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The Development of Problem-based Learning Worksheet for the Material of Optical Instruments

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ABSTRACT

Student learner-centered creates interaction and activeness of teaching and learning activities in the classroom. Students can play an active role in learning by using Problem-Based Learning (PBL) based student worksheets. This study aims to 1) Know the results of the development of student worksheets Problem-Based Learning (PBL) on optical instrument material, 2) Know the quality/feasibility of student worksheets Problem-Based Learning (PBL) on optical instrument material, 3) Know the response of students to student worksheets Problem-Based Learning (PBL) on optical equipment material. This research is a Research & Development using 4D development procedures by Thiagarajan. The development phase includes define, design, develop, and disseminate, but this research is limited to the develop stage by conducting limited and field tests. The product developed is a student worksheet based on Problem Based Learning (PBL) on optical instruments for high school students. The quality of student worksheets based on Problem-Based Learning (PBL) on optical instrument material for Senior High School class XI which was developed based on the assessment of material experts, media experts and physics teachers obtained Very Good (VG) criteria. The response of students to student worksheet in limited trials and field trials obtained Very Good (VG) criteria. These results show that student worksheets based on Problem-Based Learning (PBL) can be used as teaching material in the learning process on optical instrument materials.

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INTISARI

Pembelajaran yang berorientasi pada peserta didik mendorong terciptanya interaksi dan keaktifan kegiatan belajar mengajar di kelas. Peserta didik dapat berperan aktif dalam pembelajaran dengan menggunakan Lembar Kerja Peserta Didik (LKPD) berbasis *Problem Based Learning* (PBL). Penelitian ini bertujuan untuk 1) Mengetahui hasil pengembangan LKPD *Problem Based Learning* (PBL) pada materi alat optik, 2) Mengetahui kualitas/kelayakan LKPD *Problem Based Learning* (PBL) pada materi alat optik, 3) Mengetahui respon peserta didik terhadap LKPD *Problem Based Learning* (PBL) pada materi Alat Optik. Penelitian ini merupakan penelitian pengembangan (*Research & Development*) menggunakan prosedur pengembangan 4D oleh Thiagarajan. Tahap pengembangan meliputi *define* (pendefinisian), *design* (perancangan), *develop*

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(pengembangan), dan *disseminate* (penyebaran), namun penelitian ini dibatasi sampai tahap *develop* (pengembangan) dengan melakukan uji coba terbatas dan uji luas. Hasil penelitian ini adalah LKPD berbasis *Problem Based Learning* (PBL*)* pada materi alat optik untuk peserta didik SMA/MA. Kualitas LKPD berbasis *Problem Based Learning* (PBL*)* pada materi alat optik untuk SMA/MA kelas XI yang dikembangkan berdasarkan pada penilaian ahli materi, ahli media dan guru fisika memperoleh kriteria Sangat Baik (SB). Respon peserta didik terhadap LKPD pada uji coba terbatas dan uji coba luas mendapatkan kriteria Sangat Baik (SB). Hasil tersebut menunjukkan bahwa LKPD berbasis *Problem Based Learning* (PBL) dapat digunakan sebagai bahan ajar dalam proses pembelajaran pada materi alat optik.

A. Introduction

Physics is a natural science that studies the nature, phenomena, and interactions of nature that have a significant impact on human life. However, physics is still considered difficult because of the many abstract equations and concepts, as well as the boring and incomprehensible learning traits of students [1]. The purpose of learning physics is to not only help students comprehend concepts and principles, but also to enhance their knowledge and confidence, preparing them for higher education. Additionally, students can learn life-enhancing science and technology.

Current learning still focuses on teachers as central figures in the educational process. In fact, the curriculum requires learner-centered learning to enhance students' active participation in the classroom [2]. One of the learning models that fosters student activeness is problem-based learning (PBL) [3]. Problem-Based Learning (PBL) presents students with real-life problems in order to encourage them to be more active and cooperative in collecting information, fostering independence, and developing critical thinking skills [4]. The implementation of this model requires guidelines containing activities to solve a problem in the form of teaching materials, namely Student Worksheets [5]. Teachers expect student worksheet to enhance students' critical thinking skills, information analysis, and ability to compile activity results [6]. student worksheet are student work guidelines that can facilitate the implementation of learning so that students master certain competencies. student worksheet is a tool that can help students understand concepts and build on the knowledge gained to create a positive learning environment [7].

An interview with a physics teacher at SMA N 10 Purworejo revealed that students still struggle with optical instruments, particularly loupes and binoculars. The most difficult part is determining magnification with a microscope and binoculars. This is due to the memorization of concepts and calculations, rather than a thorough understanding. The limited availability of optical instruments in schools has led to a learning process that primarily focuses on theoretical concepts. In fact, optics is part of physics that is close to everyday life [8]. Students still need a direct picture of optical instruments, such as binoculars' original shape. Teachers still use teaching materials like text books and student worksheets, but they haven't utilized them to their full potential. Student worksheet contains concise material and practice questions that are not mastered by students, so they are unable to solve inquiries well. In addition, the physics teacher at SMA N 10 Purworejo reports that students exhibit a preference for the approach that facilitates problem-based learning. This is supported by Hendrayani's research [9], which shows that problem-based learning (PBL) effectively gives learners the freedom to work through their own problems and conduct research so as to improve their understanding of concepts.

The distribution of questionnaires to students at SMA N 10 Purworejo reveals that the use of teaching materials (textbooks and student worksheet) in physics learning has not reached its full potential. The Student worksheet used in physics learning is colorless and less attractive, so students feel bored with it. The lack of completeness in the presentation of optical instrument material in student worksheet causes difficulties for students in understanding the concepts taught. Additional problems arise because the level of difficulty of the practice questions given by the teacher is not in line with the example questions contained in the textbook and Student worksheet, making it difficult for students to do them. When the teacher presents material solely based on similarities, students often memorize it without comprehending the concepts, leading to easy forgetting. In addition, students consider optical instrument material to be one of the more difficult materials, especially in determining shadow formation and calculating magnification in optical instruments. Due to the limited availability of optical instruments and the infrequent practicum activities, students often struggle to understand the material and struggle to solve problems related to their daily lives.

Based on the observations, the student worksheet was colorless, limited compatible images with optical instrument materials such as loupes, binoculars, microscopes, and cameras. student worksheet contains a design for an experiment to find the correlation between distance, shadow distance, and focal distance in convex and concave lenses, but there are no experimental steps. This prevents students from conducting experiments on student worksheet, thereby reducing their proficiency in using optical instruments.

The aforementioned issues demonstrate the need for teaching materials that not only facilitate learning but also cater to the specific needs of students when it comes to physics instruction on optical instruments. Additionally, we anticipate that these materials will aid students in comprehending the subject matter. The focus of this research will be the "Development of student worksheet Based on Problem-Based Learning (PBL) on Optical Instruments Materials."

B. Method

This research employs the research and development (R&D) method to develop new products. Thiagarajan [10] introduced the 4D model, comprising four stages: define, design, develop, and disseminate. In this study, the stages of product development are limited to the development stage, the extensive trials. The development research culminated in the creation of a student worksheet by utilizing problem-based learning (PBL) on optical instrument material.

The researchers used non-test instruments such as interview sheets, questionnaire sheets, instrument validation sheets, program validation sheets, assessment sheets, and student response sheets for data collection. This study yielded two types of data: qualitative and quantitative. Qualitative data includes input and suggestions from the validation and assessment process (material experts, media experts, and physics teachers). Material experts, media experts, and physics teachers combine quantitative data, or numerical data from measurements or observations, with qualitative data on the assessment sheet for evaluation.

The applied data analysis is qualitative and quantitative. Qualitative descriptive data analysis describes the results of interviews and advice from experts [11]. Expert validation, expert assessment, and student responses to the developed product serve as the basis for quantitative descriptive data analysis, which determines the level of product quality [11]. The researchers carried out quantitative descriptive data analysis by processing data in the form of numbers obtained through questionnaires.

The validation instrument used by media experts and material experts is a questionnaire with questions compiled by the researcher himself. Calculating validity with Aiken's V [12] according to equation 1:

$$\mathrm{V} = \frac{\Sigma s}{[n(c-1)]} \quad \text{with } \mathrm{s} = \mathrm{r} - l_0 \qquad (1)$$

Information:

L_0 = Lowest scoring score
c = Highest scoring score
r = Score given by the rater
n = Number of experts assessing

Table 1. Average Score Percentage Criteria

Score Percentage (V)	Criteria
V≤0,5	Invalid
V>0,5	Valid

Product eligibility is assessed using a Likert scale with a maximum score of four and a minimum score of one. The final score is generated by summing all indicator scores and then averaging them to establish the percentage of product viability [13]. Table 1.2 shows the range of assessment scores. Equation 2 is used to calculate the average assessment score from physics experts and teachers [14].

$$X_{average} = \frac{\sum x}{N.n} \quad (2)$$

Information:

$X_{average}$ = Average score
$\sum x$ = Total score obtained from research
N = Number of Assessors
n = Number of questions

Table 2. Criteria for Average Percentage Score

Percentage	Criteria
1,00 – 1,75	Very Not Good (Poor)
1,76 – 2,50	Low Good (Under average)
2,56 – 3,25	Good (Excellent)
3,26 – 4,00	Very Good (Extremely Excellent)

Student response scoring is assessed using a Likert scale with a maximum score of four and a minimum score of one. To analyze the response of learners can use equation 3. The results of the percentage of learner responses are then interpreted in qualitative statements based on table 2.

C. Result and Discussion

This development research produces teaching materials in the form of student worksheet based on Problem-Based Learning (PBL) on optical instrument materials. This research uses Thiagarajan's 4D model (define, design, development, disseminate) and is limited to the development stage with extensive testing. The define stage is the first step to determine the needs of the learning process and analyze it appropriately. Needs analysis was obtained from teacher interviews and dissemination of preliminary study questionnaires to students.

The second stage is design with three main activities, namely media selection, format selection and product initial design. First, media selection identifies the right learning media with the characteristics of the material and according to the needs of students. Second, in choosing the format of teaching materials that are adjusted to the results of needs in the form of student worksheet based on Problem-Based Learning (PBL) on optical tool materials. The sections of student worksheet are adapted from

Elfina & Sylvia's research [15], including the title of student worksheet, subjects to be taken, semesters, places, study instructions, competencies to be achieved, learning indicators, supporting information, tools and materials in working on student worksheet, work steps, and assessments. Third, namely the preparation of the initial design of the product. The initial design of student worksheet is prepared in Canva and the steps of student worksheet activities based on Problem-Based Learning (PBL). In the manufacture of student worksheet products with instructions for use, experimental activities, and pictures of optical instruments.

The third stage is development with two activities, namely expert appraisal and developmental testing. Expert appraisal is an activity to validate and assess the feasibility of product design carried out by experts in their fields. For example, its activities are validation and assessment of product development. Developmental testing is a product design trial activity that involves actual subjects. Examples of activities are student response tests.

The development stage includes validation to create a final product that undergoes validity testing. The validation stages include instrument validation and student worksheet product validation. Instrument validation involves two instrument experts, and student worksheet product validation involves two material experts and two media experts. The instrument validation results are declared. The instrument is declared valid with an Aiken's V coefficient value of 0.90. This suggests that future use of the instrument is possible. In the expert validation phase, the material comprises 21 statements that address various aspects such as core competencies and basic competencies, the veracity of a concept or material, language and writing skills, presentation systematics, and problem-based learning (PBL). The media validation consists of 11 statements covering the display aspect. The material expert validation results are as follows:

Table 3. Material Expert Validation Results

Aspect	Aiken's V	Criteria
Material Aspect with KI and KD	1.00	Valid
Aspect of The Truth of A Concept/Material	0.91	Valid
Aspect of Language and Writing	0.95	Valid
Supporting Aspects of Learning Materials	0.88	Valid
Aspect of Presentation Systematics	1.00	Valid
Aspect of Problem-Based Learning (PBL)	1.00	Valid
Average	0.96	

Table 4. Media Expert Validation Results

Aspect	Aiken's V	Criteria
Display Aspect	0.92	Valid
Average	0.92	

Product quality assessment determined whether the revised product 1 was feasible or not based on the assessment of material experts, media experts and teachers. The following are the results of material expert assessments, media expert assessments and teacher assessments.

Table 5. Material Expert Assessment

Aspect	Aiken's V	Criteria
Material Aspect with KI and KD	3.67	Very Excellent
Aspect of The Truth of A Concept/Material	3.25	Excellent
Aspect of Language and Writing	3.00	Excellent
Supporting Aspects of Learning Materials	3.33	Excellent
Aspect of Presentation Systematics	3.25	Excellent
Aspect of Problem-Based Learning (PBL)	3.21	Excellent
Average	3.21	

Table 6. Media Expert Assessment

Aspect	Aiken's V	Criteria
Display Aspect	3.36	Very Excellent
Average	3.36	

Table 7. Teacher Assessment

Aspect	Aiken's V	Criteria
Material feasibility aspect	4.00	Very Excellent
Aspect of material accuracy	4.00	Very Excellent
Aspects of material presentation	3.66	Very Excellent
The graphic aspect	3.66	Very Excellent
Aspect of Problem-Based Learning (PBL)	4.00	Very Excellent
Average	3.83	

Problem-based learning (PBL) products, developed by material experts, media experts, and physics teachers, undergo a quality assessment stage. The researchers conducted both limited and extensive trials as part of the trial process. Here are the results of limited and extensive trials.

Table 8. Limited Trials

Aspect	Aiken's V	Criteria
User Friendly Aspect	3.41	Very Excellent
Display Aspect	3.38	Very Excellent
Average	3.39	

Table 9. Extensive Trials

Aspect	Aiken's V	Criteria
User Friendly Aspect	3.24	Excellent
Display Aspect	3.13	Excellent
Average	3.18	

D. Conclusion

This research generates a student worksheet that utilizes problem-based learning (PBL) with an emphasis on optical instrument materials. The developed student worksheet, based on Problem-Based Learning (PBL), exhibits a very excellent quality (VG) rating proved by the assessment of material experts, media experts, and physics teachers, with the obtained category of Very Excellent (VG) with means of 3.56, 3.28, and 3.86. Student responses to the student worksheet based on Problem-Based Learning (PBL), developed in limited trials and broad trials, fall under the Very Excellent (VG) criteria based on the mean scores: 3.4 in limited trials and 3.2 in extensive trials.

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