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[Research Article]

E-MODULES BASED ON MULTI-REPRESENTATIONS ON NEWTON'S LAW MATERIALS

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ABSTRACT

Electronic modules (e-module) are independent study materials in electronic format by utilizing various media and interactive features as well as learners' learning experiences and supports the presentation of physics teaching materials in the form of multiple representations. However, the availability and use of multiple representation-based e-modules is still limited, given the importance of learning resources and multiple representations so this research conducts a multi-representation-based e-module preparation on Newton's Law material. The research method used is R&D with an adaptation development model of the 4D development model which is carried out through the Define, Design, and Develop stages. The e-module product that has been compiled is validated by four experts and 15 students as initial users. The results of the validation analysis show that the e-modules are qualified properly in the aspects of content, media and multiple representation. In the developmental testing, a positive response was obtained and the results showed that the readability of the e-module was high with a reading of 88.65%, meaning that the e-module could be used independently. Based on the results of this study, an e-module based on multiple representation on Newton's Law material was produced with good reviews from experts and students.

Keywords: E-module, multi-representations, Newton Law's, R&D, 4D development model

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1. INTRODUCTION

Learning resources are one of the learning tools that support learning success. Learning resources are defined as anything that can support the learning process. It is explained in Permendikbud No. 22 of 2016 that learning can be based on various learning sources. Learning resources can be in the form of books, printed or electronic media, natural surroundings and other relevant learning resources. Physics learning generally uses textbooks as the main learning resource (Jhangiani et al., 2018). Textbooks in general have characteristics that emphasize the presentation of teaching materials, tend to be informative and not programmed for independent learning (Bao & Koenig, 2019; Burkholder et al., 2020). These characteristics are a weakness for textbooks as learning resources. This is not relevant to 21st century learning which emphasizes student learning activities.

The selection of learning media as a source of independent learning can motivate students to study independently and enrich the learning experience of students (Puspitasari, 2019; Stathopoulou et al., 2019). The use of media in learning can also clarify the presentation of information (Mushlihah et al., 2018). One of the media with characteristics that can be used as a source of independent learning is a module.

The module is an independent learning package that includes a series of learning experiences that are planned and systematically designed to help students master the learning competencies that have been determined (Cukurova et al., 2018; Dewi & Primayana, 2019). The use of modules provides better planned activities and can be used as a guide for students in independent learning activities (Doody & Artemeva, 2022).

Based on the learning principles in Permendikbud No. 22 of 2016 which emphasizes the use of ICT to improve learning success and the behavior patterns of students during online learning who tend to actively use digital media to obtain information compared to print media, it becomes a potential development of electronic modules (e-modules) as a learning resource (Chen et al., 2019; Wan & Niu, 2018).

The use of electronic modules as physics learning media is very effective in increasing students' learning motivation, and improving student learning outcomes (Puspitasari, 2019). In order to the use of e-modules as a learning resource is one of the innovations in physics learning, which can be used to facilitate online learning during the Covid-19 pandemic.

E-module as a learning media cannot be separated from the concept of physics as the main component. Characteristics of physics as a natural science that studies matter and energy that is abstract, the presentation of physics concepts needs to be considered so that the developed e-module can works as an independent learning medium. The presentation of a physics concept will be better when the concepts are presented using various types of representations (multi-representation). A multi-representation approach in presenting physics learning can serve as complementary information, limiting interpretation and building understanding (Ainsworth, 2006). A physics concept will be clearer when presented in various representations (Gebre, 2018). By presenting various representation formats in learning a physics concept, it provides a fairly good opportunity for students to understand the concept and communicate it, as well as how they work on a physical system and process a particular physics concept (Maknun, 2020). This is in line with Ismet's opinion (in Sari, 2018) which suggests that a productive strategy in teaching physics is to provide various representations of a physical process, in the form of words, pictures or sketches, diagrams, graphs, and mathematical equations (Campos et al., 2020; Farheen & Lewis, 2021).

The use of multi-representations is also important in physics learning to facilitate students with different intelligence backgrounds to understand a physics concept (Mardatila et al., 2019). Each student has different abilities, there are students who are able to understand physics material when given a verbal explanation or only pictures, but there are also some students who are only able to understand physics material after being given a verbal explanation and pictures (Muliyati et al., 2019). This shows that if a concept is expressed in a single representation format, then it is possible that only some students can understand it (Chusni et al., 2020). So that the use of multi-representations must always exist in physics learning (Chusni et al., 2022; Van Meter et al., 2020) including learning Newton's Laws. Therefore, multi-representation can be used as a solution in learning Newton's Law material.

However, learning resources and multi-representation in physics learning need for a multi-representation-based physics e-module on Newton's Law material. Therefore, in this study, the authors took the title "E-modules Based on Multi-representations on Newton's Law Materials", with the aim of developing multi-representation-based E-modules that can be used as teaching materials in physics learning materials, especially on Newton's law materials.

2. RESEARCH METHODS

Research and Development (R&D) are used as research method in this work, with the development model adapting the 4D development model developed by Thiagarajan in (Wardani et al., 2019). The 4D model stands for the four stages in this development model, namely Define, Design, Develop and Disseminate. However, in this study, the preparation of e-modules was limited to the Develop stage with validity activities by academics and expert practitioners, and trials were limited to 15 high school students. The research procedures carried out are shown in Figure 1

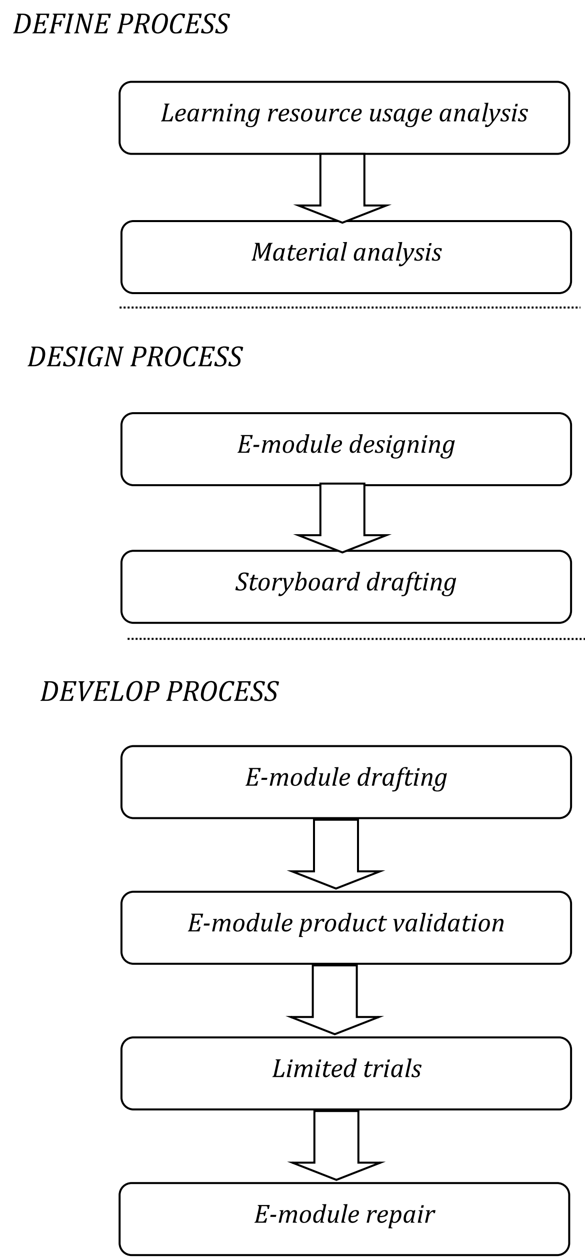

Figure 1. Research Procedure

2.1.1 Analysis of the use of learning resources.

A questionnaire distribution via Google form to collect information. The results obtained are in the form of percentage data at each questionnaire point of the use of learning resources, which are then analyzed and interpreted as a profile of learning resources used in learning physics in schools.

2.1.2 Analysis of learning resource needs.

This process conducts by using a questionnaire distribution via Google form. The results obtained are in the form of percentage data at each point of the questionnaire on learning resource needs which are then analyzed and interpreted as a profile of multi-representation-based learning resource needs in physics learning.

2.1.3 Material analysis

This process carried out by using a questionnaire distribution through Google forms and document review. The results obtained are based on the analysis of the questionnaire distribution data in the form of a learning constraint profile on Newton's Law material. Document analysis collect information of core competencies, basic competencies, and subject matter used as a reference in determining the breadth of the material, compiling indicators, and determining multi-representation content.

2.2 Design

At this stage, a multi-representation-based e-module product design is carried out on Newton's Law material, with the following activities:

2.2.1 Drafting of e-modules

This stage carried out with activities to determine the scope of the material, activities to formulate indicators of achievement of competence (GPA), mapping the use of multi-representation and content presentation. This results in a multi-representation-based e-module draft.

2.2.2 Storyboarding

This process carried out as an illustration of the layout of the e-module to be compiled. Serves as a reference so that the developer of the e-module product is well planned.

2.3 Develop (Development)

This stage is carried out as a realization of the multi-representation-based e-module design on Newton's Law material, with the following activities:

2.3.1 Preparation of e-modules

This Process carried out by developers based on drafts and storyboards that have been made in a software and converted into HTML format so that they can be accessed online. The result of this activity is an initial e-module product.

2.3.2 E-module validation

This process conducted by four experts consisting of three physics lecturers and one physics teacher. Validation activities were carried out on four aspects, namely content, media, material misconceptions and the suitability of multi-representation aspects. The result of this activity is a profile of the feasibility of e-modules as a multi-representation-based physics learning resource on Newton's Law material and used as a reference in improving e-module products.

2.3.3 Limited trial.

This study was conducted on 15 students as early e-module users, using a questionnaire distribution via Google forms with the aim of obtaining information related to the weaknesses of the e-module products that were compiled. The questionnaires distributed were the questionnaire on the difficulty level of the material in order to get responses to the level of difficulty of the material presented in the e-module, the student response questionnaire to the e-module in order to get responses to the e-module as a whole and the gap test questionnaire used to obtain a readability level profile.

2.3.4 Repair e-module

This stage carried out to correct weaknesses in the e-module product which was compiled based on the results of validation by experts and limited trials by students to produce a better e-module final product.

3. RESULTS AND DISCUSSION

3.1 Defining

The define stage is carried out by reviewing documents and distributing questionnaires via google form to 36 respondents with the criteria that they have studied Newton's Law of motion.

3.1.1 Analysis of the use of learning resources.

The define stage begins with an analysis of the use of learning resources. Analysis of the use of learning resources is carried out by distributing questionnaires via google form. The results of the 36 respondents who filled out the questionnaire the largest percentage, namely 91.7%, stated that during online learning the respondents liked to learn using online learning resources. In line with the next point which shows that 94.4% of respondents get more learning resources in the form of learning videos either through YouTube, teacher videos, learning applications and TV compared to textbooks. This is supported by 88.9% of respondents who stated that textbooks were difficult to understand. In the aspect of the characteristics of learning resources used by respondents, it is dominated by learning resources that contain pictures, diagrams, graphs and mathematical equations which are 83.3%. while interactive learning resources have the smallest percentage of 8.3%. This shows that during online learning, students use more electronic learning resources, but the use of e-modules as interactive learning resources is still rarely used (Holmes & Prieto-Rodriguez, 2018; Lau et al., 2018), so that respondents still find it difficult to understand the material, especially physics subjects and Newton's law materials using learning resources that are usually given by teacher.

3.1.2 Analysis of learning resource needs.

Learning resource needs analysis is carried out by distributing questionnaires via google form. Based on the results of the analysis, 97.2% of respondents need learning resources that can be studied independently and not dependent on the teacher, and can be used anytime and anywhere. The results of the analysis show that the largest percentage of the aspects of the need for representation in learning resources is the need for the use of multi-representations. With all respondents stating that physics learning resources need to contain text, images, diagrams, graphs, mathematical equations, videos and simulations (Benedetič, 2018; Piyatissa et al., 2018). In addition to the need for multi-representation, the majority of respondents need learning resource features that can directly respond to the results of the learning that has been done.

3.1.3 Material analysis

Material analysis was carried out by distributing questionnaires via google form. The findings from the distribution of questionnaires via google form in the form of a profile of student constraints in learning Newton's Law material (Montáns et al., 2019; Sukma et al., 2019). Furthermore, an activity was carried out to review the document of the Regulation of the Minister of Education and Culture of the Republic of Indonesia Number 37 of 2018 concerning Amendments to the Regulation of the Minister of Education and Culture Number 24 of 2016 concerning Core Competencies and Basic Competencies of Lessons in the 2013 Curriculum in Basic Education and Secondary Education. The results of the document analysis are in the form of information regarding core competencies, and basic competencies, also basic materials that are used as references in determining the breadth of the material presented.

3.2 Design

At this stage is the e-module design process. The thing to do is to compile a draft of the e-module and compile a storyboard.

3.2.1 Drafting of e-modules.

The first thing to do in the drafting of the e-module is to determine the scope of Newton's Law material according to basic competencies. The material coverage is then formulated into competency achievement indicators (GPA). After the GPA is formulated, multi-representation mapping is carried out that will be used for each subject matter, in the form of a checklist and given a brief description of the intended multi-representation. Then arrange the presentation of content based on the results of the multi-representation mapping. Content presentation is equipped with labels based on multi-representation aspects to make it easier for developers when compiling e-modules. Example Label T1.1 shows the representation of the 1st text in the 1st material (Newton's First Law).

3.2.2 Storyboarding

The next design stage is compiling the storyboard which is carried out as an overview of the layout of the e-module to be compiled. The preparation of the storyboard performed by referring to the multi-representation-based e-module draft that has been made. The preparation of the storyboard has gone through improvements that are adjusted to the results of the improvement of the e-module draft so that a storyboard is produced which is used as a reference in the preparation of the e-module. Figure 2 shows a sample storyboard which consist of title of sub topic, text, figure and diagram.

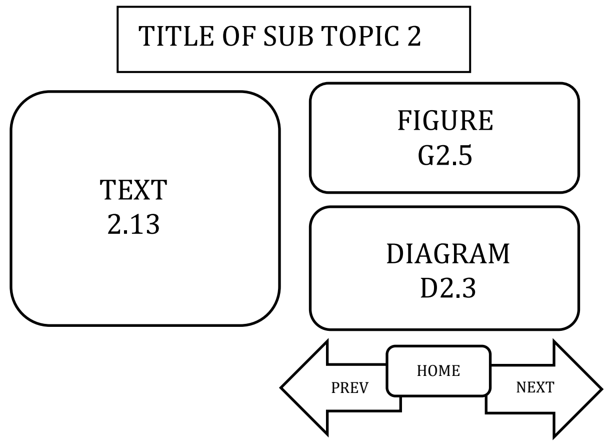

Figure 2. A sample of storyboard

3.3 Develop (Development)

3.3.1 Preparation of e-modules

The e-module preparation is carried out by a developer based on the e-module draft and storyboard. The preparation is carried out with the initial activity of compiling a draft of the e-module on the articulate storyline software based on the storyboard that has been made. Then the e-module product that has been produced is converted into HTML format so that an initial multi-representation-based e-module product is produced that can be accessed online.

3.3.2 E-module validation

After completing the preparation of the e-module, then validation or assessment from experts is carried out. Validation is performed on multi-representation-based e-modules on Newton's Law material as a product of research. The validator consists of four experts which include three lecturers and one teacher. At this stage, the assessment is carried out on four aspects, including: 1) The suitability of the e-module content with the function of using multi-representation, 2) Misconceptions of Newton's Law material, 3) Content, and 4) Media. The results of the validation of the E-Module can simply be seen in the Table 1.

Table 1. Validation of physics e-module

No	Aspect	Number of Indicators	Score			
			1	**2**	**3**	**4**
1	Content match e-module with use function multiple-representations	7	N=0	N=0	N=11 39%	N=17 61%
2	Misconception content of Newton	11	True N=0		Correct N=44 100%	
3	Content	11	N=0	N=0	N=15 34%	N=29 66%
4	Medium	10	N=0	N=0	N= 11 27.5%	N=29 72.5%

The validation results on the multi-representation aspect show that in general 61% are in the very good category and 39% are in the good category. Thus, it can be concluded that the content of the e-module is in accordance with the function of using multi-representation and qualified properly in the multi-representation aspect. The results of the validation on the misconception aspect show that 100% there is no misconception in Newton's Law material on the e-module so that it is qualified properly on Newton's Law material content. The content validation results show that 66% of the content is in the very good category. Meanwhile, the remaining 34% are in the good category. However, there are notes from the validator, namely the legibility of some images and letters needs to be improved.

The results of media validation show that 72.5% of the media are in the category of very good assessment. Meanwhile, the other 27.5% are in the good category. Thus, it can be seen that the qualified e-module is feasible in the aspect of media content. There are several notes given by the validator, including e-module need to be improved, especially in language and there are some parts that need to be equipped with operating instructions.

3.3.3 Limited trial

A limited trial was conducted on 15 students as early e-module users, using a questionnaire distributed via Google form. The level of readability of multi-representation-based e-modules was measured using a gap test. In the gap test activity, students who have used the e-module carry out the activity of completing a blank paragraph (which is missing a few words) with a total of ten entries. In the aspect of the level of readability, the average percentage of the readability level is 88, 65% when compared to the readability criteria, values above 60% are included in the high criteria or independent category. This means that students can use this e-module independently without the need for teacher assistance. Then the qualified e-module is worthy as a source of independent learning. The student response questionnaire to the e-module is used as feedback for the compiler to obtain information regarding the weaknesses of the e-module product. There are two questionnaires used to get feedback, namely the student response questionnaire to the overall e-module and to the level of difficulty of the material presented.

The results of the questionnaire response analysis of students on the technical aspect obtained an average presentation of 92.75%, in the visual aspect the presentation average was 91.92%, the interaction and feedback aspects were 90.67%, and the learning aspect was

92.18% with categories strongly agree. The results of the questionnaire analysis of student responses on all aspects showed a positive response with an average percentage of student responses of 92.18%. On the aspect of the difficulty level of the material, the overall material in the e-modules that are compiled is categorized at the easy-to-understand level.

3.3.4 Revision

In general, the products can be said good and received a positive response. However, of course, the e-modules that are compiled still require further development and improvement so that the e-modules that are compiled are really suitable for use in learning. Therefore, improvement activities on the e-module carried out based on the results of validation, suggestions, input and comments from the validator and students, to produce a better e-module final product.

4. CONCLUSION

Based on the results of the analysis and discussion of the research, several conclusions were obtained in accordance with the formulation of the problem as follows: The multi-representation-based e-module on Newton's Law material is properly qualified for the content, there are no misconceptions about Newton's Law material presented. Multi-representation-based e-module on Newton's Law material that is compiled is qualified to fit the media load, as an independent learning resource, because it shows a high level of readability or at an independent level, meaning that students can understand the material well and can operate the e-module independently. The multi-representation-based e-module on Newton's Law material that was compiled received a positive response from students. Based on the student response questionnaire to the e-module product, the average percentage of student responses was 92.18% in three aspects of assessment, namely visual, interaction and feedback.

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