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Design of e-modules to stimulate HOTS on static fluid materials with the STEM approach

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Design of e-modules to stimulate HOTS on static fluid materials with the STEM approach

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Abstract. This study aims to develop an e-module to stimulate HOTS on static fluid material with the STEM approach. The research method uses the design of research and development (R&D) using the ADDIE model which consists of five stages, namely: analysis, design, development, implementation, and evaluation. This article reported two stages namely analysis and design. The instrument used in the form of a questionnaire of product needs analysis and practitioners' validation sheets using a *Likert scale*. Source of data for needs analysis are senior high 40 school students and 18 physics educators in Lampung. Product design validation is carried out by qualified and professional physics educators in their fields with the Masters in Physics Education category. Data were collected using Google Form and analyzed using descriptive quantitative. The results showed that an e-module to stimulate HOTS on static fluid material was very needed in the field. In conclusion, the e-module design is very suitable for stimulating HOTS and can be done at the stage of developing an interactive e-module based on STEM to stimulate HOTS of students on static fluid material.

1. Introduction
Industrial era 4.0 in the 21st century every individual is required to have high-level thinking skills to be applied in terms of building society in the 21st century. Thinking skills are very important in the educational process [1]. Meeting the demands of the 21st century, knowledge must be supported by the critical thinking ability, creatively, and the ability to apply information technology. The importance of mastering technology skills and thinking skills for students to connect concepts and materials so that they can understand and solve problems in the learning process, where a person's ability to be successful in life is determined, among other things, by his thinking ability. The skills of students must be following the competencies of the 21st century, namely creative, critical thinking, communicative, and collaborative [2]. The critical thinking ability is a high-level thinking competency or HOTS. HOTS ability is a skill that must be possessed in this 21st century which has indicators of analyzing, evaluating, and creating. However, in the field currently, there are still several weaknesses that lead to the conclusion that educators must innovate to be able to create learning conditions that can direct students to develop students' HOTS abilities [3]. In fact, in the learning process, not all students have mastered these thinking skills, presumably because the HOTS ability of each student is different and the learning resources used in the learning process have not been able to develop students' HOTS abilities or are still low, and the learning process is still low, have the character of remembering, memorizing, understanding simple and still informative so that it has not been able to improve the HOTS ability of students [4].

Based on the results of preliminary research at SMA Ar-Raihan and MAN 1 Bandar Lampung, the main problem is that educators have not used the STEM learning approach, educators have not developed E-module learning resources with the STEM approach to stimulate HOTS, educators have not stimulated higher thinking skills with the STEM approach To students on Fluid Static material, educators need e-module learning resources with a STEM approach to stimulate HOTS, students assume physics is a difficult subject, and have not maximally worked on questions that are classified as high-order thinking skills. HOTS stimulus skills can be optimized through learning resources, but the learning resources used are still informative and have not yet optimized HOTS abilities [5], [6], [7]. Among the teaching materials that are expected to stimulate HOTS are e-modules. This e-module teaching material can be used anywhere and anytime independently.

Previous research to cultivate HOTS abilities was the application of scientific-based modules [8], [9], [10]. Some of the relevant researches are growing HOTS abilities, namely the application of scientific-based modules [11]. An interactive e-book development has been developed to improve higher-order thinking skills [12]. Previous research has also developed an e-module based on project-based learning [13]. Developed an e-module that combines science process skills and motion dynamics materials [14]. Development of a scientific-based basic physics e-module to improve HOTS [15]. According to some experts, learning resources in the form of e-modules can optimize HOTS abilities [16]. As for the previous research entitled development of STEM physics module integrated local wisdom "drum" to improve the creative thinking ability of junior high school students, the results obtained from this study indicate that the module to improve creative thinking skills is suitable to be used as a companion textbook in schools [17].

E-modules are equipped with characteristics in the form of images, simulations, animations, videos, and interactive questions that support effective learning and are suitable for independent learning. E-modules help students obtain information about learning materials, the presentation of material in e-modules can be packaged in the electronic form to foster HOTS skills involving complex assessment skills such as critical thinking and problem-solving. E-modules are structured to be used by students in the learning process individually in their respective homes without reducing the meaning of the scientific approach needed in the 2013 curriculum, especially for grade 11 which still uses informative and abstract teaching materials. So that in this design an e-module with a STEM approach in learning will be developed which can be accessed via android and student laptops which can make it easier for students to understand physics learning.

The novelty of this research is from previous research and to achieve the goals of education and learning according to k-13, a preliminary study is needed on the needs of educators for appropriate learning media that can help students understand the concepts of physics, the responses of educators and students regarding the availability of media used, analysis of the implementation of learning physics at SMA Ar-Rayhan and MAN I Bandar Lampung and a valid design to create an interactive e-module.

2. Method

The research method uses the design of *research and development* (R&D) using the ADDIE model which consists of five stages, namely: *analysis*, *design*, *development*, *implementation*, and *evaluation.* Researchers report the stages of this article will only report two stages, namely the first stage of analysis and the second stage of e-module design.

The first stage is the needs analysis for e-modules. Needs analysis data is taken from 40 students and 18 educators using *Google form*. The needs analysis is carried out to get information about the real conditions in the learning process consisting of 30 questions for educators and 25 questions for students. Questionnaires for students are similar to questionnaires for educators, which contain questions about the physics learning process, the availability of e-modules, and infrastructure. The data obtained were analyzed descriptively.

The second stage is the e-module design. E-module is designed to stimulate the ability to analyze, evaluate, and create static fluid material and is designed using the STEM approach. Therefore, each learning activity is designed to contain STEM components in a static fluid material. For example, in Learning Activity 4 which aims to stimulate the ability to evaluate the hydraulic jack technology on a car lift machine, the STEM components are designed as follows.

1) Science: describes the concept of pressure transmitted in all directions equally as the working principle of the car lift jack technology.
2) Technology: Visualizing the car lift engine technology in the form of a compressor flowing and pressing the oil space that is planted underground so that the oil in the space will be pressed and pushes the piston upward so that the car will be lifted and the audio is loaded in the introduction.
3) Engineering: How the car lift jack technology works.
4) Mathematics: mathematical equation of lifting force in car lift jack technology.

Furthermore, students will be asked to evaluate the construction of the car lift jack machine which is the most profitable in terms of the effort made.

Assessment of e-module design is carried out on content components, module presentation systematics, learning activity designs, appropriateness of STEM components in learning activities, and the appropriateness of e-module designs with the STEM approach to stimulate HOTS.

The second stage is the e-module design. The e-module is designed based on the results of a theoretical study and a study of the results of previous research on an effective e-module. The design of the e-module was further confirmed for its suitability to stimulate HOTS to 14 physics teachers with master's qualifications in the field of physics education. The instrument used was a Likert scale questionnaire with five choices, namely (1) strongly disagree, (2) disagree, (3) quite agree, (4) agree, (5) strongly agree. The e-module design is given in full in the form of a file as an attachment to the assessment instrument. Design assessment instruments are provided in the form of *Google form*. The results of the assessment of respondents were analyzed by calculating the average score obtained for each component of the e-module design and then converted to a qualitative statement according to table 1.

Table 1. Assessment and Decision Score

Average Score	Decision
4,20-5,00	Very suitable for stimulating HOTS
3,40-4,19	Suitable for stimulating HOTS
2,60-3,39	Enough suitable for stimulating HOTS
1,80-2,59	Less suitable for stimulating HOTS
1,00-1,79	Not suitable for stimulating HOTS

3. Results and Discussion

The results of preliminary research based on the needs analysis obtained from the google form filled in by educators in Lampung province can be observed in Table 2, which shows that K13 has been applied in the learning process as seen that all educators filled out the google form with a statement that they have used K.13, will but the application of K.13 has not been fully implemented in the learning process while the obstacles include time and media. Educators have not used the STEM learning approach [19]. Educators have not developed E-module learning resources with a STEM approach to stimulate HOTS [20]. Educators have not stimulated higher-order thinking skills with the STEM approach to students on Static Fluid material. Educators need E-module learning resources with a STEM approach to stimulate HOTS, so it is hoped that the e-module design will later be able to overcome some of the problems above. Therefore, all educators agreed to develop e-module static fluid material.

Table 2. Results of the educator's need analysis

No	Statement Analysis
1.	100% of Educators have implemented the K 13 revision in schools.
2.	88,9% Educators provide questions that contain higher-order thinking skills.
3.	100% Educators provide opportunities for students to find information with friends when discussing, exchanging ideas, looking for other sources in increasing the critical thinking ability of students, communicating physics material, solving problems in their way, carrying out experiments, displaying the results of experiments in class, and completing experiments with the concept of Physics.
4.	63,9% Educators give students the opportunity to analyze the problems given during learning.
5.	100% Educators use a scientific approach to learning.
6.	66,7% Educators use media in learning.
7.	100% Educators apply fun physics learning.
8.	72,2% Educators already have *e-module* based learning resource infrastructure.
9.	88,9% Educators have heard about e-module based learning resources.
10.	27% Educators have used the STEM learning approach.
11.	27,8% Educators have developed *e-module* learning resources with the STEM approach to stimulate HOTS.
12.	100% Educators need *e-module* learning resources with the STEM approach to stimulate HOTS.
13.	94,5% Educators are willing to apply *e-module* learning resources with the STEM approach to stimulate HOTS.
14.	100% Educators hope that *e-module* learning resources using the STEM approach can be used in the learning process.
15.	100% Educators are interested in using varied learning resources.
15.	88,9% Educators deliver Static Fluid material thoroughly.
17.	83,3% Educators provide experiments on Static Fluid material.
18.	33,3% Educators use *e-modules* when learning Static Fluid material.
18.	82% Educators provide questions related to higher-order thinking skills in learning Static Fluid material.
20.	27% Educators have stimulated higher-order thinking skills with the STEM approach to students on Static Fluid material.

Table 3. Results of student's need analysis

No	Statement Analysis
1.	62,5% Students stated that they liked Physics.
2.	67,5% Students state physics is a difficult subject.
3.	35% Students feel that learning physics is boring.
4.	35,2% Students feel lazy to learn physics.
5.	51,2% Students will give up if the physics problem given is too difficult to solve.
6.	47,5% Students can work on questions that are classified as high-level thinking skills.
7.	97,5% Students are given the opportunity to look for information with friends when discussing.
8.	95% Students are given the opportunity to exchange ideas and discuss them.
9.	92,3% Students are given the opportunity to analyze the problems given by physics educators while learning.
10.	94,9% Students are given many opportunities by physics educators to find other sources and communicate the results of the discussion.
11.	87,1% Students are given the opportunity by physics educators to solve problems in their own way.

12. 95% Students are given the opportunity to conduct experiments in physics.
13. 85% Students are given the opportunity by physics educators to display their work in the classroom.
14. 90% Students are given the opportunity by physics educators to complete experiments using physics concepts.
15. 87,5% Educators use interesting physics learning resources.
16. 95% Educators always do physics learning by linking science, technology, engineering, and mathematical engineering.
17. 92,5% The concepts of physics learned can be applied to Science, Technology, Engineering, and Mathematical Engineering.
18. 80% Physics concepts that I learned can be applied in everyday life.
19. 95% Physics learning will be effective when using interesting *e-module* learning resources.
20. 87,5% Students are interested in the *e-modules* used when learning Physics.
21. 94,8% Students feel confident that learning Physics using *e-module* learning resources will be interesting.
22. 35% Students feel that Static Fluid material is boring.
23. 90% Students agree if physics lessons especially Static Fluid material is presented with *e-module* learning resources.
24. 87,5% Students can understand Static Fluid material if using an interesting *e-module*.

Based on table 3 it can be analyzed that students assume physics is a difficult subject, and have not maximally worked on questions that are classified as high-order thinking skills, this finding is following the results of previous studies [20]. Students agree that physics lessons, especially static fluid material, are presented with E-module learning resources. Therefore, researchers consider it important to design e-modules that are valid, effective, and practical, so that they can make physics learning more interesting and able to stimulate students' HOTS. The results of the assessment of the e-module design are presented in table 4.

Table 4. Result of the e-module design assessment

No	E-module Design	Average Score
1.	Content	
	Analyzing hydrostatic pressures, the concepts of Pascal law and Archimedes' law, capillarity and viscosity.	4,00
	Evaluate the technology of hydraulic jacks for car lifters and blimps.	4,50
	Creating simple practical tools regarding the law of Archimedes on submarines.	4,33
2.	Systematics	
	Cover, Foreword, Table of Contents, Pictures List, Table List, E-Module Usage Guide, Basic Competencies and Indicators, Learning Objectives, Concept Maps, Introduction, Learning Activities 1 to 6 (Contains Objectives, Subject Materials, Study Instructions, Display, Presentation of Material, Summary, Formative Tests, Reflections), Summary, Summative Evaluation, Bibliography.	4,17
3.	Learning Activities	
	Analyzing hydrostatic pressures, concepts of Pascal law and Archimedes law, capillarity and viscosity (KB 1, KB 2, KB 3).	4,33
	Evaluate the technology of hydraulic jacks for car lift machines, blimps (KB 4, KB 5).	4,33
	Creating simple practical tools regarding the law of Archimedes on submarines (KB 6).	4,33
4.	STEM	
	Suitability of STEM components in each learning activity.	4,17
5.	Feasibility	
	The feasibility of e-module design with the STEM approach to stimulate HOTS.	4,50

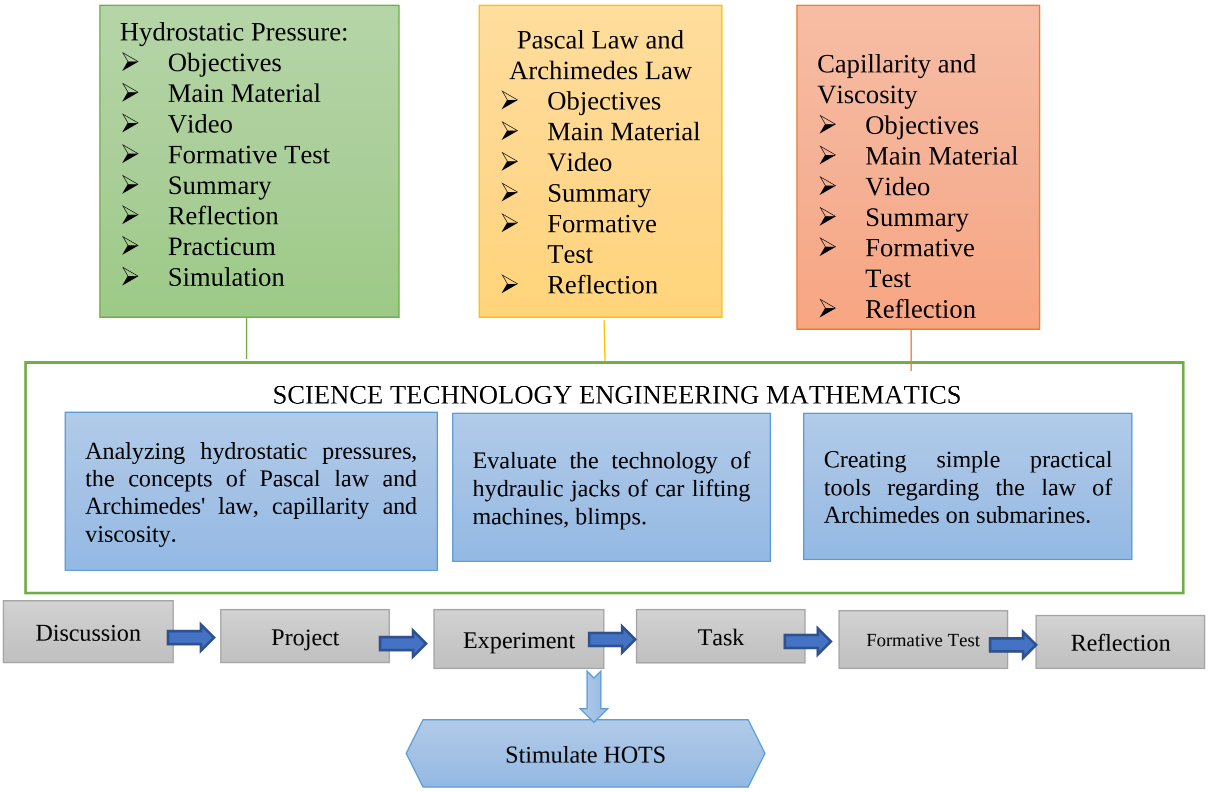

Figure 1. Diagram of e-module design

The results of the assessment of the e-module design showed that all components assessed scored above 4.20. With reference to Table 1, the e-module design is declared to be very suitable and can be used to stimulate HOTS on static fluid material.

E-modules that can be accessed by students have different benefits and characteristics. If viewed from the benefits of electronic e-modules can make the learning process more interesting, interactive, can be done anytime and anywhere and can improve the quality of learning [21]. Through videos and animations can facilitate students in understanding abstract concepts in static fluid concepts and can be used individually. Suggestions from some experts that: Overall the design has been systematic but there are some things that need to be improved namely the identity of the e-module (for what class and what level of education, adjusting Basic Competence to the objectives All objectives must answer the Basic Competence that has been presented. Therefore, it is necessary to strengthen in exploring the basic mathematical abilities of students so that it will be easier for educators to guide students in applying the existing equations in the material and work on HOTS questions. Based on the results of the design assessment, an e-module design chart is made as shown in Figure 1.

Apart from prioritizing the content of the material, this e-module also prioritizes its appearance. The point is to make students interested in using e-modules. Through the e-module students can learn in a fun way and acquire new skills, interesting, and not only contain interactive buttons but also contain simple material and videos in the hope of being able to improve students' reading performance and stimulate HOTS student.

The data from the design validation are following the success of previous research on teaching materials with the STEM approach in improving students' conceptual understanding and problem-solving in a dynamic fluid material, while the results of the study show that teaching materials with the STEM approach can improve conceptual understanding and problem-solving and skills in the dynamic electricity material [22].

4. Conclusion

Based on the data from the results of the preliminary study, it can be concluded that the development of e-modules with the STEM approach is needed to foster the HOTS abilities of students on static fluid material and validation data, namely e-module design is very suitable to stimulate HOTS and can be done at the development stage of interactive STEM-based e-module to stimulate HOTS of students on static fluid material. Future research needs to be considered and prepared to increase responses so that the data collected will be even better and more valid. Then examine parts of other broader materials such as physical optics, thermodynamics, and others in further research so that problems in physics material can be resolved properly.

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