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The Effectiveness of STEM-Based Physics Learning E-Module Education Integrated Coastal Abrasion Materials to Improve Student Knowledge and Disaster Response Attitudes

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ABSTRACT

The study aimed to determine the effectiveness of a STEM education-based physics e-module integrated with coastal abrasion material in improving students' disaster response attitudes and knowledge. The applicable curriculum and regulations explain the need for local wisdom to be included in learning materials so that students can recognize and understand regional characteristics. West Sumatra has most of the area on the coast, so it has the potential for the threat of natural disasters of beach abrasion. To provide disaster education by integrating it into learning Physics. Beach abrasion is a natural event that occurs spontaneously, so bringing it into the classroom is impossible. Therefore, electronic-based learning resources are needed. This research was conducted in wave material at SMA Negeri 1 Ulakan Tapakis 2018/2019 Academic Year. The method used in this case research is quasi-experimental. The design chosen was one group pretest-posttest design. The competencies analyzed were responsiveness and knowledge competencies. The study results mean that the STEM education-based physics e-module integrated with beach abrasion material effectively improves students' disaster response attitudes and knowledge.

INTRODUCTION

The development of science and technology requires educational institutions to prepare students as competent next generations of the nation. Students are expected to be competent in various fields, including Science, Technology, Engineering, and Mathematics, abbreviated as STEM. Applying STEM in education can encourage students to apply the knowledge gained. STEM-based education can prepare students to think scientifically and utilize technology for the future (English & King, 2015). The STEM approach perfectly matches real-world problems and problem-based learning (Torlakson, 2014). Through STEM-based education, students can be competent and ready to compete and work according to their occupation.

STEM in the Indonesian context refers to four fields of knowledge: science, technology, engineering, and mathematics. STEM-based education is a teaching and learning approach between two or more STEM components or between one STEM component and other disciplines (Becker & Park, 2011). STEM integration in teaching and learning may be carried out at all levels of education, where aspects of STEM implementation, such as

intelligence, creativity, and design ability, do not depend on age (Sanders, 2009). White (2010) states that the STEM approach to learning will provide an introduction for students after going through school. This introduction is very useful for students in continuing their education. STEM implementation in education can encourage students to design, develop, and utilize technology to hone cognitive, manipulative, effective, and applied knowledge.

Education that applies in Indonesia is organized based on the curriculum. In its implementation, Government Regulation Number 32 of 2013 states that each education unit must contain a local content curriculum regarding regional potential, regional problems, and local uniqueness. The regional potential is one of the learning resources aimed at students so that they can recognize and understand regional characteristics. West Sumatra has the characteristics of an area mostly located on the coast, namely Padang, Padang Pariaman, and Pesisir Selatan. Hence, it has the potential to face the threat of natural disasters of coastal abrasion.

Natural disasters are one of the problems that arise in the natural surroundings. According to Law Number 24 of 2007 concerning Disaster Management, a disaster is an event or series of events that threatens and disrupts people's lives and livelihoods caused, both by natural factors and non-natural factors as well as human factors, resulting in human casualties, environmental damage, property loss, and psychological impact. Natural disaster management needs to be done to reduce greater risks. In dealing with disasters, an attitude is needed to reduce disaster risk, one of which is disaster response. According to Ramli (2010), disaster response is a series of activities carried out immediately at the time of a disaster to deal with the negative impacts that have arisen, which include rescue and evacuation of victims, and property, fulfilment of basic needs, protection, management of refugees, rescue, and restoration of facilities. And infrastructure. Disaster response attitude possessed by students to reduce the risks and adverse effects of an incident.

Knowledge about efforts to deal with natural disasters needs to be given to the community, bearing in mind that efforts to deal with natural disasters are not only the responsibility of the government. One way that can be done is by providing an understanding of disaster to the community from an early age, namely through school-age children. Disaster education is very relevant to be applied through learning Physics (Fauzi, 2014). Physics is a science that describes and analyzes the structure of events in nature (Jannah, 2019). Permendikbud Number 103 of 2014 states that learning should use an approach that refers to the characteristics of learning. This is needed so that the competence of students can be achieved properly.

An analysis of the disaster response attitude of students in the coastal areas of Padang Pariaman Regency with the risk of coastal abrasion found that students still needed to understand the disaster management efforts around them. One of them is the analysis of the disaster response attitude of students at SMAN 1 Ulakan Tapakis, which is found to be in the less category (Aulyana, 2018). The analysis of the responsiveness of students at SMAN 1 UlakanTapakis found that they were still in the less category. The analysis results show that students need to have a responsive attitude to coastal abrasion disasters fully. In the indicator of fulfilling basic needs, an average percentage of 67.5% is obtained, which is in the less category. Basic human needs are the elements that humans need to sustain life. Maslow's theory suggests that one of the basic human needs is the need for safety and security (Potter & Perry, 2009). Students need to meet the need for safety and security by knowing the symptoms and impacts of disasters through socialization and information sharing that will reduce the impact of disasters. In the protection indicator, an average percentage of 64.73% is obtained, which is in the less category. Based on the description of the indicators, students rarely immediately protect themselves when a beach abrasion disaster occurs. In the indicator for the recovery of facilities and infrastructure, an average percentage of 66.27% is

obtained which is included in the less category. Students need to be more responsive to the repair of facilities and infrastructure damaged by coastal abrasion. This shows students' lack of knowledge to behave towards natural conditions in their environment.

The problems raised can be overcome by applying teaching materials in learning according to needs. Permendikbud No.26 of 2016 concerning the standard of facilities and infrastructure regulates the types of learning resources available in schools. Relevant teaching materials for use in learning are books and modules. According to Prastowo (2011), the module's functions include independent teaching materials, a substitute for the educator's function, an evaluation tool, and as reference material for students. Therefore, the module as a form of teaching material has a very important role in the implementation of an independent learning process. The module is integrated with regional characteristics, namely coastal abrasion disaster material. Beach abrasion is a natural event that occurs spontaneously, but the events and objects of the beach abrasion disaster do not allow them to be brought into the classroom. Therefore, the module as an independent teaching material is made in an electronic format called an e-module.

E-modules are electronic versions of teaching materials and learning media in book formats that contain audiovisuals, sound, and films that are easy to use and can be run on a computer or smartphone (Syafriani, 2020, p. 1). This means that there is no difference in principle between e-modules and modules. As an independent teaching material, the module has characteristics adapted to e-modules, namely self-instructional, self-contained, stand-alone, adaptive, and user-friendly characteristics. The module contains at least seven components: titles, study instructions, competencies to be achieved, supporting information, exercises, work instructions or worksheets, and evaluation (Depdiknas, 2008). E-module is one of the information technologies that can visualize natural phenomena and symptoms. The application of information technology in learning is believed to improve students' learning abilities (Ramdhani, 2014). Learning with the application of information technology can be used to improve the quality of learning.

Learning materials were analyzed by analyzing the suitability of Physics material with beach abrasion material. Material analysis was carried out using the concept fitting technique (Hamdi, 2014). The stages of the concept fitting technique are to describe the Physics material and the beach abrasion material, determine the relevant Basic Competencies (BC), and determine the relationship between the Physics material and the beach abrasion material. Material analysis was carried out on high school physics material. The analysis results obtained the most suitable material, namely high school physics material regarding mechanical waves.

Coastal abrasion occurs because sea waves and destructive sea currents cause it. Abrasion or erosion damages the shoreline due to the release of beach materials, such as sand or clay, which are continuously hit by sea waves (Munandar, 2017). The energy possessed by sea waves can erode road walls. If the objects/buildings on the beach are not strong enough to withstand the sea waves, over time, the coastal cliffs will erode, or beach abrasion will occur. Sea waves are water movements in an oscillatory manner characterized by rising and falling sea levels (Chandrika, 2016). The greater the wave strength, the greater the abrasion is carried out, and the more debris is washed away, which causes the land area affected by abrasion to become smaller and smaller (Kanisius, 2010). The damage caused by abrasion makes the beach area smaller, so it is always a problem in the coastal environment. After students know the dangers of changing waves on the beach, it will result in students having a responsive attitude to coastal abrasion disasters to reduce the impact of beach abrasion.

Based on the previous explanation, a STEM education-based Physics e-module integrated with material on coastal abrasion was developed. E-modules can be used

successfully in learning when the e-modules have an effective category. According to Wena (2011), students' effectiveness is measured based on the level of achievement of student learning outcomes. Indicators state that product implementation is said to be effective can be seen from the components of student learning outcomes, student activities, and student abilities (Rochmad, 2012). This means that the Physics e-module is effective if used in learning to increase student learning outcomes. Effectiveness can be seen in the competence of responsiveness and knowledge of students. Based on this, the researchers formulated the problem in this study: How is the level of effectiveness of the STEM education-based Physics e-module integrated with coastal abrasion disasters to improve students' disaster response attitudes. This study aimed to determine the level of effectiveness of the Physics e-module based on STEM education integrated with coastal abrasion disasters to improve students' knowledge and disaster response attitudes.

METHODS

This study uses a quasi-experimental method. The quasi-experimental method is carried out in conditions where it is impossible to control all the influential outside variables (Sugiono, 2012). The design chosen was one group pretest-posttest design. One group pretest-posttest design is a research design that has a pretest before being given treatment and a posttest after being given treatment.

This study took a population of class X MIA students in the 2019/2019 academic year at SMAN 1 Ulakan Tapakis. The sampling technique is purposive sampling (sample aims). *Purposive sampling* is a technique in which the research sample is taken with certain considerations that aim to make the data obtained later more representative. The sample in this study was class X MIA 3 SMAN 1 Ulakan Tapakis, which consisted of 30 students.

Before the research, a trial was conducted on using the Physics e-module. The trial implementation phase in this study consisted of four stages. The first stage is giving a knowledge pretest to class X MIA 3 SMAN 1 Ulakan Tapakis before learning to use the Physics e-module. The second stage is the learning process using the Physics e-module, developed along with assessing responsiveness and knowledge. Then the third stage is to provide a knowledge posttest and a questionnaire on student responsiveness at the end of the meeting. The fourth stage is conducting data analysis using appropriate statistics to determine the effectiveness of the Physics e-module.

The instrument for the effectiveness of the physics e-module was used to collect data on the effectiveness of the e-module; the data collection instrument for testing effectiveness was a self-assessment sheet (responsiveness) for attitude competence and a test sheet with 25 objective questions for knowledge competence. The effectiveness of the tough attitude sheet in this study. Before being used, it was assessed first using a responsiveness assessment instrument sheet which experts assessed. After being valid, it can be used to assess the effectiveness of student responsiveness. Each test item in this study was tested first in class XI MIA and then analyzed using validity and reliability tests.

Data analysis was carried out based on responsiveness questionnaires filled in by students at each meeting. Then converted into the category of effectiveness. In addition, an effectiveness test on knowledge competence was carried out by giving a pretest and posttest to the class being tested. To see the increase using n-gain (g). N-Gain normalization gain is classified into three categories, including 1) If the gain value is in the high classification, then the level of effectiveness is very effective, (2) if the gain value is in the moderate classification, then the level of effectiveness is effective, and 3) if the gain value is in the low classification, then the level of effectiveness is less effective (Rizkiningrum, 2020).

RESULTS AND DISCUSSION

The result of the attitude parameter assessment is responsiveness. This assessment was carried out with self-assessment instruments by students. Student attitude assessment is carried out at each meeting. Students carry out self-assessments. This assessment was carried out to see the extent to which students' responsiveness to disasters related to coastal abrasion disasters. The results of the assessment of students' responsiveness at each meeting are shown in Figure 1.

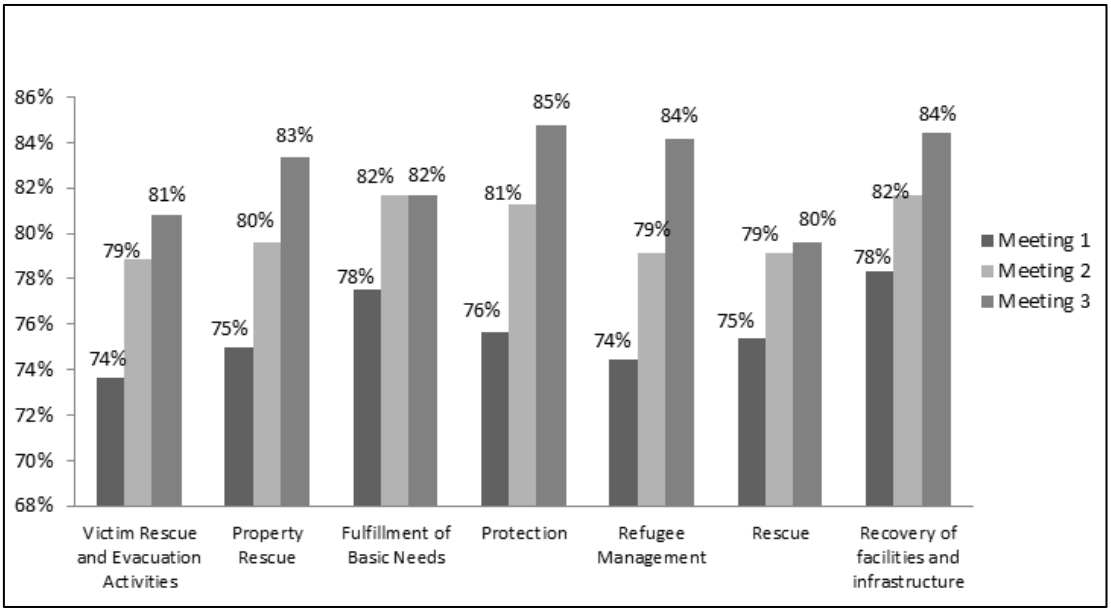

Figure 1. Results of Student Responsiveness Assessment

Figure 1 shows an increase in the responsiveness of students at each meeting. The average percentage of student responsiveness competence for three meetings is 75.3%, 80.1%, and 82.5%. This is indicated at each meeting, where disaster management knowledge is integrated with the form of efforts that students must make to overcome disasters. On the indicators of rescue and evacuation of victims, students are willing to help people around to evacuate themselves, help if someone is injured due to a beach abrasion disaster, and provide as much help as possible to the surrounding situation. On the indicator of saving property, students immediately collect and save their valuables, the indicator of fulfilling the needs of students in directly seeking information about beach abrasion that has occurred from various sources. However, the student's responsiveness remained from the 2nd to the third meeting. This was indicated because the students had fulfilled the information they got from the previous incident.

On the protection indicator, students behave, including immediately paying attention to disaster evacuation maps, staying calm, and staying away from coastal abrasion and areas prone to landslides due to coastal abrasion. On the refugee management indicator, students immediately tell others not to approach areas affected by coastal abrasion, not to frighten friends/people around, and to pay serious attention to instructions from teachers/parents. On the rescue indicator, students have paid attention to safe locations to save themselves and stay away from unsafe coastal abrasion areas. Regarding the recovery of facilities and infrastructure, students immediately work together to build sand embankments to minimize the risk of beach abrasion, work together to mark places prone to landslides due to abrasion and increase self-awareness in dealing with disasters.

The increase in students' responsiveness in each meeting indicator shows an increase in responsiveness to using STEM education-based Physics e-modules integrated with beach abrasion disaster material. This is in line with the results of Hapizoh's research (2019), where there is an increase in learning outcomes by looking at changes in the percentage of scores in each learning cycle. The increase in the percentage of scores in each cycle shows that students can follow the learning well and optimally. The average percentage of results at each meeting of the value of responsiveness was obtained at 79.53. According to Riduwan (2009), the percentage interval of 61-80 is included in the effective category. Improved student responsiveness due to using STEM education-based e-modules integrated with beach abrasion disaster material. The STEM approach positively impacts aspects of attitude, including the strength to be confident, confident in doing something, student activity, and behaviour (Lee, 2020). In addition, the teaching materials students use are by the region's characteristics. Functionally, everything around the learning activity environment can help optimize learning outcomes (Sanjaya, 2011). Hartini's opinion (2018) states that in the learning process, it is necessary to get used to continuously improving attitudes; teaching materials are one way to improve students' attitude competence.

Knowledge competency results have been obtained from data on students' pretest and posttest results. To see an increase in students' knowledge competence, N-Gain is used. Based on the normality test results, the pretest and posttest values of the students' data were normally distributed. The test results using the paired sample t-test found a significant difference between students' physics knowledge competency scores before using the physics e-module and after using the physics e-module. The results of calculating the pretest and posttest values of students' knowledge competence using the N-Gain formula can be seen in Table 1.

Table 1. Results of Knowledge Competency N-Gain Scores

Score	The Lowest Score	The Highest Score	Average	N-Gain	Category
Pretest	28	88	58.13	0,50	Medium
Posttest	68	88	79.46		

Based on Table 1, the average increase in the knowledge competence of students is based on the pretest and posttest results. The results of calculations using the N-gain formula are obtained at 0.5 in the moderate category. The results show that the Physics e-module based on STEM education integrated with coastal abrasion disaster material effectively increases students' knowledge competence. The result can be seen in the lowest score, which was higher after being given the posttest, namely from 28 to 68. Then the average class value increased from 58.13 to 79.46. The increase was not seen at the highest score, which obtained the highest score that did not increase, namely 88.

The increase in students' knowledge competence was due to using STEM education-based Physics e-modules integrated with coastal abrasion disaster material. It is relevant to research conducted by Winatha& Abubakar (2018), where this study obtained the results that using e-modules in learning activities can improve student learning outcomes. In addition, according to Lee (2020), by applying the STEM approach, student learning outcomes at school are higher than students who do not apply it. In the large group trials in the experimental class and the control class, there were significant differences in learning outcomes obtained by students with the acquisition of an analysis of calculating the average value of learning outcomes in the experimental class, which was higher than the control class (Dewi, 2021). The positive impact of using e-modules is that the presentation can be inserted

through animations, images, videos, and audio. E-modules can be used flexibly without any space and time limitations. This e-module can guide students to learn actively and independently and enables students to build and apply the concepts acquired in real life. Interactive e-modules can increase learning motivation, scientific literacy, learning outcomes, independence, and students' critical thinking skills (Wulandari, 2021). The e-module is expected to become a new learning resource for students and can further improve students' understanding of concepts and competencies.

The STEM aspect combines knowledge (Science), skills in designing a work (Engineering), and compiling it systematically and logically (Mathematics) can be used to answer problems in everyday life by utilizing current technological advances (Yuanita, 2019). The STEM approach's initial goal is to integrate various aspects to provide meaningful learning experiences and make it easier for students to understand lessons (El-Deghaidy et al., 2017). In other words, STEM-integrated learning can support students in applying their knowledge to create a design to solve a problem. STEM approach activities in learning encourage students to apply various fields in life, including science, technology, engineering, and mathematics. Solving these problems can make students understand the material being studied and apply it in everyday life.

Another advantage of e-modules is that they contain neatly packaged content to make it easier for students to understand the subject matter. The beach abrasion disaster is content in the environment of students with a magnitude in physics. The physical quantities in coastal abrasion events are deviation, period, frequency, propagation speed, sea wave height, and sea wave energy. Through e-modules provide learning experiences not only heard but also seen and done. Sudjana (2010) has also shown that people remember 20% of what they see, 40% of what they see and hear, but about 75% of what they see, hear and do simultaneously. Thus, STEM education-based physics e-modules are effective in physics learning.

CONCLUSION

The study results were seen from the achievement of student learning outcomes, namely on the competence of responsiveness and knowledge of students. The average percentage of the participants' responsiveness was 79.53, which was included in the effective category. The average increase in the knowledge competence of students using the N-gain formula is obtained by 0.5, with the level of effectiveness being in the medium classification with the effective category. The STEM education-based Physics e-module integrated with beach abrasion disaster material effectively improves students' disaster response attitudes and knowledge. Besides that, this e-module can be used by educators in the learning process and helps students understand the subject matter that contains regional characteristics to improve learning outcomes.

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