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Development of Multi Representative Physics E-Module with the Materials of the Momentum and Impulse Grade X High School/Islamic High School Students

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ABSTRACT

The module is a teaching material that is packaged practically and systematically so that it can be accessed independently by both teachers and students. E-modules are adaptations of learning modules to the current digital era, so that in operation e-modules utilize technology, both computers and cellphones. This study aims to 1) produce multi-representation-based physics e-modules on momentum and impulse material that can be used in learning, 2) determine student responses related to multi-representation-based physics e-modules that have been produced, and 3) determine the quality of physics-based e-modules multi representation that will be used in classroom learning. This research belongs to R&D (Research and Development) research with the 4D Thiagarajan development model consisting of Defining, designing, Development, and Disseminating. This research is limited to the Development stage, to be precise, in extensive trials. The instruments used in this study included validation sheets, assessment sheets, and student response questionnaires. E-Modules are validated by material experts and media experts. The validation sheet in this study uses Aiken's V scale with three scales. In comparison, the e-module quality assessment was conducted by two material experts, two media experts, and two physics teachers. The e-module quality assessment sheet uses a Likert scale with four scales. The e-module trials in this study were divided into two stages: limited and extensive. Limited trials were conducted on ten students, while comprehensive trials were conducted on 36 students. Student response questionnaires used the Guttman scale with two scales: "agree" and "disagree" statements. The results of this study include: 1) multirepresentation-based physics e-modules on the subject of momentum and impulse have been produced to facilitate students' learning styles; 2) the quality of the e-module that has been developed based on material experts, media experts, and teachers has a successive average score of 3.29 in the very good category; 3.66 with very good category; and 3.74 with very good category; 3) The response of students to the e-module in limited trials and wide trials has a successive average score of 1.00 with the agreed category; and 0.95 with the agreed category.

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INTISARI

Modul merupakan suatu bahan ajar yang dikemas secara praktis dan sistematis sehingga dapat diakses secara mandiri baik oleh guru maupun peserta didik. E-modul merupakan adaptasi modul pembelajaran terhadap era digital saat ini, sehingga dalam pengoperasiannya e-modul memanfaatkan teknologi baik itu komputer maupun handphone. Penelitian ini bertujuan untuk 1) menghasilkan e-modul fisika berbasis multirepresentasi pada materi momentum dan impuls yang dapat digunakan dalam pembelajaran, 2) mengetahui respon peserta didik terkait e-modul fisika berbasis multirepresentasi yang telah dihasilkan dan 3) mengetahui kualitas e-modul fisika berbasis multirepresentasi yang akan digunakan pada pembelajaran di kelas. Penelitian ini tergolong ke penelitian R&D *(Research and Development)* dengan model pengembangan 4D Thiagarajan yang terdiri dari *Define, Design, Development dan Disseminate*. Penelitian ini dibatasi ada tahap *Development*, tepatnya pada uji coba luas. Instrumen yang digunakan pada penelitian ini antara lain lembar validasi, lembar penilaian dan angket respon peserta didik. E-Modul divalidasi oleh ahli materi dan ahli media. Lembar validasi dalam penelitian ini menggunakan skala *Aiken's V* dengan 3 skala. Sedangkan penilaian kualitas e-modul dilakukan oleh 2 ahli materi, 2 ahli media dan 2 guru fisika. Lembar penilaian kualitas e-modul menggunakan skala *likert* dengan 4 skala. Uji coba e-modul pada penelitian dibagi menjadi 2 tahap yaitu uji coba terbatas dan uji coba luas. Uji coba terbatas dilakukan terhadap 10 peserta didik, sedangkan uji coba luas dilakukan terhadap 36 peserta didik. Lembar angket respon peserta didik menggunakan skala *guttman* dengan 2 skala yaitu pernyataan "setuju" dan "tidak setuju". Hasil penelitian ini antara lain: 1) telah dihasilkan e-modul fisika berbasis multirepresentasi pada pokok bahasan momentum dan impuls untuk memfasilitasi gaya belajar peserta didik; 2) kualitas e-modul yang telah dikembangkan berdasarkan ahli materi, ahli media dan Guru memiliki rerata skor berturut-turut sebesar 3,29 dengan kategori sangat baik; 3,66 dengan kategori sangat baik; dan 3,74 dengan kategori sangat baik; 3) Respon peserta didik terhadap e-modul pada uji coba terbatas dan uji coba luas memiliki rerata skor berturut-turut sebesar 1,00 dengan kategori setuju; dan 0,95 dengan kategori setuju.

A. Introduction

The Regulation of the Republic of Indonesia, Number 20 the Year 2003 Article 1 Clause 1 about the National Education System [1], education presents a learning process to develop the potential and skills they need. Education guides students to become citizens who are aware of their rights and duties so that they can benefit the country. The success of an education depends on the factor of learning. Pane [2] explains an ideal learning process must have an interaction between components that include teachers, students, learning objectives, learning media, teaching materials, methods, and evaluations.

The learning process aims to produce students with better quality. But the reality says otherwise, the quality of education in Indonesia is currently poor. It is based on a survey by TIMSS [3] which aims to determine the level of understanding of students related to mathematics and science. Referring to this survey, the average student answered correctly on the knowing aspect at 32%, the applying aspect at 24%, and on the reasoning aspect at 20% [3]. Indonesia ranks 45th out of 48 countries that followed the survey.

The low level of understanding of science can be influenced by several factors, such as the teaching material or modules in learning. Asyhar cited by Permadi [4] explains that a module is a print-based teaching material that is accompanied by instructions and is independently accessible by both students and teachers. Kuswandaria cited by Sa'idah [5] explains that the weaknesses of the teaching materials used today are the strategies of organizing and delivering materials that are not well structured as well as their less attractive packaging. This lack of teaching material will undoubtedly hamper the student's understanding of the material of science, especially physics.

Physics is the genius of science that triggered the radical revolution of human civilization. Abdurrahman [6] explains that physics presents a more general method for solving complex problems. Based on this, physics has a bad image as a subject in school due to its difficulty in understanding the material in it and also the low interest of students in studying physics. Jiwanto [7] explains that one of the constraints encountered by students in studying physics is that they tend to find it difficult to solve problems. Physics deals with problems that require students to be able to think critically in solving them.

Kurniasari [8] explains that the problem-solving skills of the students can be enhanced by expanding the concept and justifying the concept against the physics material taught. A lack of understanding of the concept can hinder the student from solving the problem of a phenomenon presented. Referring to that, then the student's understanding of the concept of physics should be emphasized. Therefore, there is a

need for a collaborative method to improve the understanding of concepts, one of which is the multi-representation method.

Suminar cited by Rendiyansah [9], multirepresentation refers to a method of presenting similar concepts with different methods. Murtono [10] explains that multi-representation complements the cognitive process of the learners to obtain complete concepts. Mardatila [11] explains that poor conceptual understanding requires various representations to facilitate learners in understanding the concepts. Permadi [4] explains that the student's understanding of the concept of physics is not centered on a single representation but on many representations obtained through various sources and references.

Based on the results of the preliminary study of unstructured interviews obtained that students at 08 Yogyakarta Public High School have difficulty in understanding the physical concepts, especially on matter momentum and impulses, this is because students have not mastered the concepts of vectors optimally. The difficulties experienced by the students related to the understanding of concepts, Farida cited by Sa'idah [5] states that the students make incorrectness in solving abstract problems on momentum and impulse material, the learning media used by teachers in the teaching-learning process include tablets, power points and worksheet with limited concept presentation.

Then based on the observations obtained that learning in schools is still centered on the teacher and the minimum demonstration. Physics labs in schools are also rarely used for practicums, it's marked with laboratory tools that have been dusty and also descriptions from laboratory managers. In addition, the use of technology in Yogyakarta State High School 08 is quite massive, but the empowerment of technology in learning is still lacking. Technology has the opportunity to facilitate students' understanding of concepts in the era of the 4.0 industrial revolution. Hoyles and Lagrange cited by Putrawangsa [12] explain the influence of data technology on the education system in Indonesia, due to the factors of effectiveness, efficiency, and attractiveness offered by digital technology.

Based on the above background, a multi-representation-based e-physics module is being developed on the subject of momentum and impulses for high school/MA students. The e-modules developed can be accessed independently by both teachers and pupils using their respective Android devices.

B. Method

This research applies a Research & Development method, R&D. Sugiyono [13] explains that this research method produces a product and tests the level of effectiveness of a product. The development model in this study is a 4D model proposed by Thiagarajan. The model consists of four stages that include Define, Design, Develop and Disseminate. This research is limited to the stage. The

development model is restricted to the development stage, precisely the extensive trial.

The research was conducted at 08 Yogyakarta Public High School. The research subjects were the tenth graders. The trial run was two phases, a limited trial and a comprehensive trial. The limited test involved 10 students in X Mathematics Science 1 class, while an extensive test was carried out on 36 students of X Mathematics Science 2. The data collection methods were interviews, observations, and elevation of students' responses. Interviews were conducted to determine the needs of students and teachers in the implementation of learning. The observation was useful to determine the situation and conditions of learning in the classroom. The student response questionnaire was useful in determining the quality of the developed multi-representation-based e-module. The research instruments were the product and instrument validation sheets, e-module quality assessment sheets, and student response sheets.

Product and instrument validation data analysis was Aiken's V. The obtained coefficient value ranges from 0 to 1 and is adjusted to the validity level criteria. The product quality evaluation sheet uses the Likert scale with 4 evaluation scales. The obtained data on the assessment was then analyzed using a mean equation. The mean score was then converted based on the product quality assessment criteria. The student's response sheet uses the Guttman scale with two response scales. The obtained data on the student's response sheet was then analyzed using an average equation. The obtained mean score was based on calculations and then converted according to the criteria of student response. If the results show agreed criteria then the multi-representation-based e-physics module is eligible for further use in classroom learning.

C. Results and Discussion

At the Define stage, the analysis of necessity dealt with curriculum analysis, student analysis, material analysis, and school analysis. Based on the curriculum analysis, Yogyakarta Public High School 08 used the 2013 Curriculum in classroom learning. Prihadi [14] that the 2013 curriculum requires students to seek and learn the studied materials through a variety of sources and references. The analysis of the students showed that the students experienced difficulties with physical disabilities, especially in solving problems. Students thought that physics was full of mathematical equations and memorizations of mathematic equations without knowing the physical meanings.

In the analysis of the material, the applied learning media by the teacher in delivering the material as a board, PowerPoint, and worksheet but with limited presentations. In addition, the implementation of the laboratory in the learning

process was very low. The researchers found the laboratory equipment was full of dust as explained by the librarian. Students also stated that they had difficulties understanding the concept of the matter of momentum and impulses. For the learners, momentum, and impulses were associated with vectors in determining the direction of motion of objects. However, they did not understand vector material optimally. Then the last one on the obtained school analysis was the implementation of the study based on the vision, mission, and purpose of the school. In this case, Yogyakarta Public High School 08 aims to create a school with outstanding achievements in all fields, such as science and technology.

Therefore, the school authorities allow every student to carry electronic devices. The presence of this policy is expected that electronic devices brought to schools could be used wisely by learners during classroom learning. The design phase consisted of several activities such as product selection, design of e-module concepts, material design and evaluation tools, and the e-Module initial product.At the selection of the product, the researchers determined the relevant product to the analysis of the needs. In this case, the selected product is a multi-representation-based physics module on the subject of momentum and impulses. The developed e-module is accessible only with an Android device. The e-module took the form of a learning application on a gadget. This module contains learning material with a variety of representations and also simulations connected with PhET Simulation.

In the design of the e-module concept, the researchers mapped the e-Module design and determined the contents to present. At this stage, the researchers also started designing the UI and UX design of the e-module. During the planning of materials and evaluation tools, an identification of core competencies and basic competencies was done based on the 2013 curriculum. Subsequently, a mapping of representations such as verbal, graphic, mathematical, and graphic was useful for the learners to easily understand the material of momentum and impulses. Besides preparing the e-module concept, the researchers also arranged the instruments to evaluate the e-module.

At the beginning of the e-module product, the researchers began to compile e-modules based on a previous design. The module consisted of five matters: introduction, concepts of momentum and impulse, the law of momentum conversion, restitution coefficient, and types of impact. Each of the subjects was described using multi-representation methods to facilitate learners' understanding of the concept. In addition, the e-module also features a simulation of the impact using PhET Simulation both online and offline. The simulation may last directly inside the application without the assistance of third-party applications such as Chrome, explorer, etc. The e-module also had an evaluation feature consisting of 25 dual-choice issues to determine the learning achievements.

The second stage is the development stage. This stage included validation, evaluation, and also product testing. The researchers validated the research

instrument before further implementation. In this case, the researchers validated the instrument with two expert validators of the instrument. As for the Aiken index on the validation of instruments, the obtained score was 0.92 with a high validity criterion, indicating the readiness of the instrument for the research. The next stage is product development. This stage involved two experts: material and media experts. Figure 1 shows the product validation.

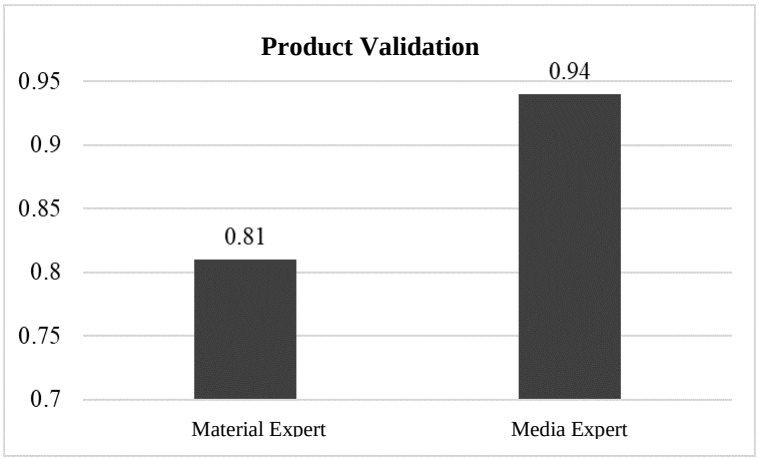

Figure 1. Product Validation Results

The figure shows the multirepresentation-based e-physics module has a "High Validity" criterion with a score of 0.81 for the material expert and 0.94 for the media expert. The values indicate that the e-module is excellent in terms of content and also presentation. In addition to providing validation scores, material experts and the media also provide suggestions and input as consideration for further revisions

The revision was the second version of the module to be assessed in terms of quality by the experts and the teachers. This assessment involved two material experts, two media experts, and two physics teachers. Figure 2 shows the assessment results of the developed module.

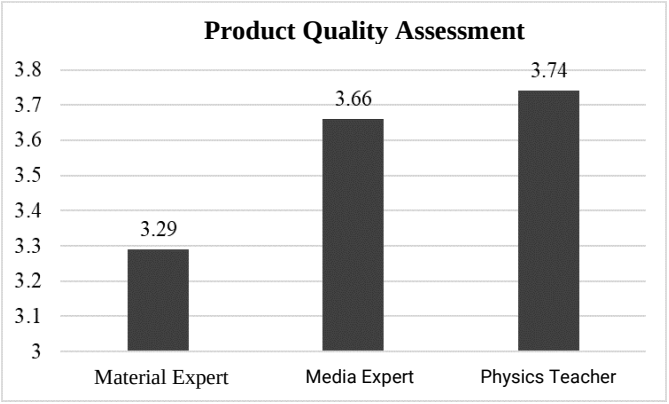

Figure 2. The Assessment Results of the Product Quality

The figure shows the developed module has the "Very Good" criterion with a score of 3.29 for materialists, 3.66 for media experts, and 3.74 for physics teachers. The values indicate that the e-module is excellent in terms of content and also presentation. Besides giving the assessment scores, the experts and teachers also shared suggestions and input as consideration for making improvements. Here is the recapitulation.

After revising, the researchers examined the revised version of the product. Product testing was useful to determine the student's response after using the module. The product trial run included two phases: limited trials and massive trials. The researchers obtained student's responses from a response questionnaire

The limited trial run involved 10 students from tenth grade. The limited test results got a score ratio of 1.00 with agreed criteria. The multi representation-based e-physics module on the language of momentum and impulses could facilitate the student's learning style in understanding the concepts of physics. The results of a limited trial show entire indicator on the multirepresentation aspect obtains a high percentage above 50%. Therefore, the developed product was appropriate and easy to understand by the learners. Students could easily understand material due to various representations such as verbal, graphic, mathematical, and graphic

Besides sharing the responses of the limited trial run, the learners also provided suggestions and input to the e-module. The respondents recommended a quiz review feature about the evaluation item answers for further learning. However, the researchers did not follow up on the recommendation because of the limited package of the features. This feature could not be modified so the researchers had to follow the features based on the software's articulate storyline.

After having the limited test, the researchers conducted a massive trial run for 36 learners from X Mathematics and Science 2. The limited test results got a score ratio of 0,95 with agreed criteria. The multi-representation-based e-physics module on the language of momentum and impulses could facilitate the student's learning style in understanding the concepts of physics. The analysis of the massive trial run found that

all indicators of multi-representation aspects had a high percentage, more than 50%. Therefore, the developed product was appropriate and easy to understand by the learners.

Besides that, the scoring responses of the massive trial run provided the opportunity for the learners to share suggestions and recommendations for the module. Here are some suggestions for the learners.

1. The researchers found errors in writing on the question example features.
2. The conclusion feature of impact simulation was not available.
3. The ratio aspect of the e-module needs optimization to provide a full-screen display on a smartphone.

Based on the massive trial run, the researchers also examined the implementation of the developed e-module. The implementation of the e-module was useful in determining the readability of the applied module in the learning. The developed e-module performance test scores a ratio of 3.5 with very good criteria. Based on the result, the multi-representation-based e-module physics is applicable as a physical teaching material for both high school/Islamic high school students in understanding the materials of momentum and impulses. Handayani [15] also explains the development of multi multi-representative physics e-module based on PBL for rigid objects. The researchers found the development obtained an extremely excellent criterion with a mean score of 89.49.

D. Conclusions

In this case, the selected product is a multi-representation-based physics module on the subject of momentum and impulses. This e-module uses the Android technology. The presented representations included verbal, figure, mathematical, and graphic representations. The quality of the developed module is excellent in facilitating the learning styles of High School and Islamic High School learners. The material and media experts and the teachers argued that the module is extremely excellent with a mean score of 3.29 for the material expert, 3.66 for the media expert, and 3.74 for the teachers. The obtained responses from the trial run include two parts: the limited and massive tests. The limited test involved 10 learners of tenth grade. The responses to the limited test obtained a score of 1 with the category of agree. The massive test involved 36 learners of X Mathematics and Science 2. The responses to the massive test obtained a score of 0.95 with the category of agree.

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