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Development of IoT-Based Physics Learning Media and Its Effect on Students' Critical Thinking Ability

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Abstract: The implementation of an independent curriculum by the government has an impact on the world of education. Classroom learning requires teachers to be active in developing project-based learning. The development of IoT (Internet of Things)-based physics learning media and its effect on student's critical thinking skills is the goal of this research. The research method used is research and development (R&D) with the Four-D model with the steps of Define, Design, Develop, and Disseminate. The results of the development of IoT-based physics learning media show that the assessment of experts (material and media experts) is in a very Worthy category. The results of the questionnaire response of 70 students also rated this media "very good" with a percentage value of 90.92%. In addition, the post-test results revealed that IoT-based physics learning media proved effective in improving students' critical thinking skills with an N-Gain value of 0.73 in the high category.

Keywords: Learning Media; IoT; Critical Thinking

Introduction

The condition of the new variant of the covid-19 virus, namely emicron, has forced the government to seek to develop a curriculum that can be accepted and applied at the learning unit scale, from Elementary School (SD), Junior High School (SMP), High School (SMA), as well as at the secondary level. University Curriculum development seeks to achieve a learning goal. So, the government is trying to find a solution to develop a new curriculum.

In 2022, the government has set an independent curriculum as the curriculum that will be used in education units. The independent curriculum is a curriculum that boils down to competence in the hope of supporting learning during the pandemic by implementing PBL-based learning (Project Based Learning) (Liana et al., 2020). Students are required to make projects according to the theme that has been determined by the subject teacher (Bakır, 2020). The independent curriculum is the last option given by the government to be able to restore the process of learning activities in schools during this omicron period. The independent curriculum is a combination of the 2013 curriculum which is still in use today (Matsun et al., 2022). The independent curriculum is the curriculum of choice for educational units that are ready to implement. So that the independent curriculum contains knowledge, skills, and attitudes as a process of developing students. Universities have an important role in preparing an independent curriculum. The role of universities in preparing teachers in the regions.

The implementation of learning in the Physics Education Study Program during the covid-19 pandemic will make students and lecturers to experience difficulties in the learning process (Liana et al., 2020). So lecturers are required to make innovations in learning both in the classroom and in the laboratory (Ahmad, 2021). With learning innovations, students are expected to be able to master technology in today's era. Students must be active in exploring and optimizing the potential that exists on campus, one of which is the internet. The internet can be used as a solution in making learning media. The development of learning innovations in the classroom during the adaptation period of new habits can use the "blended" concept,

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namely the learning process by combining three main aspects, namely, virtual-digital, online, and offline while still paying attention to health protocols (Arisa et al., 2021). These aspects can be implemented in carrying out learning activities in the classroom and the laboratory.

Lecturers of the Physics Education Study Program have not used the blended concept as much as possible in classroom learning. New lecturers apply face-to-face learning directly, while nowadays it is very necessary to combine blended learning. Study program lecturers still use conventional learning media. Especially when it comes to practicum. Practicum is only carried out in the laboratory and cannot be carried out outside the laboratory (Pratama et al., 2021). New learning media are needed by students so that the learning process in the classroom is not boring. The media used must be by the current needs of students, which is internet-based (Wasyilah et al., 2021).

Physics education study program students almost students have a laptop, and almost all students have an android cellphone. And all students use the internet to carry out the learning process in class (Prasetyo et al., 2018). Based on the survey results, the researchers tried to develop an IoT-based physics learning media (internet of think) in basic physics courses. The use of IoT (internet of think) in basic physics practicum is very important because IoT (internet of think) is a combination of a microcontroller with the internet that can be used to develop/design an internet-based practicum (Rahmadita et al., 2021).

Students who take basic physics course 2 can carry out practical work, can see cellphones without having to go to the laboratory, students can understand basic physics concepts easily. The practicum process that is used as an alternative can be used in the learning process in a laboratory that is easily accessible by all students. Therefore, it is necessary to carry out research on IoT-Based Development (Internet Of Things) for learning physics (Permatasari et al., 2019). To Support the Independent Curriculum. The learning media developed is a basic physics practicum tool that can be accessed via a cellphone or laptop, so students can study practicum at home.

Method

Students of the physics education study program at IKIP PGRI Pontianak, which involved 70 students as research subjects. The form of research is research and development with the Four-D (R&D) model. The development model is carried out by the steps of Define, Design, Depelop, and Disseminate (Rizki et al., 2021). The steps for developing IoT-based physics learning media consist of define containing material analysis, programming language analysis, and sensor analysis. The design stage, it includes the activities of making product designs, validations, and revisions. The development step includes initial trials and main trials. Disseminate step In this step the tools and materials that have been developed will be disseminated to the users of the tools, namely lecturer and students. Persentase validitas instrumen diperoleh dari nilai rata-rata angket menggunakan angket validasi skala likert. Skala yang digunakan berupa angka 4, 3, 2, 1. Score 4 If the rating strongly agrees, score 3 if the rating agrees, score 2 if the assessment does not agree, and score 1 if the rating strongly disagrees (Imamora et al., 2021). For the analysis of the results can be seen in Equation 1.

$$P = \frac{\sum X}{\sum Xi} X\ 100\% \tag{1}$$

Where:
$P =$ Percent value sought/expected
$\sum$ X = total score
$\sum$ Xi = Maximum score

The IoT (Internet of Thinks)-based physics learning media developed is said to be feasible if the interpretation is 61% and above. The criteria for the interpretation of the feasibility score are 81-100% with the Very worthy interpretation, 61-80% with the Worthy interpretation, 41-60% with the Decent enough interpretation, and 21-40% with the Less worthy interpretation, and 0%-20% with the interpretation Not worthy (Khairati et al., 2021).

Analysis of student responses to the developed media uses equation 1. Student response criteria are 81-100% with very good criteria, 61-80% with good criteria, 40-60% with poor criteria, and 40% with bad criteria. Media that has been tested and declared suitable for use, then the media is used in classroom learning to be able to improve students' critical thinking. Students' critical thinking skills are analyzed using N-gain with Equation 2.

$$N - Gain = \frac{Posttest\ Score - Pritest\ Score}{Ideal\ score - Pritest\ Score} \tag{2}$$

The results of this calculation are then converted into criteria for improving critical thinking skills based on the provisions, namely with a value of g > 0.7 with a high category, a value of 0.3 g 0.7 with a medium category, and a value of g < 0.3 with a low category. low.

Result and Discussion

Development of IoT (Internet of Thinks) Based Physics Learning Media.

The process of developing IoT-based physics learning media begins with a definition stage consisting of material analysis, the material needs to be analyzed because it is following the needs of students. The material used is basic physics material 2. Material selection is very important to support the learning process in the classroom. Programming language analysis. The choice of programming language is very necessary so that the media created can be used. The programming language used is C++. Sensor analysis, so that the developed tool can operate following the desired material, several sensors that can be used other than the Arduino microcontroller are needed, namely, load cells and ultrasonic sensors (Matsun et al., 2021).

The design stages are made so that the practical tools made are following what is desired. The design of IoT-based basic physics practicum tools is made based on needs and is easy to access and use. At this stage, the IoT-based physics learning media (internet of think) is made following the content framework of the curriculum and material analysis results (Rahman et al., 2021). The design of the IoT-based physics learning media developer can be seen in Figure 1.

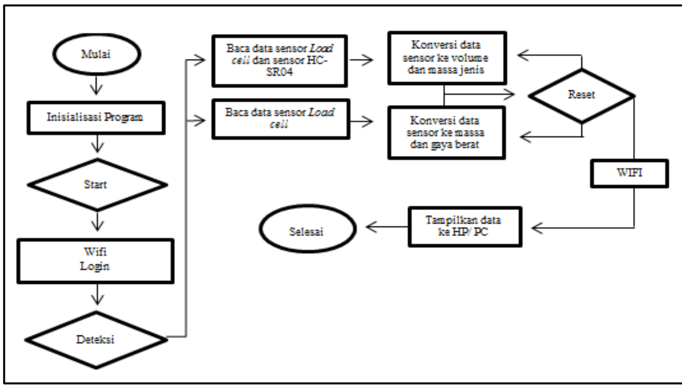

Figure 1. IoT learning media design

The development stage is carried out after the design stage is completed. This stage requires experts to assess the product being developed. Material and media experts are used to assess whether the product made is feasible or not (Fitriani et al., 2022). The results of product development can be seen in Figures 2 and 3.

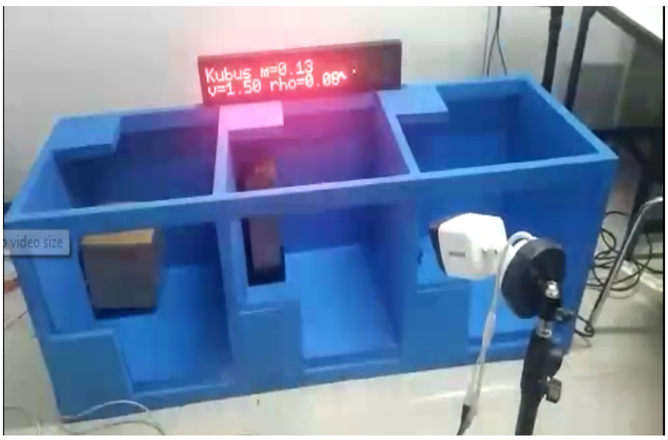

Figure 2. IoT media development products

Figure 3. Display of IoT media on student mobile

The dissemination stage is carried out by media socialization made to students and lecturers in the physics education study program. IoT (Internet of Think)-based physics practicum media If the user's response is good, then large quantities of production and marketing will be carried out so that the IoT (Internet of Think)-based physics learning media is used by a wider target (Zulhamdi et al., 2022).

Expert Validation

Expert validation results are obtained through a questionnaire given to material and media experts (Neswary et al., 2022). Material Expert Assessment with indicators of relevance to teaching materials, educational values, and understanding of the material. Media expert assessment with indicators of tool durability, tool system speed in reading measurement results, tool efficiency, aesthetics, safety, and easy access. The average value of material and media expert validation with a score of 87.50% with a very decent category. The expert validation range line can be seen in Figure 4.

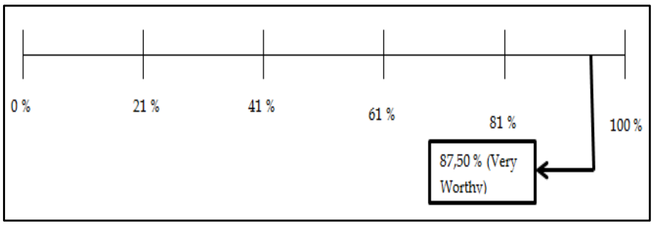

Figure 4. Expert validation range line

Student Response

Assessment of student responses to IoT-based physics learning media with indicators of learning motivation, understanding of material concepts, use of tools, and quality of tools. The assessment of student responses was carried out by students of the Physics Education Study Program A total of 70 respondents. Figure 5 shows the range of student responses to IoT-based physics learning media with a value of 90.92% with the student response criteria "very good".

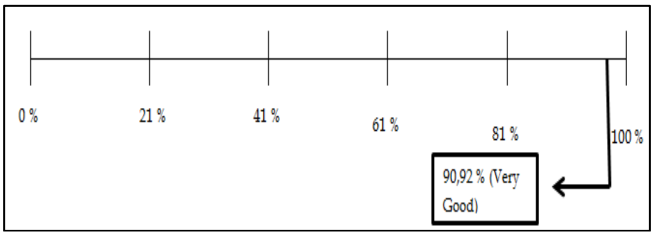

Figure 5. Lines of the student response range

Use of IoT-Based Physics learning Media to Improve Students' Critical Thinking Ability.

The next step after the IoT-based physics learning media is validated and tested and the results of the calculations have the results feasible to use, then the media developed is used in the classroom to improve student's critical thinking skills (Lee et al., 2019). The indicators of students' critical thinking skills are focus, reason, inference, situation, clarity, and overview (Rahman et al., 2021). The results of this test are presented in Table 1. Based on the statistical test results table of students' critical thinking skills, it was obtained that the pritest average value was 58, the posttest average value was 89, and the N-gain value was 0.73 in the high category.

Table 1: Statistical Results of Critical Thinking Ability

Pritest Score	Posttest Score	N-gain
58	89	0.73

The process of developing IoT-based physics learning media has been developed and has been validated with the criteria that it is feasible to be used by students. The developed media can improve students' critical thinking skills. This reason is following research conducted by (Liana et al., 2020a). The IoT-based physics learning media that was developed can improve students' ability to conclude and draw conclusions, examine reasons to strengthen opinions, clarify how far the range of reasoning is, be able to compare between two situations, be able to explain logically and be able to provide explanations so that they are not ambiguous. Research conducted by (Purnamawati et al., 2021), IoT-based physics learning media can increase students' critical thinking skills in designing and conducting experiments. Students are asked to reassemble the tools and materials used in the experiment. With these activities, students' critical attitudes can increase (Sarah et al., 2021).

The teaching and learning process in the classroom in the new normal and the application of an independent curriculum must consider the problem of student development, knowledge about student development has an important position in determining media so that IoT-based media is suitable for students. Research conducted by (Husnanda et al., 2021), virtual laboratory-based learning media showed good results on student's critical thinking skills compared to conventional methods (Widarti et al., 2020). IoT-based physics learning media is a combination of real and virtual media. Real-based media is related to the tool being developed, while the display of the results of the tool is virtual (can be viewed on mobile) (Tüysüz, 2010).

The IoT-based physics learning media that was developed is useful for facilitating learning, especially during the new normal period (Irwandi et al., 2020). From the development of IoT-based learning media, it is hoped that it will become a reference for other researchers in developing IoT-based learning media (Rizal et al., 2018). The results of this development are expected to be used in learning by students and lecturers (Prianto et al., 2021).

Conclusion

The development of IoT-based physics learning media can be used because it has a feasibility value from material and media experts with an average score of 87.50% with very decent criteria. The results of student responses are an average of 90, 92 with very good criteria. The student's critical thinking skills were obtained, namely the pritest average value of 58, the posttest average value of 89, and the N-gain value of 0.73 with a high category so that it can be concluded that IoT-based physics learning media can improve students' critical thinking skills in the high category.

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