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Development of Stem Fluid E-Modules and Flood Mitigation to Improve HOTS of Students of SMKN 1 Rejang Lebong

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Abstract. linking the concept of physics to fluid matter to flood mitigation efforts. This study aims to: (1) Describe the design, characteristics and validity of the e-module on fluid matter physics and flood mitigation with a STEM approach. (2) Analyze the effectiveness of the application of fluid matter physics and flood mitigation e-modules with STEM approaches to improve Students' High Order Thinking Skills (HOTS). (3) Knowing the practicality of applying the e-module on fluid matter physics and flood mitigation with a STEM approach based on student responses. This study used the ADDIE development model. The trial sample for the application of the e-module was 30 class X students of SMKN 1 Rejang Lebong who were selected using the Purposive Sampling technique. The e-module is designed using a STEM Project Based Learning (PjBL) model with stages of reflection, research, discovery, application and communication for students of the Technology and Engineering Group Vocational School. Based on expert validation the e-module is very feasible to use with an average score percentage of 90.03%. The e-module received a positive response from students of 91.07% or very good. The integrated fluid e-module of flood disaster mitigation can improve students' Higher Order Thinking Skills (HOTS) with an N gain of 0.69 in the moderate category. Based on the results of the t-test, the application of e-modules in learning provides a very significant correlation to the improvement of student learning outcomes, which is 0.83.

Keywords: e-module; HOTS; flood mitigation; STEM

1. Introduction

Learning design oriented towards Higher Order Thinking Skills (HOTS), integrated literacy and Strengthening Character Education (PPK) is expected to equip students with 21st century skills. The 21st century skills that students are expected to have in order to be able to compete in the Global Era, namely: being able to think critically, creatively, being able to solve problems and make decisions, as well as collaborating through collaboration and communication. One approach that can be used to develop student HOTS in learning is the STEM approach. The STEM approach develops problem-solving skills, student-centered learning, and develops higher-order thinking skills. In learning with a STEM approach, students can integrate aspects of science, technology, engineering and mathematics to solve problems in the real world. The STEM approach is a dynamic learning approach in which students actively explore problems in the real world, to acquire more in-depth knowledge to deal with various problems . One of the environmental problems that occurs around students is flooding. Flood disaster is one of the natural disasters that occurs due to natural conditions or human actions. (Boesdorfer, 2016; Gao et al., 2020; Roberts et al., 2018; Seage & Türegün, 2020)(Cheng & So, 2020; Johnson, 2019; Yang & Baldwin, 2020)(Dierking & Falk, 2016; Ibáñez & Delgado-Kloos, 2018; Wan et al., 2022)

Based on BNBP data, floods are the highest disasters that occurred in Indonesia throughout 2021, therefore flood mitigation efforts are needed. Disaster mitigation is one of the efforts in dealing with natural disasters including floods. Disaster mitigation as a series of efforts to reduce disaster risk, both through physical development and awareness and increasing the ability to face disaster threats. Flood disaster mitigation can be done by integrating it in classroom learning on relevant materials. In physics subjects, flood mitigation can be integrated in fluid materials by using a STEM approach in learning. The STEM approach is expected to be able to develop students' ability to

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connect physics concepts in fluid matter with the environment, technology, and society in everyday life, especially in flood problems, as well as be able to increase students' understanding of flood mitigation efforts.

The STEM approach is used to develop fluid modules and flood mitigation for students of the Technology and Engineering Group Vocational School. Modules are developed in electronic or digital form using flipbooks so that students can use them in online and independent learning at home, especially during the COVID-19 pandemic. The Flipbook application can make the pdf look attractive like a book and can be equipped with videos and animations. E-modules also make it easier to disseminate and share information in an easier, more engaging and interactive way.

Based on this, the formulation of the problems in this study is: (1) How is the design, characteristics and validity of the e-module in fluid matter physics and flood mitigation with a STEM approach for SMK students in the Technology and Engineering group? (2) How is the effectiveness of the application of the e-module on fluid matter physics and flood mitigation with the STEM Approach in improving the High Order Thinking Skills (HOTS) of SMKN 1 Rejang Lebong Students? (3) What is the practicality of applying the e-module on fluid matter physics and flood mitigation with a STEM approach based on student responses?

This study aims to: (1) Describe the design, characteristics and validity of the e-module on fluid matter physics and flood mitigation with a STEM approach. (2) Analyze the effectiveness of the application of fluid matter physics and flood mitigation e-modules with STEM approaches to improve Students' High Order Thinking Skills (HOTS). (3) Knowing the practicality of applying the e-module on fluid matter physics and flood mitigation with a STEM approach based on student responses.

2. Method

The type of development research used is the ADDIE Model through 5 stages; Analysis, Design, Development, Implementation and Evaluation(W Dick & L Carey, 1990). The trial sample of the application of the e-module was 30 students of class X TK 1 SMKN 1 Rejang Lebong who were selected using the Purposive Sampling technique.

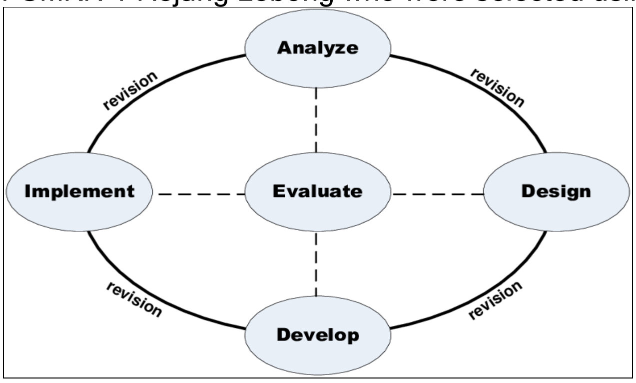

Figure 1: ADDIE Development Model

Research on the development of e-modules in fluid matter physics and flood mitigation with a STEM approach, through procedures; (1) Analysis stage, in the form of: module needs analysis, Basic Competency (KD) analysis, Competency Achievement Indicator (GPA) analysis, material analysis, as well as flood problem analysis and flood mitigation efforts. (2) Design stage, in the form of: e-module framework design, e-module design, and research instrument design. (3) Development stage, in the form of: validation of e-modules by material and media experts and making necessary revisions based on expert advice. (4) Implementation stage, in the form of: implementation through trials limited to one small group (limited trials), namely in class X students of TK 1 SMKN 1 Rejang Lebong. (5) Evaluation stage, in the form of: evaluation of the results of the implementation of the e-module. Evaluation is carried out to assess the effectiveness of e-modules in improving students' HOTS abilities and assess the practicality of using modules from student responses.

Data collection techniques are carried out using questionnaires to assess the feasibility of modules and student responses in learning. The effectiveness of the use of e-modules was carried out by measuring the improvement of students' HOTS by using the HOTS test question instrument with metacognitive skill indicators according to Brown, A.L (2007). The test was carried out with the design method of one group pretest-posttest with the experimental method according to Arikunto(2010). The results were analyzed using the Normality Gain Test, which can provide an overview of the improvement in learning outcomes scores before and after the application of the method. The test of the effectiveness of the model using SPSS is through t-test using the Paired Samples Test formula, with the following hypothesis: (1) After applying physics learning using e-modules, there is a significant increase in physics learning outcomes (average posttest results > average pretest results) (Ho: μpost = μpre; H1: μpost > μpre). (2) Test criteria: Reject Ho if the Sig. value or probability value $p < 0.05$. Accept Ho if the Sig. value or p probability value > 0.05 or Reject Ho if t-count > t-table(Hake, 1999), receive Ho if t-count < t-table. Data analyzed descriptively (Sugiyono, 2017)

3. Results and Discussion

The research and development carried out resulted in the Fluid and Flood Mitigation E-Module for Class X SMA / MAK Field of Technology and Engineering Expertise. E-modules are designed using a Project Based Learning (PBL) model with a STEM approach.

3.1 Fluid E-Module Design and Flood Mitigation

E-Modules are created using the *Flipbook application,* which makes the pdf look attractive like a book and is equipped with videos and animations. *Flipbooks* can display a diverse set of images from page one to the next, when flipped back quickly. The image appears animated by stimulated motion making it more interesting. seem *E-modules* with the *Flipbook* application are also made to facilitate learning, because they can be easily read by students using *smartphones* without using special applications. In the module, there is factual information from both texts (materials) and videos, questions, discussion sheets that encourage students to know, understand and connect flood problems and flood mitigation efforts with the concepts and laws of static and dynamic fluids.

E-Modules are generally divided into 4 chapters, namely: Introduction, Learning, Learning Assessment and Concluding. The learning stages are carried out based on the instructions on the *e-module* with the stages of the PjBL STEM learning model according to Laboy-Rush(2011), as in table 1:

Table 1: Learning Activities on Fluid E-Module & Flood Disaster Mitigation

Stages PjBL STEM	Learning Activities
Reflection	Let's Observe Let's Identify
Research	Let's Read Let's Watch
Discovery	Let's Analyze Let's Design
Application	Let's Make Let's Test Run
Communication	Let's Report

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Let's Present

3.2 Characteristics of Fluid E-Module and Flood Mitigation

The characteristics of the developed e-module are characteristic of the product developed by the researcher and distinguish it from other researchers' modules that have been developed previously. The characteristics of the developed e-modules are as shown in Table 2:

Table 2: Characteristics of Fluid E-Modules and Flood Mitigation

Characteristics of *E-Modules*	Information
Mission	Developed a Fluid and Flood Mitigation E-module for Class X SMK for Technology and Engineering Expertise. *E-modules* can be used as teaching materials for teachers in integrating flood disaster mitigation in fluid materials and designing HOTS-oriented learning, integrated literacy and Strengthening Character Education (PPK)
Competence	**Knowledge:** 1. Mentioning fluid-related phenomena in life 2. Mention of the properties of the fluid 3. Identifying static and dynamic fluid differences 4. Describes the magnitudes of static and dynamic fluids 5. Understand the concepts and laws of static and dynamic fluids 6. Applying the concept of hydrostatic pressure, the principle of Pascall's Law, Archimedes' Law, continuity equations, and Bernoulli equations in solving problems in everyday life 7. Linking the concept and application of static and dynamic fluid laws with flood contextual problems and flood mitigation efforts 8. Analyze the relationship between the working principle *of a simple flood Early Warning System (EWS)* and the laws of static and dynamic fluids. **Skills:** 1. Create a simple flood *Early Warning System (EWS)* design drawing as an application of static and dynamic fluid laws 2. Create a simple *Early Warning System (EWS)* flood as an application of static and dynamic fluid laws 3. Presenting the results of the project to create a simple flood *Early Warning System (EWS)*
Basic Theory	The Fluid and Flood Mitigation E-Module was developed using the STEM model *Project Based Learning* (PjBL) approach.
Basic Activities	The integration strategy of flood mitigation in fluid material in learning activities uses 5 phases, namely: *reflection, research, discovery, application,* and *communication*. In each phase, the learning activities that are structured are directed to stimulate and develop

	student HOTS on activities: observing, identifying, reading, watching, analyzing, designing, creating, piloting, reporting, and presenting. In the *e-module*, there are texts (materials), videos, questions, assignments and discussion/work sheets as support.
Source of Material	The source of the material comes from literature studies (literature reviews), documentation and observations of flood areas, as well as meteorological data at BMKG Kepahiang.
Assessment Characteristics	*Student HOTS* is measured using an instrument in the form of an essay question with 4 metacognitive indicators, namely: *planing*, *monitoring*, *evaluating* and *revising.*

3.3 Validity of Fluid E-Module and Flood Mitigation

The results of the *e-module* design that has been made before being tested are first validated by material and media experts. The questionnaire used to assess validation uses a likert scale. The validation of the e-module was carried out by 7 experts in physics, geography (hydrology) and environment, and digital simulation.

Table 3: Expert Validation Results

Aspects	Format of Material and Media Presentation
Material Presentation Format	93,45 %
Content/Material	91,33%
Linguistics	85,71 %
Technical Quality	100 %
Program View	83,93 %
Eligibility Percentage	90,03 %
Criterion	Very Decent

The feasibility of the e-module is assessed based on the validation results of the aspects mentioned above. The overall analysis of validation results based on the seven experts obtained an average percentage of 90.03%. Thus, it can be concluded that the Fluid and Flood Mitigation E-Module is declared very feasible as teaching material for students so that it can be implemented.

3.4 Effectiveness of Fluid E-Module Application and Flood Mitigation

Effectiveness is measured by calculating and analyzing student learning outcomes using the *HOTS* question instrument on the metacognitive skills dimension, based on student *pretest* and *posttest* assessments. The implementation was carried out on 30 students of class X TK 1 SMKN 1 Rejang Lebong in the Field of Technology and Engineering Expertise. Before the application of the e-module, *a pretest* is carried out on students first. *Pretests* are carried out to determine the effectiveness of the application of *e-modules* by comparing them with the *posttest* results given at the end of learning.

The effectiveness of the application of the Fluid and Flood Mitigation E-Module in learning was analyzed using the parametric *paired sample T Test.* In the data of *student pretest* and *posttest* results before being analyzed, a normality test was first carried out.

Normality test results showed that *Asymp. Sig. (2-tailed)* pretest = 0.410 > 0.05, and posttest = 0.667 > 0.05, this means that *the pretest* and *posttest* data are normally distributed respectively. The *posttest* average was 78.20 > the *pretest* average was 27.93. This shows an increase in learning outcomes after using the *Fluid E-Module* and Flood Mitigation in learning. The magnitude of the correlation results between pretest and posttest values based on the results of the *paired sample T Test,* shows a high correlation (r = 0.831) and significant between the *pretest* and *posttest* scores in each student. This shows that almost all students experience improved test results. The results of the *Paired Sample T Test* analysis, showed the value of *Sig. (2-tailed)* = 0.000 < 0.05. According to the test criteria if *Sig. (2-tailed)* is less than 0.05 this means that H_O is rejected or H_1 is accepted. Thus the hypothesis that states after the application of physics learning using the *E-Module* of Fluids and Flood Mitigation there is a significant increase in learning outcomes is acceptable.

Students' HOTS improvement in metacognitive skills can be analyzed based on a comparison of students' *pretest* and *posttest* results with categories referring to metacognitive skill criteria (Nana Sudjana, 2004). The improvement can also be seen from the N gain value of each metacognitive indicator that is expected to be achieved in learning, as shown below:

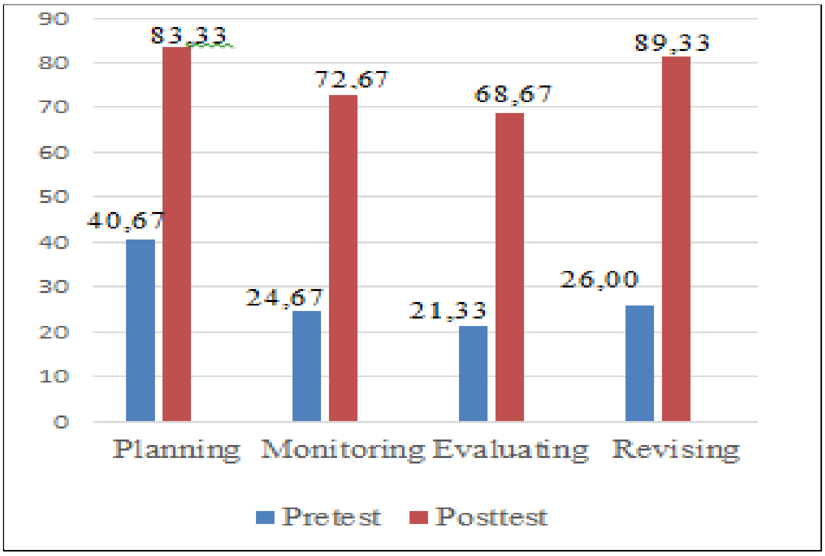

Figure 1: Increased student HOTS

Based on the results of *pretest* and *posttest* analysis of student learning outcomes, the application of the Fluid and Flood Mitigation e-module developed has been able to stimulate the improvement of student *HOTS* on each metacognitive skill indicator. In student learning outcomes seen from the comparison of students' *pretest* and *posttest* scores , there was an increase in the average score of students' scores from 27.93 to 78.20. The number of students who are complete in learning has also increased, the completion criteria are based on the KKM physics class X SMKN 1 Rejang Lebong scores. After the posttest, the number of students who did not complete learning was 4 students or 13.33% while the students who completed learning were 26 students or 86.67%.

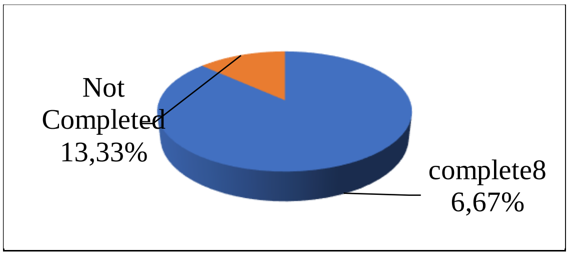

Figure 2: Student Learning Completion

From the *pretest* results and *posttest* results, students were then analyzed using a gain test and obtained an N gain value of 0.69.

Table 3:Recapitulation Gain Test Analysis Results

Aspects	Number of Students	Average	Gain Value	Criterion
Pretest	30	27,93	0,69	Keep
Posttest	30	78,20		

3.5 Practicality of Fluid E-Module Application and Flood Mitigation

The results of the student response analysis provide an average response of 91.07% meaning that the module is very good to be applied in learning fluid matter physics integrated flood mitigation. Modules can help students understand the application of fluid concepts and laws in flood mitigation efforts. Based on the results of the student response questionnaire analysis, it was found that after the implementation of the module, students could understand about flood disaster mitigation by 96% with a very good category.

Discussion

Product implementation can improve learning outcomes by increasing the average score and the number of students who complete learning. In general, students have been able to understand and connect information about the concepts and laws of static and dynamic fluids in flood problems and flood mitigation efforts. In the module, there is factual information from both texts (materials) and videos, questions, discussion sheets that encourage students to know, understand and connect flood problems and flood mitigation efforts with the concepts and laws of static and dynamic fluids. The module is expected to help students understand the application of the concepts and laws of static and dynamic fluids in flood disaster mitigation efforts both factually, conceptually, procedurally and metacognitively.

The learning process is divided into 3 learning activities using stages according to the syntax of the PjBL STEM model, namely: reflection, research, discovery, application, and communication. In each of these phases, the learning activities arranged in the module are directed to develop student HOTS. These activities are carried out by students in accordance with the instructions and commands contained in the module, namely: observing, answering questions, identifying, reading, watching, analyzing, designing, creating, piloting, reporting, and presenting. The teacher evaluates and assesses the tasks done by the students contained in the module.

Students' metacognitive abilities in planning and revising indicators are already in the good category, but monitoring indicators are still in the sufficient category, even in the evaluating indicators are still in the less category. Students still have to get used to learning and practicing independently in solving problems, as well as assessing their abilities. Teacher activities that can affect student activity include motivating or attracting students' attention so that they can play an active role, generate student activities and participation and provide feedback in learning activities (Pammu, 2014). However, although the monitoring indicators are still in the sufficient category, even the evaluating indicators are still in the less category, in general there has been an increase in these indicators. According to Mutia and Khairul (2019), metacognitive can be referred to as thinking about thinking that is the ability to reflect on known information and the circumstances that occur and the relationship between the two. The metacognitive dimension describes the ability to connect several different concepts, interpret, solve problems, choose problem-solving strategies, discovery, reasoning, and make the right decisions (Ervina, 2018).

Students can determine and make plans in the application of static and dynamic fluid laws in flood mitigation efforts and can provide plans if they live in flood-prone areas. At this stage the student is considered to have been able to reach the level of analyzing. This is in accordance with Bloom's theory, namely the analysis stage is reached if students can analyze a conclusion based on supporting evidence, decompose the material into clearer components, and can find causal relationships on a problem, especially about the concepts of fluid and flooding.

In the module, there is factual information from both texts (materials) and videos, questions, discussion sheets that encourage students to know, understand and connect flood problems and flood mitigation efforts with the concepts and laws of static and dynamic fluids. Modules can help students understand the application of static and dynamic fluid concepts and laws in flood mitigation efforts. This can be seen in the planning aspect, where students get an average score of 83.33 with good categories. Based on the results of the student response questionnaire analysis, it was also found that after the implementation of the module, students could understand about flood disaster mitigation by 96% with a very good category.

Therefore, it can be interpreted that students can already determine and make plans in the application of static and dynamic fluid laws in flood disaster mitigation efforts after the implementation of e-modules. Students have also been able to provide plans if they live in flood-prone areas as an effort to mitigate flood disasters. At this stage the student is considered to have been able to reach the level of analyzing (HOTS). This is in accordance with Bloom's theory, namely the analysis stage is reached if students can analyze a conclusion based on supporting evidence, combine the material into clearer components, and can find causal relationships on a problem, especially about the concepts of fluid and flooding.

4. Conclusion

E-modules are designed using the Project Based Learning (PjBL) model with a STEM approach through stages, namely: reflection, identification, research (watching, reading), discovery (analyzing, designing), application (creating, testing), and communication (reporting, presenting). The characteristics of the e-modules developed are characteristic of the products developed by researchers including: mission, competence, basic theory, basic activities, material sources and assessment characteristics. The Fluid and Flood Mitigation STEM E-Module for Class X SMK Technology and Engineering Group with a STEM approach has a validity value of 90.03%, so it is declared very feasible to use in learning. The e-module can improve students' High Order Thinking Skills (HOTS) on metacognitive skill indicators with an N gain of 0.69 in the moderate category. Based on the results of the t-test, the e-module has a high correlation value of r = 0.831 to the increase in student HOTS with an average student response score of 91.07%. After the implementation of the e-module, students can understand about flood disaster mitigation by 96% with very good categories. The Fluid and Flood Mitigation STEM E-Module is declared effective and practical to use in learning.

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