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Analysis Validation of Physics Learning Devices Based on Problem Based Learning Assisted by PhET Simulation to Improve Students' Creativity and Critical Thinking

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Abstract: The development of physics learning devices based on problem based learning assisted by PhET simulation to improve students' creativity and critical thinking has been successfully carried out. The goal of this development is to produce a valid physics learning devices based on problem based learning assisted by PhET simulation to improve students' creativity and critical thinking. The development of the device uses a 4D model consisting of four stages, namely: define, design, develop, and disseminate. Based on the assessment results by the validator, it can be concluded that the physics learning device based on problem-based learning assisted by PhET simulation is very suitable for use as learning material to improve students' creativity and critical thinking.

Keywords: Creativity; Critical thinking; Learning tools; Problem-based learning

Introduction

21st-century education demands that students possess critical thinking, problem-solving, collaboration, and effective communication skills (Doyan et al., 2022; Susilawati et al., 2025). Conventional learning models are often ineffective in developing these skills. Therefore, innovations in learning approaches are needed that empower students to learn actively and contextually (Doyan, Gunawan, et al., 2020; Doyan, Jufri, et al., 2020; Januarti et al., 2024; Kartini et al., 2019).

One promising learning model is Problem-Based Learning (PBL). PBL is a learning approach that places real-world problems as the starting point of the learning process (Muliyadi, 2017). Students work collaboratively to identify, analyze, and find solutions to these problems. PBL encourages students to develop higher-order thinking skills, independent learning, and teamwork (Hayati et al., 2024; Hikmawati et al., 2024; Maulana et al., 2024).

While PBL has great potential, its implementation often faces challenges. One major challenge is the availability of relevant and engaging learning resources. Computer simulations, such as PhET (Physics Education Technology) interactive simulations from the University of Colorado Boulder, offer a solution to this challenge (Muliyadi et al., 2023b; Munandar et al., 2024; Susilawati et al., 2022). PhET provides interactive simulations that allow students to visualize abstract concepts, conduct virtual experiments, and explore scientific phenomena in depth (Muliyadi et al., 2023a; Susilawati et al., 2021).

The use of PhET simulations in learning can improve students' conceptual understanding, learning motivation, and problem-solving skills (Susilawati,

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Doyan, & Muliyadi, 2023). Integrating PhET simulations into the PBL model is expected to provide a more meaningful and effective learning experience. PhET simulations can be used as a tool to facilitate problem exploration, data collection, hypothesis testing, and solution development (Banda et al., 2023; Erika et al., 2024; Liana et al., 2023; Liswar et al., 2023; Mashami et al., 2023).

Based on the description above, this study aims to investigate the effect of using a PBL model assisted by PhET simulations on student learning outcomes. This research is expected to provide empirical evidence on the effectiveness of technology integration in science learning and provide practical recommendations for teachers and curriculum developers.

Method

This research is a research and development (R&D) approach, adopting the 4D development model. The 4D model encompasses several stages: define, design, develop, and disseminate (Sugiyono, 2021). This research is limited to the development stage, which includes validity testing (Susilawati, Doyan, Rokhmat, et al., 2023).

The data obtained from this study are data from the results of the assessment by the validator. The media validation was carried out by experts consisting of material experts, learning media experts, and learning experts, each consisting of two people. The data obtained in this study were analyzed using equation 1 (Khasanah et al., 2019). Furthermore, the level of validity can be determined based on the criteria according to Arikunto (2015) which include: Very Valid ($4.2 \geq V \leq 5.0$), Valid ($3.4 \geq V \leq 4.2$), Fairly Valid ($2.6 \geq V \leq 3.4$), less valid ($1.8 \geq V \leq 2.6$), and very less valid ($1.0 \geq V \leq 1.8$).

$$V = \frac{average\ expert\ validity\ value}{maximum\ score} \quad (1)$$

Result and Discussion

The study aimed to determine the feasibility of a problem-based learning physics learning tool, assisted by PhET simulations, in enhancing students' creativity and critical thinking. The tool was developed using a 4D model that includes several stages: define,design, develop, and disseminate.

The define stage aims to define and establish learning requirements. This define stage consists of five main steps: problem analysis, student analysis, task analysis, material analysis, and specification of learning objectives. The problem analysis was conducted on high school students. The purpose of this analysis was to identify and identify the basic problems faced in physics learning. The results of the problem analysis and student analysis showed that students' abilities to receive and respond to physics learning materials vary. This is because the material in physics discusses more abstract physics concepts, thus affecting student enthusiasm during the learning process. This is what causes low creativity and critical thinking skills in students.

Based on these issues, a physics learning tool is needed that can enhance students' creativity and critical thinking in learning physics, which largely covers abstract topics. To address this issue, an alternative is needed: developing a physics learning tool based on problem-based learning supported by PhET simulations to enhance students' creativity and critical thinking.

The next stage is design, where researchers design problem-based learning physics learning tools using PhET simulations. This design stage involves compiling physics materials, specifically electricity, that align with the curriculum, selecting appropriate media for the objectives, selecting a format, and conducting an initial design. After completing the learning tool design process, the next step is the development stage.

The development phase aims to develop a physics learning tool based on problem-based learning supported by valid PhET simulations to enhance students' creativity and critical thinking, particularly in electricity. The physics learning tool developed consists of a syllabus, student worksheets, teaching materials, and evaluation instruments that measure students' creativity and critical thinking.

During the development stage, validation of the learning tools was carried out by two validators (Doyan: Atlantis Press). The results of the learning tool validation are shown in Figures 1, 2, 3, 4, and 5.

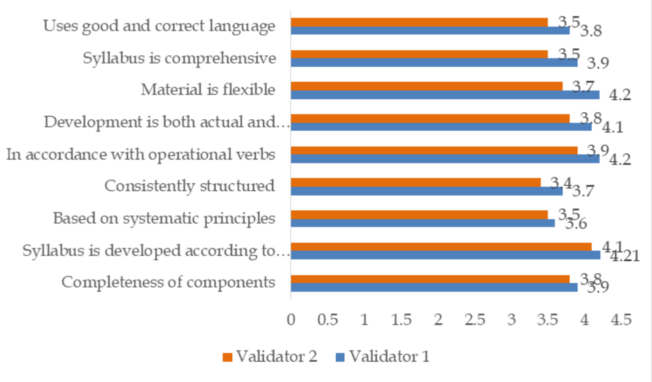

Figure 1. Validation results of the syllabus

Figure 1 shows the results of the syllabus validation. The syllabus was assessed on 9 components, namely a) completeness of components, b) the syllabus was developed according to relevant material, c) based on systematic principles, d) consistently structured, e) in accordance with operational verbs, f) development is actual and conceptual, g) the material is flexible, h) the syllabus is comprehensive, and i) uses good and correct language. The validation results show an average achievement above 3.4 with a proper interpretation in all measured aspects. This means that the developed syllabus is suitable for use as physics learning material in improving students' creativity and critical thinking.

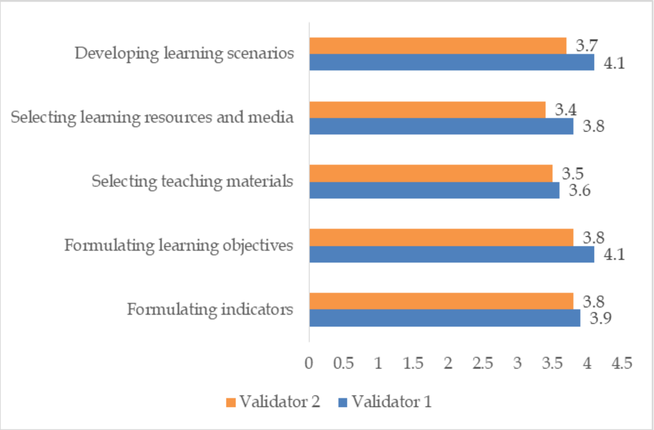

Figure 2. Validation results of the lesson plan

Figure 2 shows the validation results of the lesson plan. The lesson plan was assessed based on five components: a) indicator formulation, b) learning objective formulation, c) selection of teaching materials, d) selection of learning resources and media, and e) learning scenarios. The validation results showed an average achievement score above 3.4, with a reasonable interpretation for all measured aspects. This indicates that the developed lesson plan is suitable for use as a physics learning material to enhance students' creativity and critical thinking.

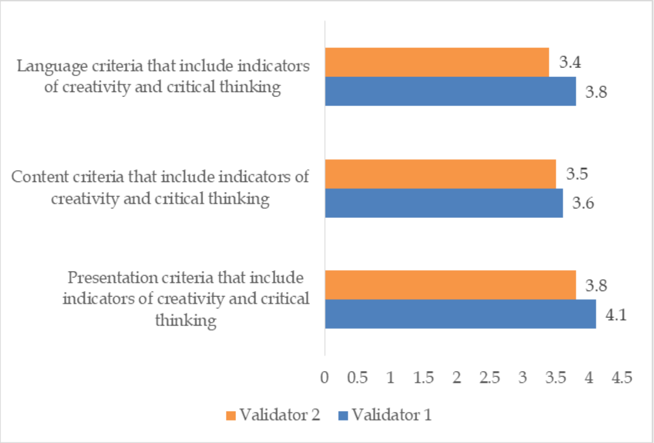

Figure 3. Validation results from student worksheets

Figure 3 shows the validation results of the student worksheet. The assessment in the lesson plan consists of three components: a) presentation criteria, which include indicators of creativity and critical thinking; b) content criteria, which include indicators of creativity and critical thinking; and c) language criteria, which include indicators of creativity and critical thinking. The validation results show an average achievement above 3.4 with a reasonable interpretation for all measured aspects. This means that the developed student worksheet is suitable for use as a physics learning material to improve students' creativity and critical thinking.

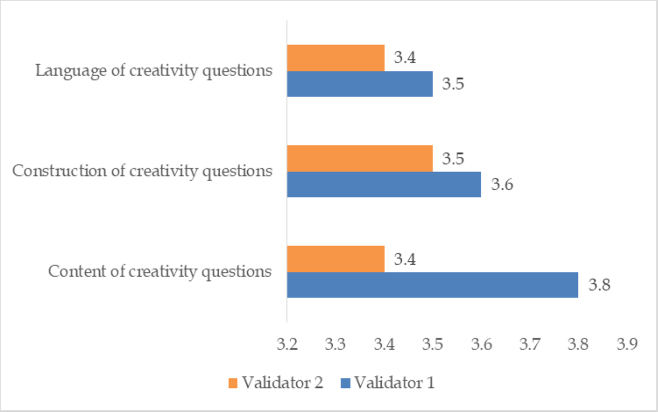

Figure 4. Validation results of the creativity instrument

Figure 4 shows the validation results of the creativity questions. The three components assessed in the creativity questions are: a) the content of the creativity questions, b) the construction of the creativity questions, and c) the language of the creativity questions. The validation results show an average achievement above 3.4 with a reasonable interpretation of all measured aspects. This means that the developed creativity question instrument is suitable for measuring students' creativity levels.

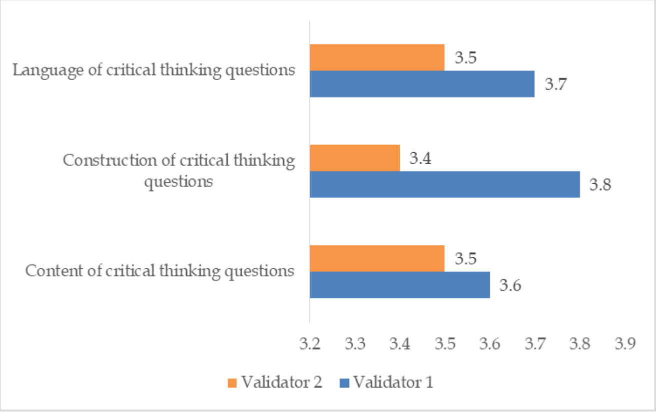

Figure 5. Validation results from critical thinking questions

Figure 5 shows the validation results of the critical thinking questions. The critical thinking questions were assessed based on three components: a) the content of the critical thinking questions, b) the construction of the critical thinking questions, and c) the language used in the critical thinking questions. The validation results showed an average achievement score above 3.4, with appropriate interpretations for all measured aspects. This indicates that the developed critical thinking questions are suitable for measuring students' critical thinking levels.

Conclusion

Based on the results of the assessment by the validator of the physics learning device based on problem-based learning assisted by PhET simulation, it can be concluded that the device is suitable for use as learning material to improve students' creativity and critical thinking.

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