



Development of Student Worksheets Based on Problem Based Learning (PBL) Assisted by PhET Simulations to Improve Mastery of High School Physics Concepts

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Abstract: This development research aims to produce a product in the form of a Student Worksheets (known LKPD) based on a problem-based learning model that is feasible, practical and effective for improving students' mastery of concepts. This research is included in Research and Development (R&D) with a 4D model, which consists of defining, designing, developing, and disseminating. The product developed is Newton's Law LKPD supported by other independent curriculum tools: Learning Outcomes, Learning Goal Flow, Teaching Modules, and concept mastery test instruments. Data collection techniques use validation sheets, learning implementation observation sheets, student response questionnaires, and test instruments. The validity of the product was assessed by three expert validators, who were physics lecturers, and three practitioner validators, who were physics subject teachers. Their evaluations were performed using a Likert scale. Practicality is obtained from the teacher's observation sheet and student response questionnaires regarding learning. Effectiveness was obtained from the results of limited product trials in the form of an increase in pretest and posttest scores, which were analyzed using the n-gain test. The results of the validity of the product developed have a percentage, namely LKPD 92.12%; Learning Achievement 92.08%; Flow of Learning Objectives 92.60%; Teaching modules 89.78% and test instruments 91.15% with very valid and reliable categories above 75%, so the product can be said to be suitable for use. The results of the product's practicality were in the form of an implementation sheet by the teacher. Student responses of 92.08% and 82.10% were written in the convenient category. The results of the n-gain test for students' concept mastery were 0.74 in the medium category and included in the very effective criteria. Thus, the LKPD, Learning Outcomes, Learning Goal Flow, Teaching Modules and test instruments produced are feasible, practical and effective in improving students' mastery of concepts.

Keyword: LKPD Newton's Law; Problem Based Learning; Concept Mastery.

Introduction

Education is crucial for everyone and the nation to prepare for a better future. Through education, an individual can increase his or her essential potential, including physical, intellectual, emotional, mental, social and ethical, towards forming quality education (Fitriani, 2017). Facing the challenges of the 21st century, educators must be able to prepare for changes in the

identity of their students to become investigators, problem solvers, collaborative and creative thinkers. The challenges of this century encourage teachers to create learning methods that can develop skills to strengthen social capital and intellectual capital, abbreviated as 4C: communication, collaboration, critical thinking and creativity, which are expected in learning. Produce innovation and problem-solving (Aji et al., 2017).

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Physics learning is a branch of natural science requiring broad and in-depth knowledge of concepts. Based on observations made at one of the high schools in Praya, namely SMAN 1 Praya, in September 2023, students' mastery of concepts still needs to improve. In students' eyes, learning physics could be more exciting and easier to understand. So, the generic science abilities related to Physics learning are low (Kurniasih, 2018). Therefore, teachers are required to innovate learning by developing learning tools. Learning methods that use problems as the core of learning can direct students to find solutions to problems that have been presented independently.

To create an active and independent learning process in solving problems, it is necessary to use supporting learning tools, one of which is student worksheets (LKPD). LKPD can provide the benefit of creating fun and meaningful learning, which can have a positive impact on learning and allow students to absorb learning material to the maximum (Mujiansyah, 2021). LKPD is a tool that supports the learning process.

One model that can facilitate student-oriented learning is Problem-Based Learning (PBL). PBL is a learning model that is faced with an authentic problem that expects students to be able to construct their knowledge, develop inquiry and higher thinking skills, and increase their self-confidence (Rusmono, 2012). Apart from that, this learning model can be interpreted as a series of learning activities emphasising solving problems students face scientifically (Hamdayama, 2014).

The PBL model can also be applied electronically, assisted by PhET (Physics Education Technology) Simulation media. PhET media is an interactive simulation media that invites students to learn. PhET is used to clarify physical concepts. Additionally, using PhET media makes the learning process more enjoyable to see, read, digest, and remember (Ramadani & Nana, 2020).

This research aims to develop problem-based learning LKPD assisted by PhET Simulations to improve students' mastery of physics material concepts. It is hoped that the development of this LKPD can replace the conventional LKPD that has often been applied so far. Students are expected to learn more actively, and teachers as facilitators are only one of the primary learning sources in learning activities. In this way, students become more active in learning to increase their mastery of concepts.

Method

This research uses development research or Research and Development (R&D). According to Hayati

(2012), research and development (R&D) is a method used to produce products by testing the product according to needs, which impacts the wider community. The product of this research is a student worksheet (known LKPD) based on the Problem-based Learning model assisted by PhET Simulation, which is expected to improve students' mastery of concepts in high school. This research design uses a 4D model developed by Thiagarajan et al. (1974), which is divided into four stages: define, design, develop, and disseminate. In this research, researchers will test the LKPD using feasibility, practicality and effectiveness tests. Feasibility is seen from the validation results and reliability by the validator, practicality is seen from the results of student responses and learning performance sheets, and effectiveness is seen from the results of the test instruments.

Feasibility Analysis of Learning Devices

The suitability of a learning tool can be determined through a validity test carried out by a validator using expert validation and practitioner validation sheets. Data analysis uses a Likert scale. Percentage of learning device product validation using equation 1.

$$\text{Validity}(v) = \frac{\text{total validation score}}{\text{maximum total score}} \times 100\% \quad (1)$$

The percentage data obtained is converted based on the learning device validation criteria, namely 85.01%-100% (very valid), 70.01%-85% (fairly valid), 50.01%-70% (less valid), 0%- 50% (invalid) (Fatmawati, 2016). The reliability of this research uses the Borich (1994) method known as Percentage of Agreement (PA), namely the percentage of agreement between assessors which is a percentage of value agreement between the first researcher and the second researcher. PA can use equation 2. The instrument is said to be reliable if the percentage agreement value is more or equal to 75%. If the calculation result is less than 75%, it must be tested for clarity and approval from the validator (Borich, 1994).

$$(\text{PA}) = \left(1 \frac{A-B}{A+B}\right) \times 100\% \quad (2)$$

Analysis of the Practicality of Learning Devices

This practicality data analysis was obtained from the results of student responses, then analyzed to determine the level of practicality of the product being developed. The data analysis technique used to find the practicality value uses equation 3. The practicality test results are converted based on the practicality criteria in Table 1.

$$\text{Practical Score (\%)} = \frac{\text{total score obtained}}{\text{maximum total score}} \times 100\% \quad (3)$$

Table 1. Learning Device Practicality Criteria

Range	Classification
85 - 100	Very Practical
70- 85	Practical
50- 70	Quite Practical
01 -50	Impractical

(Nurjannah, 2011)

Analysis of the Effectiveness of Learning Tools

The effectiveness of learning tools is analysed through student test instruments, namely pretest and posttest scores. Analysis of improvements in student learning outcomes can be calculated using the Solikha (2020) method with the N-Gain test. The amount of N-Gain can be calculated using Equation 4. The criteria for the level of effectiveness of the student worksheets (LKPD) used are shown in Table 2.

$$N - \text{gain} = \frac{S_{\text{posttest}} - S_{\text{pretest}}}{S_{\text{maksimal}} - S_{\text{pretest}}} \times 100 \% \quad (4)$$

Table 2. Product effectiveness percentage criteria

Rage	Classification
85-100	Very effective
70-85	Effective
50-70	Effective enough
01-50	Ineffective

(Solikha, 2020)

Result and Discussion

Define Stage

The define stage is the initial stage in the learning planning process, which aims to obtain relevant information related to problems that arise during the implementation of learning in the classroom. This stage also involves collecting information regarding the curriculum used by the teacher, learning materials, learning models, learning methods, and student characteristics. This stage is divided into five activities: beginning-to-end analysis, analysis of students' abilities, concept analysis, task analysis, and specification of learning objectives. The initial analysis started from observation activities, with the results finding compatibility between using an independent curriculum oriented towards student activity and with teaching methods that still used conventional teacher-centred methods. This causes an imbalance between the roles of teachers and students, where teachers are more dominant in the learning process. Apart from that, the interview results also revealed that the learning tools needed to be completed, especially using student worksheets (LKPD) in the classroom, which was still

rare. Therefore, at this stage, the problems can be seen in the final analysis, namely the need to develop LKPD based on problem-based learning assisted by PhET simulations to increase students' mastery of concepts.

The LKPD developed was applied to three meetings through task analysis, which included the Pancasila Student Profile and Phase F Learning Outcomes by the Newton's Law material used. Of course, concept analysis is needed through task analysis to identify concepts that students must understand and master. The final stage is the specification of learning objectives to formulate learning objectives based on the Pancasila Student Profile, Learning Achievements, and Flow of Learning Objectives on Newton's Law material.

Design stage

The design stage is designing the initial draft of Newton's Law LKPD based on the problem-based learning model. However, in developing the LKPD, other supporting learning tools are needed, such as Learning Achievements, Learning Goal Flow, Learning Modules and concept mastery ability test instruments. Therefore, the products that will be produced are Newton's Law LKPD, Learning Achievements, Learning Goal Flow, Learning Modules and concept mastery ability test instruments designed to collect results in the form of data on students' improvement in mastering concepts using Newton's Law material.

Develop Stage

The development stage is the stage for producing development products, carried out through product validation tests and limited trials. The validation test in this development stage aims to assess three expert validators and three practitioner validators regarding the developed product, namely LKPD based on Problem-Based Learning assisted by PhET simulations. Practical learning tools can be seen from the learning implementation sheet and students' responses to the learning tools used. Practical learning tools can be seen from students' pretest and posttest scores. The Reliability of learning tools aims to determine whether the learning tools developed can be trusted. The Reliability of this research uses the Borich method, which is known as Percentage of Agreement (PA). The results of calculating the Reliability of the learning tools developed can be seen in Table 5.

Table 3. Validation Results by Expert Validators

Product	Validity (%)	Category
LKPD	91,05	Very Valid
Learning Outcomes	93,33	Very Valid
Flow of Learning Objectives	90,74	Very Valid
Teaching Module	87,88	Very Valid
Test Instruments	87,50	Very Valid

Table 4. Validation Results by Practitioner Validators

Product	Validity (%)	Category
LKPD	93,18	Very Valid
Learning Outcomes	90,83	Very Valid
Flow of Learning Objectives	94,45	Very Valid
Teaching Module	91,67	Very Valid
Test Instruments	94,79	Very Valid

Based on the validity and reliability results obtained in this research, the product produced can be feasible because it has been proven to be very valid and reliable. This can be seen from the average values obtained, namely LKPD 91.05% and 93.18% (very valid), Learning Achievements 93.33% and 90.83% (very valid), Learning Goal Flow 90.74% and 94.45% (very valid), teaching module 87.88% and 91.67% (very valid) concept mastery test instrument 87.50% and 94.79% (very valid). Meanwhile, the reliability value for LKPD is 93.64%, Learning Achievement is 92.07%, Flow of Learning Objectives is 94.30%, Teaching Module is 91.94%, and the concept mastery test instrument is 94.46%.

Table 5. Learning Device Reliability Results

Product	Hasil Validasi (%)	Category
LKPD	93,64	Reliabel
Learning Outcomes	92,07	Reliabel
Flow of Learning Objectives	94,30	Reliabel
Teaching Module	91,94	Reliabel
Test Instruments	94,46	Reliabel

Practicality Analysis Results

The practical analysis in this research used an observation sheet on the implementation of learning

given to physics subject teachers and a student response questionnaire regarding the implementation of learning activities in class 11 at SMAN 1 Praya, Central Lombok Regency. The results of the assessment by physics subject teachers and students regarding the learning carried out can be seen in Table 4 and Table 5.

Table 6. Results of the implementation of learning activities

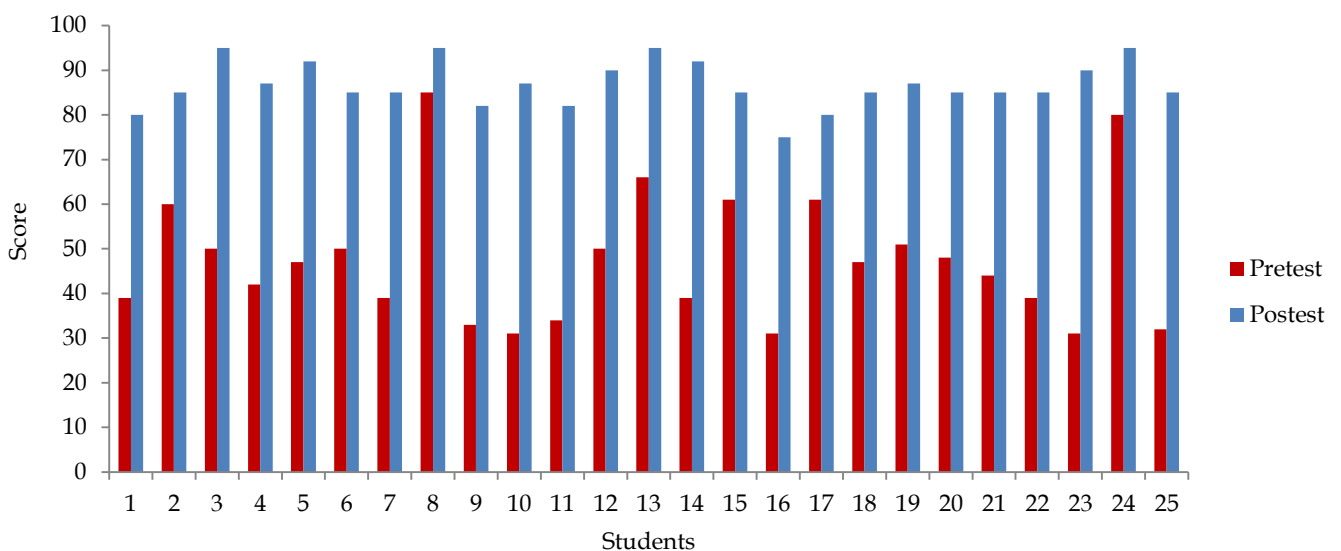
Meeting	Practical Score (%)	Criteria
I	90.00	Very Practical
II	95.00	Very Practical
III	91.25	Very Practical
Average	92.08	Very Practical

Table 7. Hasil analisis angket respon peserta didik

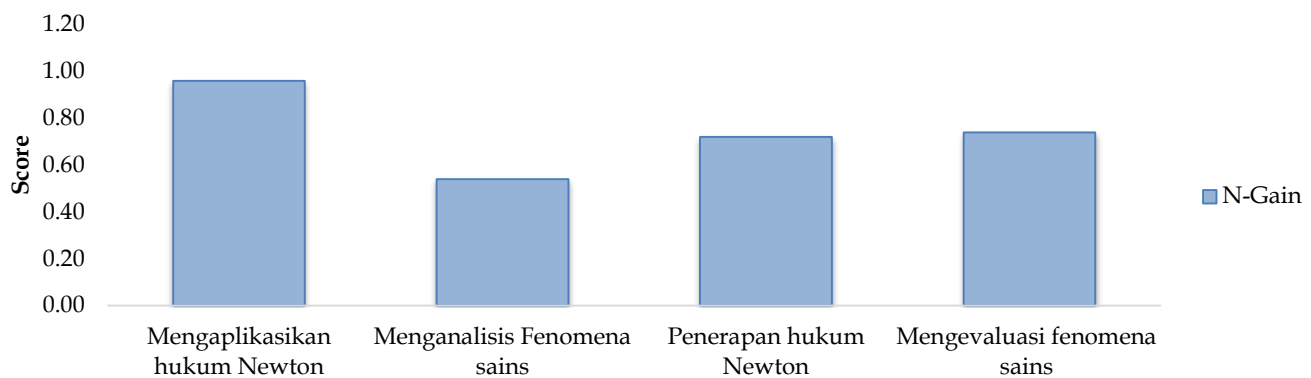
Statement	Average (%)	Criteria
SS	54.11	
S	27.87	
TS	0.00	
STS	0.11	
Average	82.10	Very Practical

Effectiveness Analysis Results

The effectiveness of learning tools is analysed to determine the effectiveness of the learning tools developed. The effectiveness of the learning tools can be seen from the pretest and posttest results given before and after learning, consisting of 10 questions with cognitive domains from C3-C6. The students' pretest and posttest results were then analysed using the N-Gain test. The following students' pretest and posttest scores can be seen in Figure 1.



Gambar 1. Student Pretest and Posttest Results



Gambar 2. N-Gain mastery of concepts per indicator

The increase in students' mastery of physics concepts based on the N-Gain test, if classified in the cognitive domain, can be seen in Figure 2. The increase in students' mastery of physics concepts the enhancement of student's understanding of physics principles is evident in Figure 1's comparison between pretest and posttest outcomes. The data illustrates that posttest scores surpass pretest scores, indicating an improvement in mastery. Figure 1 shows that the posttest scores are higher than the pretest scores. This is because applying LKPD in learning helps students understand and strengthen their cognitive structures, resulting in increased mastery of concrete concepts. The pretest and posttest outcomes underwent analysis utilizing the N-Gain test to assess the efficacy of the created educational resources. The results of the N-Gain test obtained an average value of 0.74, with the effectiveness interpretation category being quite effective. Specifications for the number of students in the high category are 18, and the medium category is 7.

Students' mastery of concepts is classified into the cognitive domain, as shown in Figure 2. This shows that students' learning outcomes have increased in each indicator. This is, of course, due to the influence of the LKPD applied in learning, so the LKPD learning tools developed are very effective in improving students' mastery of physics concepts.

Conclusion

Based on the results of the research and discussion, a conclusion can be drawn from this development research, namely that the LKPD based on problem-based learning assisted by PhET, which was developed, is feasible, practical and effective to be used to improve students' mastery of physics concepts by obtaining average test scores for validity, practicality and effectiveness. Respectively, namely 91.55% (valid category), 87.09% (very practical category) and 0.74 (quite effective category).

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Conflicts of Interest

The authors declare no conflict of interest

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