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Validation of PhET-Based Core Physics Teaching Materials to Improve Activities and Learning Outcomes of Physics Education Students

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Abstract: The development of PhET-based core physics introductory teaching materials to increase the activities and learning outcomes of physics education students has been successfully carried out. The purpose of this development is to produce teaching materials for introductory PhET-based core physics courses that are feasible to increase the activity and learning outcomes of physics education students. The device development uses a 4D model (define, design, develop, and disseminate). The tools developed are in the form of Semester Program Plans, Student Activity Sheets, core physics teaching materials, student activity instruments and student learning outcomes instruments. The results showed that the PhET-based core physics teaching materials were very valid. This means that the teaching materials for introductory core physics courses based on the use of PhET are very feasible to use in increasing the activities and learning outcomes of physics education students.

Keywords: Activity; Core physics; Learning outcomes; PhET

Introduction

In the industrial era 4.0 at this time, the development of information and communication technology is taking place very quickly so that it changes the mindset of people in seeking and obtaining information (Ilyasir, 2019). One of the fields that has had a significant impact from this development is the field of education (Doyan et al., 2023; Elyas, 2018). In the field of education the use of technological media makes learning more effective and efficient (Doyan, Gunawan, et al., 2020; Susilawati, Doyan, & Muliyadi, 2022). This is no exception in core physics courses (Oktova et al., 2018; Saraswati, 2019; Swandi et al., 2014).

Core Physics is one of the subjects studied in tertiary institutions with a weight of 3 credits (semester credit system) (Pathoni et al., 2017). Core physics is a compulsory subject that provides high-level knowledge and continuation of lectures related to atomic nucleus material and provides a basis for further physics lectures so that students master knowledge about atoms, and can develop and apply them in science and technology in accordance with developments (Susilawati, 2014).

The reality that occurs in the field related to the core physics lecture process shows that student learning outcomes are still low. This is because students still have difficulty understanding the concepts in core physics courses that seem abstract. In addition, this material is rarely experimented with in the laboratory, in addition to the equipment being very expensive and the risks involved if an error occurs in the experiment. This problem needs to be addressed immediately so that prospective teachers have a comprehensive mastery of core physics. Therefore, one solution to overcome this problem is to use learning media in the form of a PhET (Physics Education Technology) virtual laboratory

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(Oktavia et al., 2020; Saputra et al., 2020; Susilawati, Doyan, Mulyadi, et al., 2022).

PhET is a learning media software in which there are several physics learning simulation materials for the benefit of teaching in the classroom or can be used for the benefit of individual learning (Meadows et al., 2019; Muzana et al., 2021). The simulation provided by PhET is very interactive, inviting students to learn by exploring directly (Susilawati, Doyan, et al., 2021). This PhET software creates abstract physics animations or cannot be seen by the naked eye, such as: atoms, electrons, photons and magnetic fields (K. K. Perkins et al., 2012). For quantitative exploration, this PhET software has measuring tools in it such as a ruler, stopwatch, voltmeter and thermometer (K. Perkins et al., 2006).

The use of virtual laboratories is expected to increase student activity so that learning becomes easier, interesting and interactive and able to motivate students to study this material both individually and in groups.

Method

This research is development research using a 4D model. A 4D model includes several phases: definition, design, development, and dissemination (Sugiyono, 2014). This study is limited to the development stage and includes efficacy testing. Data from validity testing were obtained from the results of review and evaluation of aspects of the content and learning activities by three expert verifiers. The first products developed were in the form of Semester Program Plans, Student Activity Sheets, Core Physics Materials, Student Activity Instruments and Student Learning Outcomes Instruments. Data obtained in this study were analyzed using equation 1 (Khasanah et al., 2019). Furthermore, the level of validity can be determined based on criteria according to Arikunto (2012) which include: Very Valid ($4.2 \geq SV \leq 5.0$), Valid ($3.4 \geq SV \leq 4.2$), quite Valid ($2.6 \geq SV \leq 3.4$), less valid ($1.8 \geq SV \leq 2.6$), and very less valid ($1.0 \geq SV \leq 1.8$).

$$SV = \frac{\text{the average value of expert validity}}{\text{max score}} \quad (1)$$

Result and Discussion

This research is a development research with a 4D model. The 4D model includes several stages, namely define, design, develop, and disseminate. In this study it is limited to the development stage, which includes validity testing.

The define stage includes problem analysis, student analysis, concept analysis and basic competency analysis (Doyan et al., 2022). The problem analysis in this study aims to identify and define the problems faced by students in the Introductory Core Physics learning, so that the basic requirements needed to develop teaching materials for introductory physics courses based on the use of PhET emerge. Based on these problems and needs, alternatives for developing teaching materials for introductory physics courses based on the use of PhET are developed which are relevant to solving these problems. Some things that need to be considered in raising problems are the curriculum, future challenges and current conditions (Susilawati, Hardjono, et al., 2021).

Analysis of students is carried out to determine the characteristics of students which include the level of cognitive development of students and sociocultural. Concept analysis on the Preliminary Core Physics material aims to identify the essential concepts that will be taught so that they can be arranged systematically so as to make it easier for students to understand the material. The next analysis is basic competency analysis. The results of the analysis of basic competencies and indicators are used as a reference for formulating learning objectives. The material discussed in the introduction to nuclear physics consists of the Atomic Nucleus, Radioactivity, Nuclear Decay, Nuclear Reactions, Radiation Interactions, Radiation Detectors, and Benefits of Radiation.

The next stage is design, where at this stage the researcher designs teaching materials for the Introduction to Core Physics course based on the use of PhET. The designed learning tools consist of Semester Program Plans, Student Activity Sheets, Core Physics Materials, Student Activity Instruments and Student Learning Outcomes Instruments. After the learning device design process has been completed, the next step is the develop stage (Susilawati, Rahmana, et al., 2022).

The develop stage aims to develop teaching materials for introductory core physics courses based on the use of valid, practical, and effective PhET to increase the activities and learning outcomes of physics education students (Doyan, Jufri, et al., 2020). At the development stage, learning device validation is carried out. The device validation was carried out by three validators. The results of learning device validation are shown in Figures 1, 2, 3, and 4.

Based on Figure 1, it can be seen that on average the Semester Program Plan that has been developed has very valid criteria. This is because the aspects of format, language, and content are in accordance with or meet the criteria for a good Semester Program Plan. However, in the format aspect, the average score is the smallest compared to the other two aspects. This is because it still needs to be improved in terms of writing basic competencies, indicators, and learning objectives.

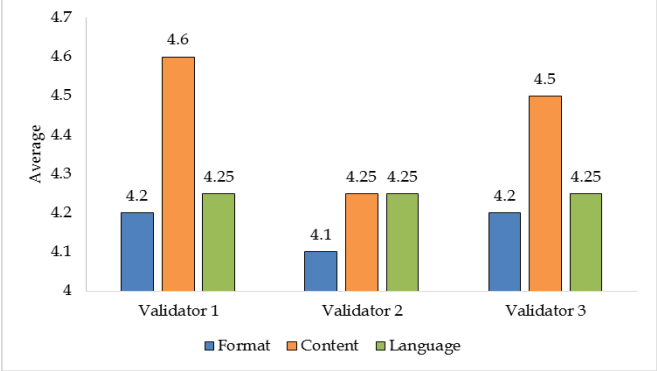

Figure 1. Validation results from semester program plans

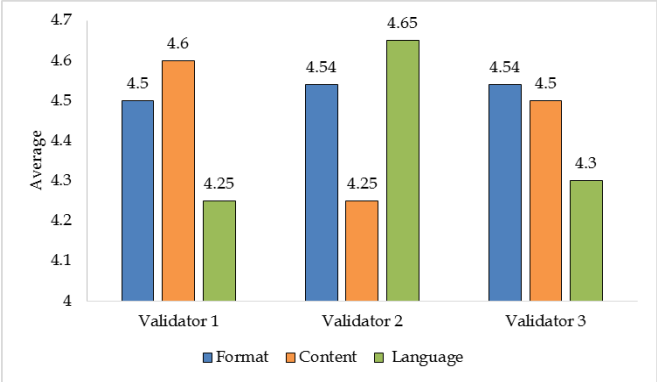

Figure 2. Validation results from student activity sheets

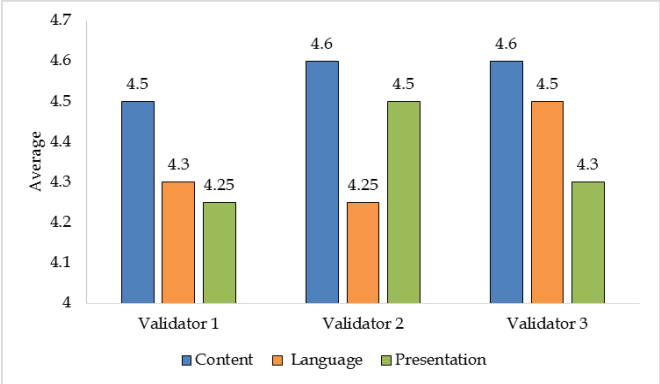

Figure 3. Validation results from core physics materials

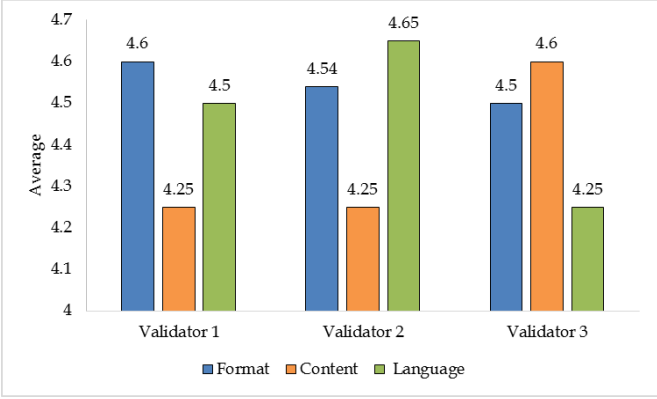

Figure 4. Validation results from student activity instruments and student learning outcomes instruments

Based on Figure 2, it can be seen that the student worksheets that have been developed show that the three aspects, namely: aspects of format, aspects of language, and aspects of content, on average have very valid criteria. This means that the worksheets that have been developed are feasible and can be used as learning tools.

Based on Figure 3, it can be seen that the core physics teaching materials developed show that the three aspects, namely: content aspects, language aspects, and presentation aspects, on average have very valid criteria. This means that the core physics teaching materials developed are suitable for use in the learning process.

Based on Figure 4 it can be seen that on average the activity instruments and student learning outcomes that have been developed have very valid criteria. This is because the aspects of format, language, and content are appropriate or meet good criteria. This means that the instrument is appropriate to be used as a tool to measure student learning activities and outcomes. In general, the teaching materials for the PhET-based introductory core physics course are very appropriate for use in introductory core physics courses.

Conclusion

The results showed that the PhET-based core physics teaching materials were very valid. This means that the teaching materials for introductory physics based on PhET are very suitable for use in increasing the activities and learning outcomes of physics education students.

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Author Contributions
Conceptualization, Susilawati, Joni Rokhmat, Gunawan, I Wayan Gunada, and Hikmawati; formal analysis, Susilawati, Aris Doyan, and Lalu Muliyadi; investigation, Susilawati, Joni Rokhmat, Gunawan, I Wayan Gunada, and Hikmawati.

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Conflicts of Interest
The authors of this article declare no conflict of interest.

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