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Validation of Physics Kit Based on Sensor and PjBL Model to Improve Students' Digital Literacy, Science Process Skills, and Learning Outcomes

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Abstract: The development of of physics kit based on sensor and PjBL model has been carried out to improve the digital literacy, science process skills, and learning outcomes of students. This development aims to describe the validation of physics kit teaching materials that are suitable for use in learning activities. The development model design used is 4D which consists of definition, design, development and dissemination stages. This research is limited to the development stage. Validation activities have been completed in the development process. The validity of of physics kit based on sensor and PjBL model was assessed by 3 competent experts who are competent at Mataram University. In addition to the validity of the physics kit, there are several learning tools that are assessed for validity to support the quality of the kit developed. Some of these learning tools include lesson plans, worlsheets, test instruments for digital literacy, science process skills, and learning outcomes. The validation results showed that the physics kit received an average score of 93.35%, the lesson plans 87.50%, the student worksheets 94.17%, the digital literacy instrument 87.54%, the science process skills instrument 92.59%, and the learning outcome instrument 88.63%. Based on these results, all components were categorized as "Very Valid". These findings indicate that the physics kit based on sensors and the PjBL model is highly valid and can be effectively used in science learning activities at school.

Keywords: Physics kit; PjBL model; Sensor; Validity

Introduction

Education is a crucial aspect of human resource development, and technology plays a key role in advancing learning methods (Wilson, 2012). However, amidst technological advancements, there are challenges related to developing effective learning methods (Okoye et al., 2021). The need for innovative and integrated learning is becoming increasingly urgent, especially with the incorporation of sensor technology as an alternative in teaching physics in modern education today (Matsun et al., 2018).

Modern education is closely linked to digital literacy, which has become a critical skill for students to succeed in both learning and everyday life (Murray et al., 2014). Digital literacy includes the ability to access, evaluate, and effectively use information through various digital platforms and tools (A'yuni, 2015). In physics education, digital literacy plays an important role in facilitating access to online learning resources, interactive simulations, and virtual experiments (Perdana et al., 2019). The development of sensor-based physics kits aims to provide an immersive learning experience and leverage students' digital literacy by utilizing sensor technology in both virtual and direct

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practical physics experiments (Panskyi et al., 2024). On the other hand, the effective use of kits in learning can enhance students' scientific process skills (Fa'izah, 2021).

Scientific process skills, such as observing, classifying, and predicting, are fundamental in understanding physics concepts comprehensively (Nurhemy et al., 2011). Through scientific process skills, students can develop a deeper understanding of the principles of physics and build critical thinking skills in analyzing natural phenomena (Zeidan et al., 2014). The development of sensor-based physics kits can increase student engagement in the physics learning process by providing hands-on experience in conducting experiments and observing the results (Reis et al., 2023). Therefore, sensor-based physics kits can be an effective tool in developing students' scientific process skills in the learning environment while also supporting the improvement of their learning outcomes (Ismail, 2016).

Student learning outcomes are the primary measure of learning effectiveness (Dakhi, 2020). The use of sensor-based physics kits and the PjBL model is expected to significantly enhance student learning outcomes (Panskyi et al., 2024). By allowing students to engage in more practical and relevant physics experiments, sensor-based physics kits can help improve their understanding of physics concepts (Kuhn et al., 2016). Moreover, the implementation of the PjBL model provides opportunities for students to develop collaboration, critical thinking, and communication skills, which directly contribute to their learning outcomes (Haryudo et al., 2021). Therefore, the development of sensor-based physics kits and the PjBL model is expected to be an effective innovation in improving student learning outcomes in physics (Fan et al., 2023).

Improving the quality of education can be achieved by incorporating various technologies, such as PhET simulations (Banda et al., 2023). Although these simulations provide an interactive visual experience, they are often limited in terms of actual interactivity, particularly in the context of development and direct learning (Rizaldi et al., 2020). Along with the need for more practical and creative approaches to learning, sensor-based physics kits can serve as an alternative solution (Cao et al., 2021). The advantages of sensors lie not only in their ease of use and affordability but also in their ability to facilitate teachers and students in designing teaching aids that meet learning needs (Irvani et al., 2023). These tools are useful for illustrating scientific concepts, conducting measurements and data recording, as well as providing practical experiences that enrich learning (Krajcik et al., 2014). Therefore, the use of sensors is a promising solution to improve the quality of science education in Indonesia (Oktafiani et al., 2017).

This research has a high urgency considering the need for learning that is responsive to technological developments and students' ability to understand scientific concepts. By utilizing sensor technology and innovative learning models such as PjBL, this research is expected to make a significant contribution to improving the effectiveness of physics education, strengthening digital literacy, and developing students' scientific process skills (Suryani, 2024). Thus, this research is not only relevant to meet the current learning needs but also serves as a foundation for the development of better learning approaches in the future.

Based on the previous explanation, this research aims to develop a sensor-based physics kit and apply the PjBL model to enhance digital literacy, scientific process skills, and student learning outcomes in physics. This is expected to provide a more meaningful learning experience and improve students' understanding of physics concepts holistically.

Method

This research is development research that will produce a product in the form of physics kit based on sensor and PjBL model. This study uses a 4D models which consists of the definition, design, develop and dissemination stages (Sugiyono, 2017). This research is limited to the development stage (develop).

The define stage is carried out to find out the problems and needs of students in the learning process. This stage consists of a front-end analysis. The design stage aims to design a product according to what is required at the define stage.

The develop stage aims to analyze the validity of draft 1 that was made in the previous stage. The validity test was carried out by three expert validators. Validity data was obtained from the results of reviews and evaluations of content aspects and learning activities. The main product developed is a physics kit based on sensor and pjbl model. To support the developed e-module, syllabus, Lesson Plans, Student Worksheets and Evaluation Test Instruments were also developed. The data obtained in this study were analyzed using the equation:

$$SV = \frac{\text{the average value of expert validity}}{\text{max score}} \times 100\% \quad (1)$$

The level of validity will be determined based on the criteria in the table below:

Table 1. Instrument Validation Criteria (Arikunto, 2019)

Validation Percentage Value Range (%)	Validation Level
0-20	Invalid
21-40	Less Valid

Validation Percentage Value Range (%)	Validation Level
41-60	Valid Enough
61-80	Valid
81-100	Very Valid

Result and Discussion

This research is a development study that uses the 4D development model. The 4D development model consists of four stages: define, design, develop, and disseminate. The aim of this research is to produce a product in the form of a sensor-based physics kit and Project-Based Learning (PjBL) model.

The define stage aims to identify and define the problems faced by students in learning (Doyan et al., 2022; Susilawati, Doyan, Rokhmat, et al., 2023), which led to the basic need to develop a sensor-based physics kit facilitated by the PjBL model. During this defining stage, several activities are carried out to assess the needs and problems in the learning activities. This stage consists of preliminary and final analysis, including student needs analysis, material and concept analysis, task analysis, and curriculum analysis (Susilawati, Doyan, & Muliyadi, 2023).

The needs analysis results show that students urgently need a portable physics kit to support learning. The existing kits are impractical due to their large size and outdated condition. Additionally, the laboratories conversion into a classroom has increased the urgency for a more efficient and portable kit.

The curriculum analysis indicates that the learning outcomes of phase F, which involve understanding the concept of sound wave phenomena and their application in daily life, are highly suitable to be developed into the foundation for creating a sensor-based physics kit with the PjBL model.

Figure 1. Design of the kit and its components

The next stage is the design stage, where researchers design a sensor-based physics learning kit and PjBL model. This kit consists of several systematically arranged components, including: (a) ultrasonic sensors, (b) Arduino Uno, (c) breadboard, (d) jumper cables, (e) buzzer, and (f) servo motor. These components are designed to be combined into devices such as a radar system and parking alarm. Students will then analyze this system in practical activities to understand the application of sound waves in daily life. The design of the developed kit can be seen in Figure 1.

The next stage is the development stage, which aims to produce a valid physics kit based on the assessment of three expert validators. In this stage, validity testing is conducted on the physics kit and other supporting educational materials. The validated materials include the teaching module, Student Worksheets, digital literacy questionnaire, science process skills observation sheets, and learning outcome test instruments.

The results of the validity testing show that the validity, based on the expert validators' assessments, falls within the percentage range of ≥ 80, which is categorized as 'very valid'.

Based on the validity analysis results from three validators, the sensor-based physics kit and accompanying learning tools, including lesson plans, student worksheets, and instruments for digital literacy, science process skills, and learning outcomes, have all been rated as *Very Valid*. The results show high average validity scores across all components, indicating that these tools are well-developed and appropriate for use in the intended learning context.

Kit Validity

The kit received an average score of 93.35%, with scores from individual validators ranging from 91.25% to 96.30%. These high scores reflect that the kit is highly relevant, practical, and effective for teaching and learning physics. The score also suggests that the kit is well-designed in terms of its components and ease of use, further supporting its validity as an educational tool.

Lesson Plan Validity

The lesson plans obtained an average score of 87.50%, categorized as Very Valid. Validator scores ranged from 85.00% to 90.00%. While the lesson plans are considered valid and applicable for classroom use, there may be minor areas for improvement in alignment with curriculum standards or instructional design to ensure even greater effectiveness.

Table 2. Validity Analysis Results

Validator	Kit	Lesson Plans	Student Worksheets	Digital Literacy Instrument	Science Process Skills Instrument	Learning Outcome Instrument
1	92.50	87.50	92.50	83.33	88.89	84.09
2	91.25	90.00	90.00	86.11	91.67	88.63
3	96.30	85.00	100.00	93.18	97.22	93.18
Average	93.35	87.50	94.17	87.54	92.59	88.63
Criteria	Very Valid	Very Valid	Very Valid	Very Valid	Very Valid	Very Valid

Student Worksheet Validity

The student worksheets showed excellent validity with an average score of 94.17%. One of the validators even gave a perfect score of 100.00%, indicating that the worksheets are clear, relevant, and appropriately structured to facilitate student learning during practical activities. The high validity suggests that the worksheets are highly effective in guiding students through the learning process, especially when using the sensor-based kit.

Digital Literacy Instrument Validity

The digital literacy instrument received an average score of 87.54%, also falling into the Very Valid category. Validator scores ranged from 83.33% to 93.18%, showing that the instrument effectively measures students' digital literacy, though some improvements could be made to further enhance the clarity and comprehensiveness of the assessment items.

Science Process Skills Instrument Validity

The instrument for assessing students' science process skills received an average score of 92.59%, with scores ranging from 88.89% to 97.22%. This indicates that the instrument is highly valid and accurately measures students' ability to apply scientific methods and reasoning during experiments. This strong validity ensures that the tool is appropriate for evaluating students' progress in science process skills, particularly in practical-based learning environments.

Learning Outcome Instrument Validity

The learning outcome instrument obtained an average score of 88.63%, classified as Very Valid. Validators gave scores between 84.09% and 93.18%, reflecting that the instrument is suitable for measuring students' learning outcomes in terms of knowledge retention and application. While the instrument is valid, there may be potential to refine some of the questions to better align with the learning objectives.

The physics kit based on sensor and PjBL model are analyzed based on eight important aspects: relevance, durability, accuracy, efficiency, safety, aesthetics, completeness, and storage. Each of these aspects is considered crucial in the development of the kit product, in this case, the sensor-based physics kit. The results of the validity analysis from the three expert validators for this kit can be seen in Table 3.

Table 3. Kit validity Analysis Results

Aspect	Validator 1	Validator 2	Validator 3
Relevance	83.33	91.67	91.67
Durability	100	100	100
Accuracy	91.67	87.5	100
Efficiency	83.33	91.67	91.67
Safety	100	91.67	100
Aesthetics	87.5	87.5	87.5
Completeness	100	100	100
Storage	100	100	100

The validation results of the sensor-based physics kit by three validators show excellent outcomes, with high average scores in each aspect. Eight assessment aspects were validated, namely relevance, durability, accuracy, efficiency, safety, aesthetics, completeness, and storage. Each aspect was evaluated by three validators using a percentage scale, providing an overall picture of the kit's quality.

Relevance

Validator 1 gave a score of 83.33%, while validators 2 and 3 gave the same score of 91.67%. This indicates that most validators agree that the kit is relevant to the needs of learning, although there is room for improvement based on feedback from 1st validator.

Durability

All validators gave a perfect score of 100% for the durability aspect. This means that the sensor-based physics kit is considered highly durable and capable of withstanding repeated use, which is essential for intensive laboratory activities.

Accuracy

For this aspect, validator 1 gave a score of 91.67%, validator 2 gave 87.5%, and validator 3 gave 100%. While most validators rated the kit highly in terms of accuracy, the variation in scores suggests that there may be differences in perception regarding the consistency of the measurements or the performance of the sensors used in the kit.

Efficiency

Validator 1 gave a score of 83.33%, and validators 2 and 3 both gave 91.67%. Although the scores are relatively high, validator 1 suggests that there might be room for improvement in efficiency, possibly in terms of ease of use or the time required to operate the kit.

Safety

The safety aspect received perfect scores of 100% from validators 1 and 3, but validator 2 gave a slightly lower score of 91.67%. This indicates that the kit is generally safe to use, though validator 2 raised some minor concerns about safety that could be addressed for further improvement.

Aesthetics

The aesthetics aspect received the same score from all validators, 87.5%. While not the most critical aspect in terms of functionality, aesthetics still play a role, particularly in the visual presentation and appeal of the kit to students.

Completeness

The completeness aspect received a perfect score from all three validators, 100%. This shows that all necessary components for conducting physics experiments are available and meet the initial design expectations.

Storage

The storage aspect also received a perfect score of 100% from all validators. This indicates that the kit is easy to store, does not require a lot of space, and is practical to use.

The validity test results for the developed physics kit show that the aspects of relevance, durability, accuracy, efficiency, safety, aesthetics, completeness, and storage have an average score of ≥ 80, which falls into the 'very valid' category. This validity was determined from the assessments provided by three expert validators, each of whom evaluated these aspects.

Conclusion

The development of the sensor-based physics kit integrated with the PjBL model has proven to be a highly valid educational tool, as indicated by expert validation results. The kit effectively supports learning in the field of physics by promoting hands-on experiences, enhancing digital literacy, improving scientific process skills, and leading to better learning outcomes. The kit's practical, safe, and efficient design makes it an appropriate resource for teaching physics in both theoretical and experimental settings. By incorporating modern technology and innovative pedagogical approaches, this product contributes to improving the quality of physics education, helping students to better understand scientific concepts, and fostering critical thinking and collaboration.

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