning for students, because currently the development of teaching materials in the form of modules is a very urgent need. The learning objectives are to improve the efficiency and effectiveness of learning in school, good time, funds, facilities, or personnel to achieve an optimal [9]. Modules can be a source of learning when accessible or used by students, to help students learn independently, and facilitate students in learning the material [10]. STEM education (Science, Technology, Engineering, and Mathematics) needs to be developed as a solution to face the challenges of this century [11]. Learning using STEM can help students to solve problems and draw conclusions from previous learning by applying them through science, technology, engineering and mathematics [12].

Building a strategic approach to integrate the concept of STEM requires conceptual understanding and a solid foundation of the students to learn and implement STEM [13]. Problem-based learning (Contextual problem) is one way to keep students motivated because it provides a real challenge to students [14]. STEM-CP (science, technology, engineering, mathematics-contextual problem)-based module is intended to enhance understanding of the concept of Fluid in Physic using contextual problems. The student is expected to analyze and understand the science concept of an event and apply them in the development of science and technology appropriate in the industrial revolution era 4.0. STEM education has a purpose of applying and practicing the basic content of STEM in their situation [15]. Students are the center of success at every
level, which means we must demand to serve those students in the best way we can at every level. STEM-CP (science, technology, engineering, mathematics-contextual problem) will train students for having skill to preserve and respect nature, knowing the goals and limits of science and technology, determine, the relationship between science and technology, have a common foundation and key ideas of science, have the ideas to provide solutions on issues relating to science and technology.

Hallbrook et al. stated that science literacy practice is parallel with the development of life skills, given that science literacy is a requirement that must be owned by students in adjusting rapid changing times as a challenge [16]. Although science educators often talk about scientific literacy as a goal for students, in summary the definition of scientific literacy has proven to be a difficult task to understand [17]. Science literacy indicators developed by Gormally was chosen because it is simple and easy to implement and reflects the ability of scientific literacy. According to Gormally [18] to the Program for International Student Assessment (PISA), the indicators of science literacy are as follow:

Table 2. The Science Literacy in TOSLS (Test of Scientific Literacy Skills) Indicators

<table>
<thead>
<tr>
<th>No</th>
<th>Indicators</th>
<th>Sub Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Understand the methods of inquiry, which leads to scientific knowledge.</td>
<td>Use literature search effective</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Identify proper scientific arguments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Use scientific information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Understand the elements of research design and its impact on scientific invention</td>
</tr>
<tr>
<td>2</td>
<td>Organize, analyze, and interpret quantitative data and scientific information</td>
<td>Make a chart/graphic to interpret data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Read and interpret data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Troubleshoot capability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Understand basic statistic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Present conclusion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Predict based on quantitative data</td>
</tr>
</tbody>
</table>

Source: Gormally, 2012 [18]

The quantitative data on students’ science literacy skills were obtained from pretest and posttest scores. The instrument of pretest and posttest consisted of open-ended questions following the indicators of scientific literacy

Table 3. Score Results Literacy Test Realm of Cognitive Science in Product

<table>
<thead>
<tr>
<th>Indicators of Science Literacy</th>
<th>No. Question</th>
<th>The score per sub-indicators on pretest</th>
<th>The score per sub-indicators on posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.Understanding inquiry method which lead to scientific knowledge</td>
<td>1, 2</td>
<td>60</td>
<td>85</td>
</tr>
</tbody>
</table>
Students are required to be keen on reading the discourse in identifying the proper scientific arguments and presenting conclusions, predictions based on quantitative data. In general, students assume that an argument is correct, but they only focus on numbers generated mathematically without giving a good reason. In table 2 Students’ answers showed good categories in the four sub-indicators, which are using an effective literature search, read and interpret data, evaluation in the use of scientific information,
and use of literature effective. The questions presented in the instrument represented a contextual problem that was related to the environment around students. It makes the questions easier to understand. The highest result obtained from sub-indicators of creating graphs to represent data. From the results of the research above, it can be concluded that the students' scientific literacy ability must continue to be improved, especially using the physics module based on STEM-CP so that students are accustomed to science literacy capable of applying concepts or facts obtained in classroom learning.

Figure 1. Scientific Literacy skills of pretest and posttest answer students of Cognitive Science in Product

Figure 1 imagines the results of the scientific Literacy skills of pre-test and post-test answer students of Cognitive Science in Product. The average of each sub-indicator increases in the post-test, the highest increase in the second sub-indicator is identifying appropriate scientific arguments that reach a score of 85 and solving problems using quantitative abilities including statistical probability with a score of 85. On these two sub-indicators, students increase their understanding related to arguments that discuss how to make more understanding in the discussion, as well as solving problems using quantitative abilities including statistical probabilities that they don't need difficulties.
In figure 2 displays the Scientific Literacy skills of the pretest and posttest answers of students of cognitive science in the process, in cognitive science in this process selected only two sub-indicators that read two aspects of scientific literacy abilities, this is when our cognitive process gets data from the results of practicum students, in our opinion in practicum activities that are very easy to see, these two sub-indicators namely how students can understand the elements of research design and how it will influence scientific findings and create graphs to represent data. For these two sub-indicators, the highest score is placed on the sub-indicator, Understanding the elements of research design and how they affect scientific findings that score 79.

CONCLUSION

STEM-CP based modules (Science, Technology, Mathematics, Contextual Problem, and Engineering) can make student science literacy skills increased. It can be seen from the scores of the sub-indicator. STEM-CP based modules (Science, Technology, Mathematics, Contextual Problem, and Engineering) can be a solution, especially in vocational students in the era of industrial revolution 4.0, so that students will be skilled in finding solutions to the contextual issues in everyday life, especially related to science and technology. Science literacy is an ability that is very needed, especially for vocational students to be able to compete globally and be able to go directly to the community.

REFERENCES


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