Viability Analysis of the Development of STEM-Integrated Module on Alternative Energy Topics

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Abstract - *The study aims to determine the feasibility that STEM-based physics modules on alternative energy topics. The method used in this research is Research and Development with a 4D development model (Four-D Models). The validity test was conducted by two lecturers of the Master of Physics Education at the Indonesian University of Education and one physics teacher at a senior high school in Karawang. Readability test conducted by 7 students of grade x. The instruments used are material conformity instruments with STEM aspects, teaching material feasibility test instruments, and student readability sheets. Based on the results of the study, it can be concluded that the STEM-based physics module on the topic of alternative energy developed is feasible because it obtains valid criteria in each validation category, including the component of material suitability with STEM, 0.8 is categorized as Valid. In the feasibility component of teaching materials (modules), 0.79 is categorized as Valid. In the presentation component, 0.79 is categorized as Valid. In the linguistic component, 0.8 is categorized as Valid. Meanwhile, the readability test results conducted were at a high criterion of 86.43%. Thus, the development of STEM-based physics modules on alternative energy topics is "feasible" to be widely applied.*

Keywords*: Alternative Energy; Integrated Module; STEM; Viability Analysis*

INTRODUCTION

Integrating science with other fields of learning has been carried out by several developed countries, namely by developing STEM (Science, Technology, Engineering, And Mathematics) education (National Research Council, 2012; Next Generation Science Standard, 2013; OECD, 2016). OECD (2013), White (2014), and Winarni et al. (2016) states that STEM education can support critical thinking skills that will make learners solve problems creatively so that they are beneficial to their world of work. STEM learning will indirectly require learners to think critically in solving problems and be able to find the right solutions according to the problems they face (Balka, 2011; Bybee, 2013; Suwarma et al., 2015).

Cobb (2003) and Opera & Nkasiobi (2011) said that teaching materials are learning resources in the form of visual and audiovisual that can be used as alternative channels for communication in the learning process so that interaction between teachers and students occurs, both visually and audiovisual. In the Independent Curriculum, learning planning is called a teaching module. Teaching modules are learning tools or facilities containing material, learning methods, limits, and ways of evaluating learning activities that have been designed systematically and interestingly to help achieve the expected competencies. Research on learning modules to improve STEM literacy has been carried out by Rahdiyanta (2016), Utami (2019) and Harpian (2023) who conducted research on the development of STEM-based modules to improve students' STEM literacy and it was found that STEM-based modules provide increased knowledge of students.

The module is a form of teaching material that is packaged as a whole and

systematically, where the module contains a set of planned learning experiences and is designed so that students master the complete learning objectives (Mahadiraja & Syamsuarnis, 2020). Meanwhile, Santrock (2009) and Gufron & Suminta (2010) said that the learning module is the smallest unit of teaching and learning programs learned by students themselves either individually or taught. So it can be concluded that modules are subject matter logically, sequentially, and regularly, guiding students through content and assessment to achieve the expected learning goals during the learning process.

Each discipline in STEM will add color to the modules developed, making it easier for students to understand the concepts conveyed and the learning process becomes more meaningful by the demands of the independent curriculum. With various activities arranged in the module, it is hoped that it will train students' STEM literacy skills.

RESEARCH METHODS

The methods used in this study are Research and Development with a 4D development model (Four-D Models) adopted from Thiagarajan et al. (1974). Research and development methods (Research and Development) is a research method that uses steps to produce certain products and test the effectiveness of these products (Sugiyono, 2017). Research and Development (R&D) is a research method used to design new products and procedures that are field-tested and refined to meet certain criteria (Borg & Gall, 2003). In this study, the product in question is teaching materials in the form of STEM-based physics modules to train STEM literacy in alternative energy materials (Tati, 2017).

The 4D development model consists of 4 main stages, namely: Define, Design, Develop and Disseminate. However, this research is limited only to the development phase. The stages of development research according to Thiagarajan et al. (1974) consist of Define, Design, and Development.

Based on Figure 1 Define, contains activities to determine what products will be developed, along with their specifications. This stage is a needs analysis activity, which is carried out through research and literature studies. Design contains activities to design a predetermined product. Development consists of making designs into products and testing product validity repeatedly until the product is produced to the established specifications. The validity test was conducted by two lecturers of the Master of Physics Education at the Indonesian University of Education and one physics teacher at a senior high school in Karawang. Readability test conducted by 7 students of grade x. The instruments used are material conformity instruments with STEM aspects, teaching material feasibility test instruments, and student readability sheets.

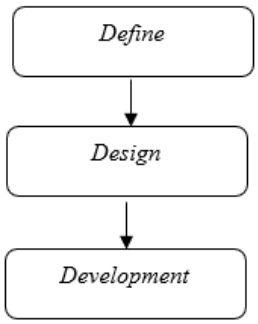

Figure 1. The DBR with a 4D model that is modified into 3D.

Data analysis techniques from validation results against STEM-based modules that have been developed using Aiken validation techniques.

$$V = \frac{\sum s}{|n(c-1)|} \quad (1)$$

Table 1. Eligibility Criteria for Research Results

Achievement Level	Qualification
0.00 – 0.11	Not worth using
0.12 – 0.20	Worth using with certain considerations
0.21 – 0.35	Worth using
0.36 – 1.00	Very worth using

(Djatmiko et al., 2018)

From the results obtained, the data that was originally in the form of quantitative percentages was changed to descriptive qualitative (Cresswell, 2018). The quality of product eligibility (module) can be determined by the following validation eligibility criteria.

a) Module Comprehension Test Analysis

The module comprehension test aims to find out whether the STEM-based modules used already use language that can be understood and understood by users or not. The comprehension test of this module was carried out using questions according to Sinaga et al. (2021) which consisted of four parts, namely: (1) the main idea of discourse; (2) details supporting the discourse that supports the main idea; (3) words that are not understood and (4) sentences that are difficult to understand. The data obtained were processed using the Guttman scale. The Guttman scale can not only be made in the multiple-choice form but can also be made in checklist form, where answers can be made with the highest score of one and the lowest zero. This instrument if students understand will be given point 1, while students who do not understand are given point 0 which will then be analyzed using percentage values, as follows.

$$\text{Percentage value(p)} = \frac{\text{Total score given}}{\text{Overall score}} \times 100\% \quad (2)$$

After obtaining the results, then interpret the understanding of modules with classification based on criteria according to Rankin & Culhane (1969) according to the Table 2.

Table 2. Module Comprehension Interpretation Criteria

Percentage	Criteria
$0 < x \leq 40$	Low
$40 < x \leq 60$	Keep
$X > 60$	High

RESULTS AND DISCUSSION

The procedure in this study was carried out according to the steps of the 4D model as follows.

1. Define

At this stage, an analysis of the curriculum that is being used, namely the independent curriculum, is also carried out observations to schools to analyze the needs and obstacles of schools in implementing the independent curriculum, especially in physics subjects.

2. Design

Based on curriculum analysis and obstacle analysis in schools, the design of learning tools in the form of draft 1 was carried out. The initial step of developing the module is to collect references and design the initial design of the module. At this stage, develop instruments such as STEM literacy instruments, knowledge aspects, and STEM literacy questionnaires, attitude aspects. Then the instrument is validated by experts.

3. Development

The initial design of the module at the design stage is validated by experts, namely physics lecturers and teachers revising according to direction and input, the revision results are in the form of draft 2. Draft 2, namely the results of revisions, is tested for the understanding of the module students.

After revision based on the results of understanding, it produces a draft 3. At this stage, a pretest is carried out to measure STEM literacy skills and take questionnaire data. Implementation of modules that have been prepared (draft 3). Then a posttest was conducted measuring STEM literacy skills after module implementation.

The validity test was conducted by two lecturers of the Master of Physics Education at the Indonesian University of Education and one physics teacher at a senior high school in Karawang. The validity test aims to determine the level of validity of the module measured based on the validator's assessment. The results of the validator assessment are shown in Table 3.

Table 3. Table of analysis of module validation results by experts

Component	Validation	Category
Material and STEM Compatibility	0.8	Valid
Feasibility Test of Teaching Materials (Module)	0.79	Valid
Penyajian	0.79	Valid
Language	0.8	Valid

In the component of material conformity with STEM, 0.8 is categorized as Valid. In the feasibility component of teaching materials (modules), 0.79 is categorized as Valid. In the presentation component, 0.79 is categorized as Valid. In the linguistic component, 0.8 is categorized as Valid.

Table 4. Readability test table by students

Sample	Score max	Percentage (%)		Criteria
		Understand	Don't understand	
7	20	86.43	13.57	High

The readability test aims to find out whether STEM-based physics modules already use language that users can understand or not. Readability results can be seen in Table 4.

Based on the results in Table 4, it can be seen that the results of the readability test conducted by 7 grade x students are at a high criterion of 86.43%. While the percentage of students who do not understand is 13.57% on low criteria. Variations in students' understanding of reading modules can come from the individual abilities possessed by each student.

CONCLUSION

Based on the results of the study, it can be concluded that the STEM-based physics module on the topic of alternative energy developed is feasible because it obtains valid criteria in each validation category, including the component of material suitability with STEM, 0.8 is categorized as Valid. In the feasibility component of teaching materials (modules), 0.79 is categorized as Valid. In the presentation component, 0.79 is categorized as Valid. In the linguistic component, 0.8 is categorized as Valid. Meanwhile, the readability test results conducted were at a high criterion of 86.43%. Thus, the development of STEM-based physics modules on alternative energy topics is "feasible" to be widely applied.

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