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Multi-representation-based interactive physics electronic module as teaching materials in online learning

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ABSTRACT

This study aims to describe the validity and practicality of the Interactive Physics Electronic Module (IPEMo) based on multiple representations. This study uses the ADDIE research and development method to produce a product in the form of a multi-representation-based IPEMo on the magnetic field. Product validity is viewed from the material aspect which was validated by 2 material experts and the media aspect validated by 2 media experts. The product practicality test was carried out on respondents consisting of 16 students of Tadris Fisika UIN Antasari Banjarmasin using a practicality questionnaire. Descriptive analysis was carried out on the validity and practicality of the product. The results showed that in the material aspect, the product was included in the very valid category with details on the subject matter 94%, auxiliary information 90%, affective considerations 80%, and pedagogy 90%. In the media aspect, the product is also declared to be very valid with the percentage of details on each aspect of the interface 97%, navigation 100%, and robustness 100%. The level of practicality of the product according to the respondents is included in the very practical category with details of subject matter 95%, auxiliary information 94%, affective considerations 94%, pedagogy 94%, interface 91%, navigation 98%, and robustness 93%. The results of this study have implications for the provision of valid and practical magnetic field teaching materials for use in online learning.

INTRODUCTION

The policy of implementing online learning during the Covid-19 pandemic is a challenge for teachers and students. Teachers must quickly adapt and innovate with online learning systems. One of the innovations in learning can be done by developing teaching materials that can facilitate students in online learning.

Electronic modules (e-modules) help students learn independently in online learning. The electronic module contains materials, methods, and evaluations that are systematically arranged to achieve certain learning objectives that are packaged in digital or electronic form (Laili, 2019). E-modules can be used without limitation of place and time and can replace the role of teachers (Syafutri & Pramudya, 2019; Feriyanti, 2019) so that these teaching materials can be accessed independently by students. E-modules are more effective than conventional modules or print modules (Sujanem, 2012). E-modules can display physics phenomena/ demonstrations/ simulations through pictures and videos to help students understand abstract physics concepts (Nurhasnah et al., 2020). In addition, e-modules are also able to present to teachers through audio and visual and even provide feedback on student work so that e-

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modules are interactive (Darmaji et al., 2020; Fisnani et al., 2020)

Several studies have revealed the effectiveness of using interactive e-modules. Research by Sidiq & Najuah (2020) shows that Android-based interactive e-modules can improve student learning outcomes in teaching and learning strategies courses. Web-based e-modules can increase the knowledge competence of students with high N-gain categories on static electricity and dynamic electricity (Solihudin, 2018). Electronic modules are very effective in increasing students' motivation, learning outcomes (Santhalia & Sampebatu, 2020), and critical thinking skills (Puspitasari, 2019). Previous research conducted by Nisa et al., (2020) developed an e-module in the introductory solid-state physics course. Research by Ritonga et al., (2020) has also investigated interactive but Schoology-based e-modules on Impulse and Momentum material. However, the development of interactive e-modules must also pay attention to the pedagogical aspect, namely, how to teach the material in the module so that it is easy for students to understand especially in complex subjects.

Magnetic and electricity is one difficult physics material for students because it is abstract and complex (Wardana et al., 2017). Research by Dega et al. (2013) shows that students find it difficult to understand the concept of electromagnetic induction because they lack mastery of the concepts of electric fields, magnetic fields, and magnetic fluxes. Students tend to find it easier to solve electric-magnetic problems using mathematical formulas rather than using physics concepts (Wardana et al., 2017). Students also have difficulty solving qualitative physics problems (Kaliampos et al., 2021), such as explaining the motion of charged particles in a magnetic field (Wardana et al., 2019). Research by Özdemir & Coramik (2018) shows that students have difficulty applying the right-hand rule (RHR) which is often used to determine the direction of vector products. This is because there are still misconceptions about magnetism, a lack of understanding of vector algebra, and the complexity of spatial thinking.

One of the learning methods that help students in explaining abstract concepts is the multi-representation (Abdillah et al., 2021; Taqwa et al., 2020). The multi-representation method can explain one concept using multiple representations (Kurnaz & Arslan, 2014; Opfermann et al., 2017). This method can facilitate students who have multiple intelligence backgrounds to help students understand abstract physics concepts (Abdillah et al., 2021). Therefore, by using this multi-representation method, students can study the material according to their respective characters and ways of learning. The multi-representation method has proven to be effective in improving students' understanding of physics concepts (Sutopo & Waldrip, 2014; Kurnaz & Arslan, 2014; Harijanto, 2018; Kurniasih et al., 2020). In addition, the multi-representation method can also improve problem-solving skills (Aha et al., 2020), and students' scientific reasoning (Sutopo & Waldrip, 2014). Many alternative teaching materials were developed in the Magnetic and Electricity course. However, no one has developed yet a multi-representation-based Interactive Physics Electronic Module (IPEMo). Therefore, this study aims to describe the validity and practicality of the multi-representation-based Interactive Physics Electronic Module (IPEMo).

METHODS

This study uses the ADDIE model which consists of the Analyze, Design, Develop, Implement, Evaluate stages (Branch, 2009) to produce a product in the form of IPEMo based on a multi-representation of magnetic field materials. This research was carried out at UIN Antasari Banjarmasin involving 4 experts and 17 students of Tadris Fisika. The product development procedure can be seen in Figure 1.

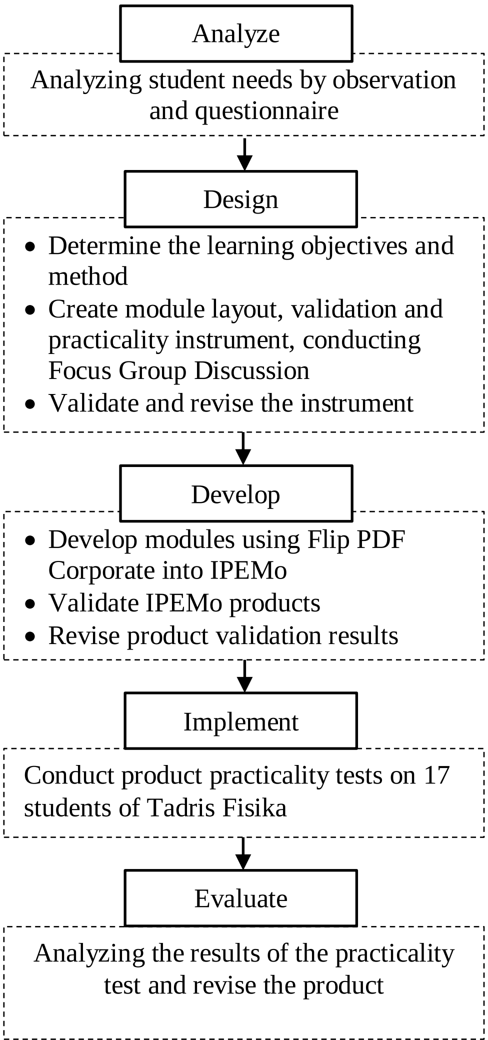

Figure 1. Research procedure

Products that have been developed are then validated on the material and media aspects. Validation was carried out by 2 material expert lecturers and 2 media expert lecturers using a validation sheet. Analysis of product validation results using a formula adapted from (Akbar, 2013).

$$P = \frac{\sum x}{\sum x_i} \times 100\%$$

P : percentage validity
$\sum x$: the total number of expert ratings on each aspect
$\sum x_i$: the total number of ideal values in each aspect

The validation results are interpreted based on the criteria shown in Table 1 and revised according to the suggestions from the validator.

Table 1. Validity Criteria

Percentage validity	Validity level
85,01-100 %	Very Valid
70,01-85 %	Valid
50,01-70 %	Less Valid
01,00-50 %	Invalid

(Adapted from Akbar, 2013)

Furthermore, at the implementation stage, a practicality test was carried out on 17 students of Tadris Fisika UIN Antasari Banjarmasin using a practicality questionnaire. The results of this test were analyzed using a formula adapted from (Akbar, 2013).

$$P = \frac{\sum TSe}{\sum TSh} \times 100\%$$

P : a percentage value
$\sum TSe$: total score of student answers
$\sum TSh$: maximum score

Student assessments of the practicality of teaching materials are interpreted based on the criteria shown in Table 2.

Table 2. Practicality Criteria

Practicality percentage	Practicality level
81,00-100 %	Very Practical
61,00-80,00 %	Practical
41,00-60,00%	Less Practical
21,00-40,00 %	Impractical
0,00-20,00 %	Very Impractical

(Adapted from Akbar, 2013)

RESULTS AND DISCUSSION

Multi-representation Based IPEMo

Multi-representation-based Interactive Physics Electronic Module (IPEMo) is an electronic module packaged using Flip PDF Professional on magnetic field material so that it can be accessed online via a PC or mobile phone as shown in Figure 2.

Figure 2. Product front page view

This module consists of two lessons which include lesson I: Magnetic Field, Magnetic Force, and Torque in a Current Loop in a magnetic field; and lesson II: Motion of Point Charges in a Homogeneous Magnetic Field and the Hall Effect. The components in each lesson consist of learning objectives, materials, sample questions, summaries, practice questions with feedback and answer keys, and self-assessment.

This module is equipped with features that allow interaction between readers and teaching materials. The flip feature functions to open the module pages so that readers can open each page like reading a printed book. The table of contents serves as navigation for readers to quickly select the desired page (see Figure 3). The video play button functions as navigation that directs readers to video links on Youtube. The audio play button functions as a button to play the lecturer's voice when explaining the material. Assistants equipped with lecturers' voices replace the presence of lecturers when studying online. In addition, it is also equipped with Google Form integrated practice questions that will provide direct feedback on student answers. An answer key link is also provided at the end of the essay question exercise in the hope that students can correct their answers based on the scores listed in the answer keys.

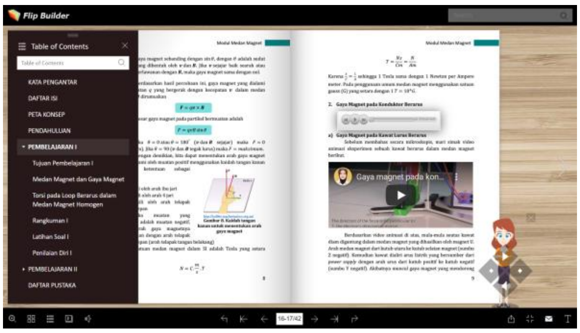

Figure 3. Product features

This module uses a multi-representation method in presenting the material. The multi-representation method is a learning method that explains a concept using more than one representation such as verbal, pictures, graphics, symbols, formulas, or tables (Kurnaz & Arslan, 2014). Verbal representation can be in the form of text or audio that can be played directly via the audio play button. According to Kurniasih et al., (2020) this method is effective for increasing students' understanding of concepts.

Validity of Multi-representation Based IPEMo

Validation by material experts is carried out to assess the content of the module in terms of four aspects, namely subject matter (related to the content or subject matter), auxiliary information (additional information such as introductions, instructions, summaries), affective considerations (related to how the product motivates student learning), pedagogy (related to learning strategies, interactivity, evaluation, and quality of feedback). The validation results from the two experts can be seen in Figure 4.

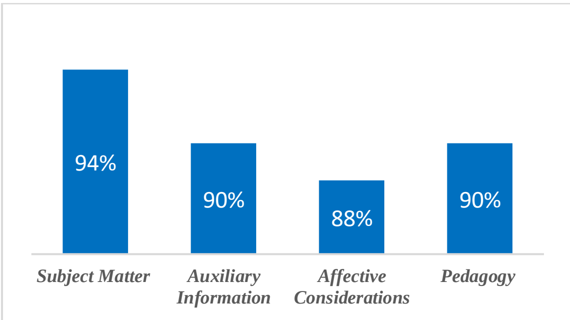

Figure 4. Percentage of product validity in each aspect according to material experts

The percentage of validity of the four aspects is in the range of 81%-100%, which means that the IPEMo is considered very valid by material experts. The subject matter aspect received the highest rating, which was 94%, and auxiliary information 90%. It means that the concept and systematic presentation of the material were very valid. No errors in concept were found in the module. This aspect is very important because the module is one of the teaching materials that can be a factor causing misconceptions (Yuliati, 2017). Therefore, the presentation of adequate and systematic material substance in teaching materials will help students achieve the learning objectives that have been set (Sari et al., 2019) without any misconceptions (Khoiri et al., 2017).

In the aspect of affective considerations, the experts assessed 88% which was included in the very valid category. Affective considerations relate to how the product can motivate student learning. The existence of apperception at the beginning of each learning stage is expected to motivate and focus students to understand the material. At the apperception, a video with the original voice of the teaching lecturer is presented. This is related to the teaching style of the lecturers and is carried out so that there is an emotional closeness between the lecturers and students even though the learning is carried out online. A teacher's teaching style which includes variations in voice and emphasis on certain sentences has a positive effect on learning motivation (Khunaini & Sholikhah, 2021) and student learning achievement (Anwar et al., 2020; Khunaini & Sholikhah, 2021).

Validation by media experts is carried out to assess the appearance of the module in terms of three aspects, namely interface (multimedia display such as text, graphics, animation, audio, and video), navigation (how to use switching pages in multimedia), robustness (product durability that minimizes multimedia errors when used). The validation results from the two experts can be seen in Figure 5.

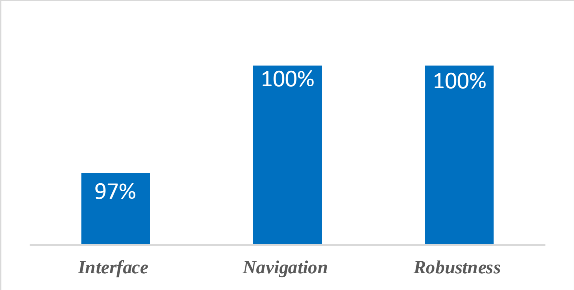

Figure 5. Percentage of product validity in each aspect according to media experts

The three aspects, namely interface, navigation, and robustness, respectively obtained a percentage validity rating from experts of 97%, 100%, and 100% so that the three aspects were included in the very valid category. The percentage of aspects of navigation, and robustness are rated maximally by experts (100%). This shows that the IPEMo can be used easily and smoothly. The features provided by the software such as table of content links, google form integrated question links, answer key links, and buttons make it easier for users to use this module. All features can be accessed smoothly without any errors when the module is run.

Meanwhile, the interface aspect gets a percentage of 97%. This aspect is related to the appearance of both the module cover design and the module content design. The media expert's assessment is included in the very valid category. However, the media expert also provided some corrections including 2 pictures with the same description on pages 7 and 8. In addition, it is also necessary to rearrange the use of Table 1 spaces on page 4 of the Magnetic Field module.

The achievement of validity in the very valid category according to media experts shows that in the aspect of media use, the teaching materials developed are feasible to use. These results are in line with the research of Nisa et al., (2020) that the e-module (electronic module) based on a multi-representation in solid-state physics introductory subject has been successfully developed with good validity. The use of interactive multimedia that has been declared feasible in a teaching material will assist students in explaining abstract phenomena (Prabowo & Saptasari, 2016) making it easier for students to construct their knowledge (Chen et al., 2010).

The practicality of Multi-representation Based IPEMo

The practicality test was carried out to determine student responses regarding the attractiveness, usefulness, and ease of use of the product. It was described in 7 aspects, namely subject matter (related to content or subject matter), auxiliary information (additional information such as introductions, instructions, summaries), affective considerations (related to how the product motivates student learning), pedagogy (related to learning strategies, interactivity, evaluation, and the quality of feedback), Interface (attractiveness of multimedia displays such as text, graphics, animation, audio, video), navigation (ease of use, switching pages in multimedia), robustness (durability of the product that minimizes multimedia errors when used). Researchers distributed questionnaires to students to fill out according to their perceptions of the products developed. The results of the practical IPEMo Magnetic Field test can be seen in Figure 6.

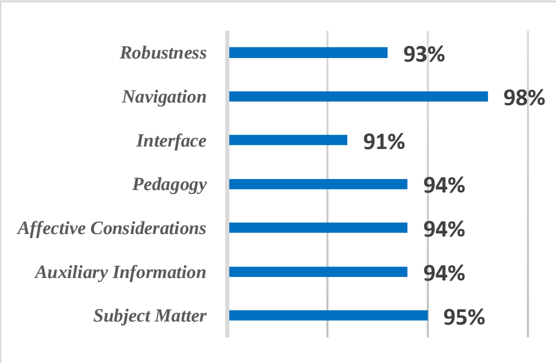

Figure 6. Product Practicality Test Results on Every Aspect

Based on the results of the practicality test, it is found that in each aspect the percentage of practicality is in the range of 81.00%-100%. The percentage of practicality in all aspects shows in the very practical category (Akbar, 2013). Student responses to this practicality test are in line with the results of research by Nisa et al., (2020). The practicality of the product shows that the teaching materials developed are useful and interesting for students which will affect their understanding of the material (Kartikasari et al., 2015). Thus, the developed magnetic field teaching materials can be used in online learning.

CONCLUSION AND SUGGESTION

The validity of IPEMo based on multiple representations of magnetic field material according to material experts is included in the very valid category in every aspect, namely aspects of subject matter 94%, auxiliary information 90%, affective considerations 80%, and pedagogy 90%. The results of media expert validation also stated that it was very valid with the percentage of every aspect of the interface 97%, navigation 100%, and robustness 100%. The level of practicality of the product according to the respondents is included in the very practical category based on 95% subject matter aspects, 94% auxiliary information, 94% affective considerations, 94% pedagogy, 91% interface, 98% navigation, 93% robustness. These results indicate that IPEMo based on multiple representations of magnetic field material has been valid and practical to use as teaching materials in online learning. Moreover, further research is needed to determine the level of effectiveness of using the product.

AUTHOR CONTRIBUTION

IR contributes to product content arrangement and analysis of research results; NN and MRA participated in the media design of the product and data collection. All authors participated in compiling the manuscript.

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