Development of STEM Based e-Module Using Flip PDF Corporate on Energy Conservation Law Materials

Dwi Sulistyaningsih, Rifa'atul Maulidah and IfaRifatul Mahmudah
Physics Education, Siliwangi University, Siliwangi Street No. 24, Tasikmalaya 46115, Indonesia

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Abstract: This study aims to develop a STEM-based e-module on energy conservation law. This research uses the Research and Development (R&D) method with a 4D development model. The 4D development model consists of four main stages: define, design, develop, and disseminate. The evaluation of validators comprised of media and material experts carried out this research to the build stage. The Data collection techniques are through interviews; the student needs analysis and validation questionnaires from media and content experts. The results showed that the percentage of product value based on media experts was 94.91%, with valid criteria covering aspects of appearance, presentation, and quality of supporting media. The product value based on material experts is 95.00%, with valid criteria, including parts of the suitability of practicum objectives with learning outcomes, clarity of practicum series, and STEM components. Thus, the STEM-based e-module on the energy conservation law material has met the valid criteria for teaching materials in practical activities.

1 INTRODUCTION

Education is the most crucial aspect of the development of a country because education aims to prepare quality human resources to face challenges in the 4.0 industrial revolution era(Syahirah et al., 2020). Education that is held must be able to improve the quality of one's self in order to be able to adapt to advances in the field of technology which is increasing rapidly(Sari, 2020). The creation of intelligent, responsible and adaptive human beings to the development of the times can be realized through education, in particular through science learning. Science learning aims for individuals to have mastery of the basics of science followed by mathematical abilities. Mastery of the basics of science and mathematics can be obtained through learning using the STEMapproach(Zulaiha & Kusuma, 2020).

STEM is an approach that integrates science, technology, engineering and mathematics in the learning process. The application of technology is a supporting tool to help students understand the concepts being studied. The application of the technique aims to train students to design, assemble, draw, and do other activities so that students understand the procedures for solving problems. Furthermore, mathematics aims to simplify the concept of science itself more systematically and mathematically(E. Susanti et al., 2021). Applying STEM to learning can encourage students to design, develop and utilize technology and apply knowledge(A. Susanti, 2020).

Accuracy in choosing the presentation method or approach is the key to success in actualizing the learning outcomes that have been formulated(A. Susanti, 2020). In addition to the choice of approach, the quality of learning and the achievement of learning objectives are also influenced by the use of teaching materials(Arisya et al., 2021). One of the teaching materials that educators can develop is a module. A module is a teaching material that is systematically arranged in a language that is easily understood by students according to their level of knowledge and age so that they can learn on their own (independently) with minimal assistance or guidance from educators(Prastowo, 2012). Technological advances have developed the print module into an electronic module (e-module). E-module is an embodiment of multimedia-based teaching materials. E-modules were born due to teaching materials integrated with technological advances(Pratiwi, 2021). E-modules can be developed on a STEM basis. STEM-based e-modules are electronic learning

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modules that integrate related disciplines. The use of STEM-based modules in learning can build professional characters who have skills, good time management, work with colleagues, use technology and effective ways to solve a problem being discussed (Syahirah et al., 2020).

The law of conservation of energy in this study describes the conservation of mechanical energy. The law of conservation of mechanical energy explains that an object's total mechanical and potential energy at any point is always constant. The magnitude of the mechanical energy at any point is sometimes constant due to the influence of non-conservative forces acting on objects(Sulistyaningsih et al., 2022). The amount of mechanical energy that is not constant due to non-conservative forces is a discussion that needs further study by students in learning. Proof of the law of conservation of energy can be done by using a mini roller coaster.

The mini roller coaster is a prototype designed to resemble the trajectory of a roller coaster ride(Maulidah et al., 2022). This tool has been successfully designed in the fundamental physics laboratory, but the module for using this tool in learning fundamental physics has yet to be available. Therefore, the researchers took the initiative to develop a STEM-based e-module on energy conservation law. In developing the e-module, researchers will use the software flip PDF corporate. This software is easy to use, with the appearance of publishing as a flip (back and forth) like an actual book.

2 METHOD

This study uses the Research & Development (R&D) method. In this study, the crucial target is developing STEM-based e-modules on energy conservation law materials to be used in fundamental physics courses. This study used a 4D model consisting of four main stages: define, design, develop and disseminate. This research is limited only to the development stage. The activities carried out at each stage of development are described as follows.

2.1 Define

The define stage is a stage that aims to determine and define the needs in the development process. This stage is often called a needs analysis. In the context of developing teaching materials in the form of e-modules, the definition stage is carried out by:

2.1.1 Curriculum Analysis

Curriculum analysis is carried out by reviewing the curriculum documents used by the study program so that the curriculum needs develop teaching materials.

2.1.2 Formulate Learning Objectives

Learning objectives need to be formulated to limit the extent to which teaching materials will be developed.

2.1.3 Analysis of Student Needs

Analysis of students' needs for teaching materials in the form of e-modules needs to be done to determine whether development needs to be carried out based on the needs of students. Student needs are analyzed by distributing questionnaires to students who have contracted fundamental physics courses.

2.2 Design

The design stage aims to produce a prototype that will be made. The activity carried out at the design stage is to outline the e-module that will be developed.

2.3 Develop

The Develop stage is the development stage of the outline made at the design stage. After the product has been successfully created, it is then evaluated by a media and material expert validator. Validation is done by giving a questionnaire to the validator to assess the product developed according to the Likert scale, which consists of four categories, namely: Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD). In addition to providing an assessment, validators are also asked to provide suggestions to produce even better products. The assessment results from the validator are then presented using equation (1).

$$P(\%) = \frac{\sum x}{x_m} \times 100\% \quad (1)$$

With:

P = average value (in%)

$\sum x$ = total score

x_m = maximum score

The calculation results are then interpreted based on the table of product validity criteria presented in Table 1.

Table 1: Product Validity Criteria.

Percentage (%)	Category
81 – 100	Very high
61 – 80	High
41 – 60	Moderate
21 – 40	Low
0 – 20	Very low

(Riduwan, 2010)

3 RESULTS AND DISCUSSION

The product of this research is a STEM-based practicum e-module on the law of energy conservation. In developing this e-module, the steps taken by the researcher are as follows.

3.1 Define

In the define stage, the researcher performs several activities to determine and define the needs in the development process. These activities are curriculum analysis, formulating learning objectives, and analyzing students' needs for practicum e-modules. The analysis results are used as a reference in the development of STEM-based e-modules on the law of energy conservation.

3.1.1 Curriculum Analysis

In the curriculum analysis stage, the researcher reviewed the curriculum document in the form of the Syllabus for the Basic Physics I course used in the Department of Physics Education, FKIP, Siliwangi University. As a form of confirmation regarding the contents of thedocument, the researcher also conducted interviews with the lecturers in charge of the courses. The results of the selected Sub-CPMK curriculum analysis are Sub-CPMK-5; namely, students can comprehensively identify the concept and application of business and energy. Students are expected not only to understand concepts but also to be able to use the concepts learned to solve problems related to everyday life. Support is needed in the form of hands-on and contextual learning methods.

3.1.2 Formulate Learning Objectives

The learning objectives to be achieved through practicum activities using STEM-based e-modules on the law of energy conservation consist of goals from knowledge and skills aspects. From the aspect of knowledge, the learning objectives to be achieved are that students can apply the concept of work and energy to solve problems related to energy conservation law on mini roller coasters. From the skill aspect, students can design practicums to solve problems related to the motion of objects on a roller coaster trajectory.

3.1.3 Analysis of Student Needs

Analysis of student needs for STEM-based practicum e-modules on the law of conservation of energy is carried out by distributing questionnaires to students who have contracted Basic Physics courses. The questionnaire consists of 3 parts: an analysis of the use of practicum modules in general, an analysis of the use of practicum modules on the law of conservation of energy, and an analysis of the usefulness and components of the module. The questionnaire consists of 17 questions, with details of 16 questions being fixed responses and one other question being an open question. The number of respondents to the questionnaire is 80 students. Based on the results of the needs analysis that has been carried out at the define stage, a practicum e-module is needed to help guide the practice of the law of conservation of energy with the following specifications: (1) The module is solving practical problems and only contains guiding questions so that students can solve and design own practicum, (2) Integrate technological advances (software) to help analyze the physics data of the practicum results (3) Have an attractive design and contain various representations (video, images, text, animation, etc.), (3) Easy to access using a PC or mobile and does not require ample storage space.

3.2 Design

At the design stage, the researcher outlines the e-module that will be developed. The outline of the STEM-based e-module on energy conservation law material consists of a Cover, Preface, Table of Contents, Description of the Practicum Module, Instructions for the use of the Module, Graduate Learning Outcomes, Course Learning Outcomes, Course Learning Sub-Achievements, Learning Objectives, Real World Problems, Tools and Materials, Exploration, Conclusions, and Bibliography. The module outline or writing plan containing a module's outlines is then developed at the development stage.

3.3 Develop

The development stage aims to produce a STEM-based e-module on the material of the law of conservation of energy that is valid and practical. However, the research achievements reported in this progress report have only reached the stage of validator evaluation. In contrast, trials for students to see the practicality of e-modules have yet to be carried out.

The development stage is done by developing the module outline that was prepared at the design stage. The outline was developed in Microsoft Word, which will later be converted to PDF format and flipped using Flip PDF Corporate software. The cover display of STEM-based e-modules on the law of conservation of energy can be seen in Figure 1.

Figure 1: The cover display of STEM-based e-modules.

The validator then evaluates the product that has been developed. The validator consists of media experts and material experts.

3.3.1 Product Validation Results by Media Expert Validators

Three media expert validators validated the developed e-module with an instrument in the form of a questionnaire. The questionnaire for product assessment in terms of media consists of 3 aspects, namely appearance, presentation, and quality of supporting media, which are translated into ten statements. The results of the media expert validation are presented in Table 2.

Table 2: Media Expert Validation Results.

No	Assessment Aspect	Total Score	Max Score	Percentage (%)
1.	Appearance	32	36	88.89
2.	Presentation	36	36	100
3.	Supporting media quality	46	48	95.83
Final Score Overall Media Expert Validation (%)				94.91

In Table 2, the percentage of the final value of the overall media expert validation is 94.91%, with very high interpretation criteria.

3.3.2 Product Validation Results by Material Expert Validators

Three material expert validators has validated the developed e-module with an instrument in the form of a questionnaire. The questionnaire for product assessment in terms of the material consists of 3 aspects, namely the suitability of practicum objectives with learning outcomes, clarity of practicum series, and STEM components, which are translated into 11 statements. The results of the material expert validation are presented in Table 3.

Table 3: Material Expert Validation Results.

No	Assessment Aspect	Total Scores	Max Score	Percentage (%)
1.	Conformity of practicum objectives with learning outcomes	24	24	100
2.	Explanation of the practical circuit	56	60	93.33
3.	STEM Components	44	48	91.67
Final Score Overall Media Expert Validation (%)				95.00

In Table 3, the percentage of the final value of the overall material expert validation is 95.00% with very high interpretation criteria.

The research product in the form of a STEM-based practicum e-module has been successfully developed through this research. The developed products are categorized as valid for use in learning activities based on the assessment of media and material experts. Media experts provide assessments related to three aspects, namely appearance, presentation, and quality of supporting media, each of which meets valid criteria. From the appearance aspect, the design, colour composition, and appearance of the letters are appropriate and attractive. The presentation aspect gets the maximum percentage, meaning that the e-module is presented wholly and systematically to facilitate the achievement of learning objectives. The next aspect of the media expert's assessment is the quality of the supporting media. Supporting media here include pictures and videos so that they are multi-representative to support students in solving the

problems presented. In addition to assessments from media experts, there are also assessments from material experts covering three aspects: the suitability of practicum objectives and learning outcomes, clarity of practicum sequences, and STEM components, which also receive assessments with valid criteria.

The aspect of conformity of practicum objectives with learning outcomes gets the maximum rating from the validator. This means that the practicum objectives in the e-module are by the learning outcomes to be achieved and have been formulated at the defining stage. The next aspect is the practical aspect. The practicum series is presented by considering the complexity of the problems and their suitability for application at the higher education level. To support problem-solving, the e-module is equipped with a video that presents real-world problems and illustrated images adapted to the existing concepts in the material on the Law of Conservation of Energy. The e-module is made so that students can design their practicum to reach solutions to the problems to be solved so that the questions presented at the exploration stage are constructed correctly and correctly according to the concepts in the Law of Conservation of Energy material. The third aspect is the STEM component aspect. The e-modules developed for practicum activities have facilitated aspects of science, technology, engineering, and mathematics in the STEM approach presented in the practicum series.

This research has only reached the stage of testing the validity level of the developed media. Follow-up is needed from this research, namely to determine the level of practicality of the developed media. A practicality test is needed to see whether the media developed meets students' needs and the desired product specifications based on the results of the media development needs analysis (Wulandari et al., 2022). In addition to validity and practicality, this media also needs to be implemented in learning to see the effectiveness of the media being developed so that it can have a good influence on learning. These influences include increasing problem-solving abilities, creative thinking abilities and students' understanding of concepts (Zulaiha & Kusuma, 2020).

4 CONCLUSIONS

Based on the results of the research that has been carried out, it can be concluded that:

1) The STEM-based practicum e-module on the law of energy conservation has been successfully developed through the 4D development method. The steps taken to produce a research product in the form of an e-module are defined, designed, and develop (up to the evaluation stage of the validator).
2) The validity of the STEM-based practicum e-module on the conservation of energy law material based on media experts gets a percentage of 94.91% with valid criteria covering aspects of the display, presentation, and quality of supporting media. Based on the material expert, the validity of the e-module gets a percentage of 95.00% with the criteria of valid, covering aspects of the suitability of practicum objectives with learning outcomes, clarity of practicum series, and STEM components.

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