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RESEARCH ARTICLE

THE APPLICATION OF STEM-CP-BASED SOUND WAVE MODULE TO IMPROVE STUDENTS' CRITICAL THINKING SKILLS AND INDEPENDENT LEARNING

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Abstract

Competition in science and technology inthe 21st-century created challenges in the field of education that triggered the development of scientific approaches. One of them was the STEM-CP approach which consisted of Science, Technology, Engineering, Mathematics and Contextual Problems. One of the advantages of the STEM-CP approach was that it could train students' critical thinking skills. The STEM-CP approach could be applied in learning media, one of which was a module that was useful for training students' learning independence. The purpose of this study was to describe the application of the STEM-CP-based sound wave module to the critical thinking skills and learning independence of high school students in physics. The research design used was one group pretest-posttest. As the results of the study, students experienced an increase in students' critical thinking skills with an N-gain value between 0.67 to 0.74 in the medium and high categories. The fairly good category changed to 85 in the impressive category. So that the application of the STEM-CP-based sound wave module was proven to be successful in improving students' critical thinking skills and independent learning.

Introduction:-

Competition in science and technology in the 21st-century created challenges in various aspects of life, especially in the field of education. Education in the world responds by making 21st-century skills the goal of achieving the educational process. The Government of Indonesia responds to the challenges of world education through the Regulation of the Minister of Education and Culture concerning Competency Standards for Graduates of Primary and Secondary Education (Kemendikbud, 2016), stating that every graduate of primary and secondary education units has competencies in three dimensions, namely attitudes, knowledge, and skills. The importance of applying the skills dimension in Indonesian education is reaffirmed in the 2013 curriculum which emphasizes that learning must integrate strengthening character education, literacy, and 4C skills (Creative, Critical thinking, Communicative and Collaborative).

In the 21st-century, critical thinking skills are essential for students (Redhana, 2019). Critical thinking skills were provided at all levels of education and in several subjects, one of which was physics. Physics is the science of natural phenomena and natural behavior that humans could observe (Syuhendri, 2013). Physics was given to the students to master the concepts and principles. In addition, students were expected to be able to develop skills and self-confidence to face the demands of the times with increasingly developing technology (Kemendikbud, 2014).

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However, in the process of achieving it, there were many obstacles experienced by students in studying physics, so they were unable to meet their academic demands.

Physics as one of the subjects in schools still got a bad reputation in Indonesia, which was considered difficult to learn and was less favorite to most students (Rahma et al., 2019). Based on the results of questionnaires given to 20 teachers and 30students in high schools in Jember Regency, the data obtained were that students had difficulty understanding physics material on sound wave material and still had low critical thinking skills on the material. These results were in accordance with research by Rohmah (2017) about students' low critical thinking skills in wave material. Various obstacles in learning physics must be overcome immediately, wildly wave material because it is strongly related to other physics materials (Sutopo, 2016). These learning obstacles, especially regarding 21st-century skills in physics subjects, led to many solutions and innovations.

Various innovations are carried out in several developed countries to realize an educational process that can improve the skills of the 21st-century in all subjects. The educational product currently developing is the integration of STEM (Science, Technology, Engineering, Mathematics) approaches in all subjects, one of which is physics. According to Ceylan and Ozdilek (2014), STEM can help learners develop one of the 21st-century skills, namely critical thinking skills.

The STEM approach began with giving problems that follow a particular concept. The problems usually given in the STEM approach were real worldwide problems (Torlakson, 2014). However, the problems given were not all contextual or occurred in the environment around students. According to Johnson et al. (2015), contextual problems were problems in everyday life that functioned to stimulate the brain to compile patterns that were actualized into a concept. According to Satriawan (2016), contextual learning could help students to understand physics material. The addition of contextual problems to the STEM approach was known as STEM-CP (Science, Technology, Mathematics, Engineering - Contextual Problem).

Several researchers have carried out research using the STEM-CP approach, namely Sutarto et al. (2020), getting the results that STEM-CP-based modules can increase the level of creativity of students in physics learning. According to Sari et al. (2020), STEM-CP-based modules can improve students' literacy skills in physics learning. Meanwhile, according to Sari et al. (2019), STEM-CP-based textbooks can improve students' critical thinking skills in the physics of optical tool materials. Based on this research, selecting problems that only use Contextual Problems in STEM approaches is considered to provide good results to improve 21st-century skills.

Based on the problems in physics subjects regarding the sound wave material, it was necessary to have teaching materials integrated with the STEM approach and contextual problems to assist teachers in improving students' critical thinking skills. According to Adlim et al. (2015), one of the teaching materials in accordance with the STEM approach was the learning module. According to Waluyo (2020), STEM-based teaching materials improved students' critical thinking skills. Thus, to solve these problems, a module was needed in which there was a STEM approach with contextual problems to improve students' critical thinking skills.

In addition to improving critical thinking skills, one of the advantages of using the module was that it enabled students to learn independently (Kemendikbud, 2015). The module was much needed considering that students in online learning needed learning independence during the Covid-19 pandemic. According to Hidayat et al. (2020), students' independence for online learning tends to be low. Their low independence was caused by their study habits, unsuitable learning resources, and unsupportive technology. So, this learning module helped students to increase their learning independence.

Based on the explanation above, this study aimed to describe the application of the STEM-CP-based sound wave module to the critical thinking skills and learning independence of high school students, especially in physics.

Research Method:-

This type of research was quantitative research. The study was conducted at SMAN Pakusari in Jember - Indonesia, in class XI MIPA, with 34 respondents. The study was conducted in as many as three meetings. The data obtained from this study are critical thinking skills and learning independence. The research design used a one-group pretest-posttest using a class that was chosen intentionally, and then a pretest was carried out symbolized by O_1, followed

by giving a treatment symbolized by X, and at the end of the lesson, a final test (posttest) was given symbolized with O_2. The design research can be stated in Figure 1.

O_1	X	O_2

Figure 1:- One group pretest-posttest design.

Information:
O_1 = Value before learning
X = Treatment
O_2 = Value after learning

Critical thinking skills used some indicators by Robert Ennis (2011), which included 1) providing simple explanations, 2) building basic skills, 3) concluding, 4) providing further explanations, and 5) Setting strategies and tactics. Analysis of critical thinking skills using N-Gain analysis was obtained from pretest and posttest scores. This analysis aims to determine the effect of using STEM-CP-based sound wave modules on improving students' critical thinking skills. The N-Gain analysis equation is:

$$N - Gain = \frac{posttest\ score - pretest\ score}{100 - pretest\ score}$$

The result of the N-Gain calculation is interpreted using normalized gain. The interpretation of the normalized gain assessment can be seen in Table 1.

Table 1:- Normalized gain value index.

N-Gain	Interpretasi
$0.7 < g < 1$	High
$0.3 \leq g \leq 0.7$	Middle
$0 < g < 0.3$	Low

The learning independence of students measured in this study included five indicators, they were (1) independence; (2) confidence; (3) initiative; (4) responsible; (5) discipline. The learning independence of students was measured using a questionnaire given before and after learning using a STEM-CP-based sound wave module.
The learning independence questionnaire score will be processed using the following formula.

$$P = \frac{S}{N} \times 100$$

Information:
P : Mastery score of each aspect
S : Total scores for each aspect
N : Total score

The results of the calculation of mastery of each aspect of learning independence are then included in the categories presented in Table 2.

Table 2:- Criteria for learning independence.

Scores Each Aspect	Category
84-100	Very Good
68-83	Good
52-67	Enough
36-51	Bad
20-35	Very Bad

Result and Discussion:-

The STEM-CP-based sound wave module is a physics learning module on sound wave material that has been systematically arranged according to core competencies and basic competencies associated with aspects of Science, Technology, Mathematics, Engineering, and Contextual Problem. The STEM-CP-based sound wave module is designed to improve students' critical thinking skills and learning independence. The features in the STEM-CP-based sound wave module can be seen in Figure 2.

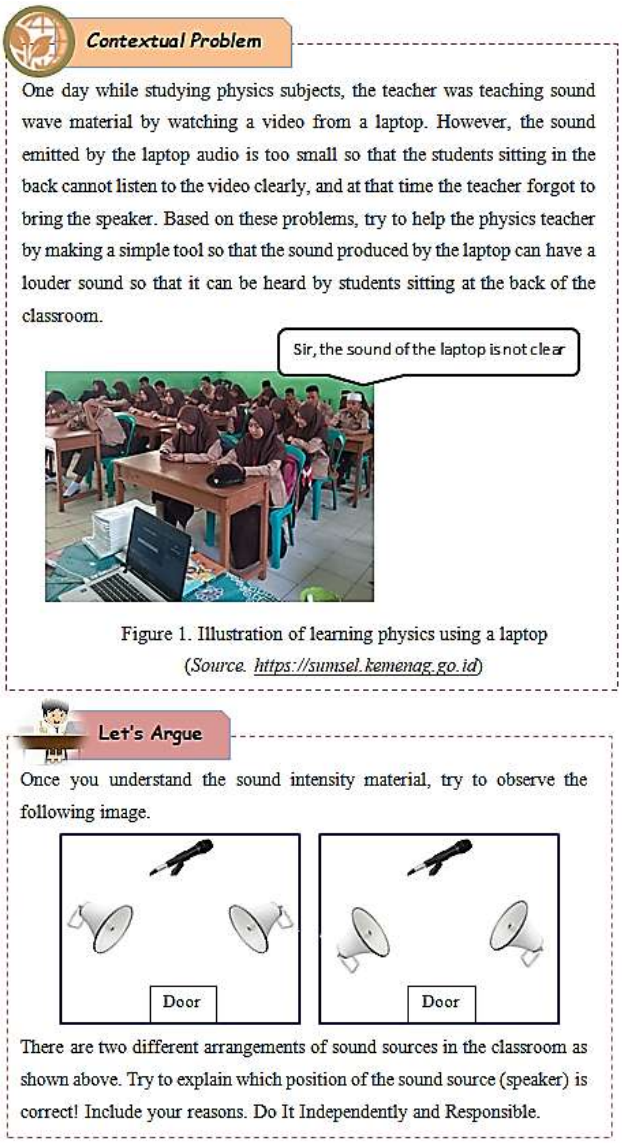

Figure 2:- Features in the STEM-CP-based sound wave module.

Based on Figure 2. Contextual problem aspects in the STEM-CP-based sound wave module contain readings about problems experienced by students in everyday life, namely the sound of laptops, and students are directed to be able to provide solutions to these problems. The activity feature of 'Let's Argue' aims to train one of the indicators of critical thinking skills, namely the skill of providing simple explanations and training learning independence on independent indicators and responsible.

Critical thinking skills test results are obtained from pretest and posttest scores at each meeting. Pretest and posttest are in the form of essays that have been adjusted to the indicators of critical thinking skills with five questions. The following pretest and posttest results are presented in Table 3.

Table 3:- Critical thinking skills test results.

Meeting	Test	Respondents	Average Score	N-Gain	Category
1	Pretest	34	44.38	0.67	Middle
	Posttest		82.29		
2	Pretest		38.97	0.74	High

	Posttest		84.24		
3	Pretest		40.38	0.72	High
	Posttest		83.32		

Based on Table 3, it can be seen that the critical thinking skills test results at the first meeting obtained an N-Gain of 0.67 in the medium category, the second meeting obtained an increase of 0.74 in the high category, and the third meeting experienced a slight decrease in N-Gain of 0.72 in the high category. The description based on each indicator of critical thinking skills can be explained as follows.

The first indicator was to provide a simple explanation. The skill of giving simple explanations could be trained by focusing on questions, analyzing statements and asking questions, or answering questions about an explanation. In the use of the STEM-CP-based sound wave module, it was obtained that students were able to answer the questions in 'Let's Argue' section. Based on the analysis results, students could answer problems and explain them appropriately, provide correct and precise concepts, and show a coherent flow of thinking in providing explanations. These results indicated that the skills of giving simple explanations in this study could be mastered well by students. 'Let's Argue' was in accordance with the results of research by Leicester & Taylor (2010), which stated that students were able to master critical thinking skills gradually through the habit of answering questions that required explanation.

The second indicator was building essential skills. Building fundamental skills could be trained by considering whether the source was reliable or not, observing and considering the results of observations. In the STEM-CP-based sound wave module, it was found that students could answer questions in the 'Tech Info' section. Based on the analysis results, students were able to build basic skills by observing the working principles of a seismograph and considering whether these principles could be applied to estimate the distance of a sound source to the listener. Learning activities that involving students directly in finding concepts would be stored in long-term memory (Latifa et al., 2017).

The third indicator was to conclude. Conclusion skills could be trained by deducing and considering the results of deductions, inducing and considering the results of inductions, or making and determining the value of considerations. In using the module, it was found that students were able to deduce and consider the results of waveform deduction on the Doppler effect in the 'Let's be Logic' section. Based on the analysis results, students could make deductions and consider the results of the deductions. The deduction was drawing general conclusions to be more specific ones (Qing et al., 2007). The skill of concluding by deduction makes students understand the right concepts and have the right way of thinking (Rahmawati, 2016).

The fourth indicator was to provide an advanced explanation. The skill of providing advanced explanations could be trained by identifying the terms and definitions of considerations and assumptions. In using the 'technology' section of the module during the second learning activity, students were able to explain contextual problems and provided some opinions about the model to determine the form of an effective loudspeaker to amplify sound, which must have a wide cavity so that the amplitude of the sound wave was also massive. According to Hughes (2014), students who were able to think critically had good and rational thinking in finding solutions.

The fifth indicator was to set strategy and tactics. Strategy and tactical skills could be trained by determining actions and interactions with other people. In the use of the 'engineering' section of the module during learning activities III, students solved contextual problems and provided solutions by designing and making noise-canceling devices from eco-friendly materials that could be utilized at home. According to Arifin (2017), students who could make decisions in solving problems had strong critical thinking power. Critical thinking skills made students wiser. From the research results, it was known that all N-Gain were in the medium and high categories. In addition, the activities of students on each indicator showed an increase in critical thinking skills. The research indicated that learning using STEM-CP-based sound wave modules improved students' critical thinking skills. This was in accordance with the results of research conducted by Sari et al. (2019) that stated STEM-CP-based module were proven to improve students' critical thinking skills in physics learning (Gunawan & Liliasari, 2013).

Meanwhile, learning independence data was obtained from questionnaires completed by students before and after learning using STEM-CP-based sound wave modules. The results of learning independence are presented in Figure 3.

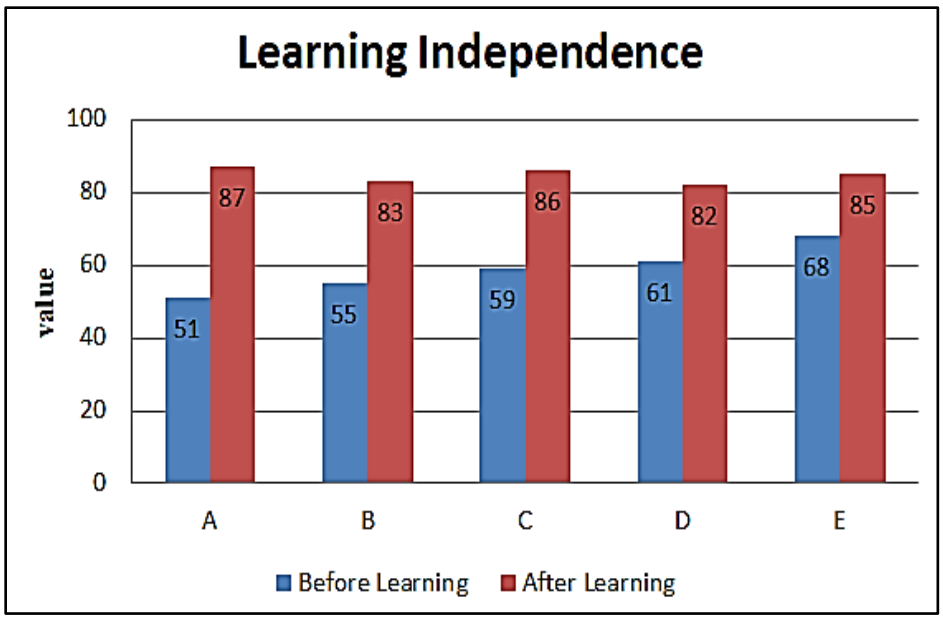

Figure 3:- Results of learning independence.

Information:
A : Indicators of independent
B : Indicators of confidence
C : Indicators of Initiative
D : Indicators of responsible
E : Indicators of discipline

Based on Figure 2. data were obtained that students experienced an increase in independencelearning on each indicator. Overall, before the learning process, students got an average score of 59 in the fairly good category. After implementing a learning approach, the STEM-CP-based sound wave module, students got an average score of 85 in the impressive category. These results were in accordance with a research Izza (2021) conducted about the STEM-based e-modules on temperature and heat material that was proven to increase students' learning independence.

Applying the STEM-CP-based sound wave module made students more active and enthusiastic in their learning participation. Students who took the initiative showed excitement during the learning process and signified their enthusiasm for obtaining better scores. In addition, students were proven to be more confident in completing assignments and solving problems. The use of contextual problems in the STEM-CP-based sound wave module provided its charm so that it fostered student interest in learning independently because the problems described in the module could be encountered in everyday life. Students were also responsible for studying modules, solving problems, and submitting assignments on time.

Conclusions:-

The application of the STEM-CP-based sound wave module was proven to improve students' critical thinking skills, with N-Gain values between 0.67 to 0.74 in the medium and high categories. In addition, applying the STEM-CP-based sound wave module increased the students' learning independence from an average score of 59 in the fairly good category to 85 in the impressive category.

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