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Development of Student Worksheets Based on HOTS Model Problem Based Learning to Improve Student Learning Outcomes

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ABSTRACT
This study aims to develop Higher Order Thinking Skills - based Student Worksheets using the Problem Based Learning model to improve student learning outcomes. This research is a Research and Development study and uses the 4D (Define, Design, Develop, and Disseminate) development model. The developed student worksheets has been validated by media experts with a score of 89.50% and by subject matter experts, showing content feasibility of 83.45% and linguistic aspects of 91.42%. The results of the pilot test through a student response questionnaire obtained an average score of 82%, which indicates a very practical category. Meanwhile, student learning outcomes showed an average score of 57.96% with a moderate category. Thus, it can be concluded that the HOTS-based student worksheets using the Problem Based Learning model has been tested and is feasible for use as teaching material in physics practicums.

INTRODUCTION

The 21st century is known as the century of knowledge that demands creativity, higher-order thinking skills, and adequate life skills to deal with the complexity of global issues [1]. One of the important competencies that students must have is Higher Order Thinking Skills, which are the abilities to think critically, creatively, analytically, and to be able to solve problems independently [2]. This competency is becoming increasingly relevant because 21st-century learning emphasizes a student centered learning approach that demands more complex cognitive activities.

In the context of education, students are no longer positioned solely as recipients of information through lecture-based methods, but are required to be actively involved in the learning process. In developing physics teaching materials to integrate students' interests and help them understand physics concepts through contexts that are close to their lives [3]. Critical and creative thinking skills are a must for students to be able to student worksheets deal with real-world problems comprehensively. One of the learning tools that can facilitate the development of these skills is the Student Worksheet.

Student worksheets is a medium to help and facilitate active and effective interaction between students and learning resources, thereby improving their learning outcomes [4]. Effective student worksheets not only contains supporting information, but also activities and questions that encourage higher-order thinking processes. Student worksheets can develop students' skills [5]. The integration of HOTS in student worksheets can help students think critically and solve problems [6]. Therefore, student worksheets that meets the demands of 21st-century learning is needed.

The quality of student worksheets greatly affects student learning outcomes. Teaching materials such as student worksheets must attract students' attention and make them interested in learning, understanding, and mastering concepts [7]. Student worksheets components consist of titles, learning instructions, basic competencies or subject matter, supporting information, work steps, and assessments [8]. However, the results of interviews conducted by researchers with science teachers at a school in Palu City showed that the student worksheets used was still not optimal in developing HOTS skills. Although the structure of the student worksheets was in accordance with the student activity guidelines, the exercises and questions presented still focused on basic skills and did not challenge students to think critically, creatively, and analytically.

In addition to the quality of student worksheets, the learning model also plays an important role in developing students' HOTS. One of the models recommended in the 2013 curriculum is Problem Based Learning. Problem Based Learning is one of the learning models that can be applied because it encourages students to think critically, be skilled at solving problems, connect knowledge about problems, and real-world issues [9]. PBL encourages students to learn through authentic problem solving that requires the ability to analyze, evaluate, and create solutions. Conceptually, HOTS and PBL are strongly related because both emphasize higher-order thinking processes through investigation, data processing, communication, and logical conclusion drawing [10] [11].

Several previous studies have shown that HOTS-based student worksheets are effective in improving learning outcomes. Research by Nadhiroh Nuraini (2018) shows that HOTS based student worksheets on thermodynamics material are very feasible with validation from subject matter experts (92%) and media experts (100%), as well as effective in trials [12]. Research by Noprinda & Soleh (2019) also showed that HOTS-based student worksheets on static electricity material had validity and was effective in improving learning outcomes [13]. However, these studies did not specifically apply HOTS-based student worksheets to physics material in a school in Palu City and did not fully integrate PBL syntax into the student worksheets structure.

This study aims to develop and test the feasibility of HOTS-based Student Worksheets with the Problem Based Learning model as an effort to improve student learning outcomes. The developed student worksheets is expected to not only help teachers in identifying misconceptions that are still experienced by students, but also serve as a basis for designing more effective learning strategies in line with the demands of the 21st century. In addition, this student worksheets is expected to be used by students as a means of independent learning to assess, deepen, and improve conceptual understanding. The results of this study are expected to make a real contribution to improving the quality of learning at the secondary school level and to serve as a reference in the development of student worksheets for other physics materials and the broader field of science.

METHOD

This study used the Research and Development method with the 4-D model developed by S. Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel in 1974 [14]. The 4-D model consists of four stages, namely define, design, develop, and disseminate. However, the dissemination stage was not carried out because it required a large sample, high costs, and a long time. Therefore, this study only carried out three stages, namely define, design, and develop.

The research subjects consisted of 27 grade XI students from a public high school in Palu City who had studied physics on the topics of temperature and heat, kinetic theory of gases, and the laws of thermodynamics. The research was conducted following the steps of the 4-D model as follows Table 1.

Table 1. Stages of the 4-D Model

Stage	Description of Activities
Define	Analyzing learning needs through: (a) initial-final analysis to identify gaps in learning conditions, (b) task analysis, (c) concept analysis, and (d) formulation of learning objectives.
Design	Designing student worksheets prototypes through: (a) selection of relevant teaching materials, (b) determination of student worksheets format, and (c) preparation of initial designs. This stage produces initial products.
Develop	Developing the product through: (a) validation by subject matter experts and media experts, (b) revision based on validator suggestions, and (c) limited testing (simulation) with students to assess practicality.
Disseminate	Not applied in this study.

Research instruments are used to obtain data on validity, practicality, and effectiveness. The instruments consist of expert validation sheets, teacher response questionnaires, student response questionnaires, and learning outcome tests.

Table 2. Research Instruments

Instruments	Number of Items	Scale	Sample Item
Expert validation sheet (material & media)	15-25	Strongly disagree to Strongly agree	"Student worksheets helps students develop higher-order thinking skills (HOTS)."
Teacher response questionnaire	10-15	Strongly disagree to Strongly agree	"Student worksheets is easy to use in the learning process."
Student response questionnaire	10-20	Strongly disagree to Strongly agree	"The activity instructions in the Student worksheets are easy to understand
Learning outcome test	10-20	Nominal scale	HOTS questions related to physics material..

Validation is carried out by two experts, namely one media expert and one subject matter expert, with the following qualifications: the media expert holds a Master's degree in physics education, while the subject matter expert holds a Bachelor of Science. The validators assess the feasibility of the content, presentation, language, and construction of the student worksheets. Suggestions and comments from the validators are used to improve the product before it is tested.

Data analysis was conducted to determine the level of validity, practicality, and effectiveness of HOTS-based student worksheets using the Problem-Based Learning model. Validity analysis was carried out by calculating the average score using the established formula. By calculating the total score for each assessment aspect, the following formula is used.

$$\bar{x} = \frac{\sum x}{n} \quad \ldots (1)$$

Explanation:
$\bar{x}$ = Average assessment score
$\sum x$ = Total score obtained
n = Number of statements
Percentage of eligybility:

$$\text{Result} = \frac{\text{Total score obtained}}{\text{maximum score}}\ x\ 100\% \quad \ldots (2)$$

The percentage of eligibility obtained is then categorized based on the media eligibility criteria as presented in Table 3.

Table 3. Media Suitability Criteria

No	Score in percent %	Eligibility Category
1.	< 21 %	Very unfit
2.	21-40 %	Ineligible
3.	41-60 %	Fairy acceptable
4.	61-80 %	Worthy
5.	81-100 %	Highly acceptable

The student worksheets is declared valid if it falls into the "suitable" or "highly suitable" category.

The practicality of the student worksheets was assessed based on the results of questionnaires completed by teachers and students, which were then calculated using the formula:

$$\text{Practicality} = \text{P} = \frac{\text{F}}{\text{N}}\ \text{x}\ 100\% \quad \ldots (3)$$

Explanation:
P = percentage of practicality
F = total score obtained
N = maximum score
The percentage of practicality assessment results is then interpreted using the practicality criteria shown in Table 4.

Table 4. Criteria for Practicality Scoring

Percentage (%)	Criteria
0 – 20 %	Not practical
21 – 40 %	Less practical
41- 60 %	Fairy practical
61 – 80 %	Practical
81 – 100 %	Very practical

Student worksheets is considered practical if the percentage falls within the 61-80% category.

The effectiveness of student worksheets is calculated based on pretest and posttest scores using the standard gain (N-Gain) formula:

$$\text{Std} < g > = \frac{\underline{\times}\, after - \underline{\times}\text{ before}}{\underline{\times}\text{ max} - \underline{\times}\text{ before}} \qquad \dots (4)$$

Nilai N-gain yang diperoleh kemudian diinterpretasikan berdasarkan kriteria indeks N-gain sebagaimana disajikan pada Tabel 5.

Table 5. Interpretation of the N-gain Index

N-gain Score (g)	Interpretation
g > 0,7	High
0,7 > g > 0,3	Moderate
g > 0,3	Low

Student worksheets is declared effective if the N-gain value is in the high category (0.7).

RESULTS AND DISCUSSIONS

1. Definition Stage (*Define*)

A pre-development study was conducted to identify the need for learning tools, particularly physics worksheets at a high school in Palu City. Observations and interviews with teachers showed that worksheets had been used, but most of them still focused on LOTS questions and did not integrate the PBL model and higher-order thinking skills. Conventional worksheets were often procedural and did not challenge students' analytical abilities.

Task analysis showed that the activities provided were still in the form of memorization and comprehension, thus not encouraging critical thinking or problem solving processes. Therefore, the development of HOTS-based student worksheets was considered important to encourage analytical (C4), evaluation (C5), and creative (C6) skills.

Concept analysis was conducted based on the 2013 curriculum, covering the topics of temperature and heat, gas kinetic theory, and the laws of thermodynamics. These three topics are suitable for the PBL approach because they contain contextual phenomena and relationships between variables that can be investigated through experiments. Learning objectives were formulated based on experiments so that students would analyze the factors that influence changes in temperature and heat, explain the relationship between gas pressure and volume empirically, and analyze the relationship between work, heat, and energy in thermodynamic processes. These objectives are also aimed at facilitating higher-order thinking skills in line with the demands of 21st-century learning.

2. Design Stage

This stage produces an initial prototype of the student worksheets through three steps. The first step is the selection of teaching materials. Materials are selected based on basic competencies and relevance to the development of HOTS. The three topics (heat, gas kinetics, thermodynamics) were chosen because they allow students to observe phenomena, analyze variable relationships, and solve problems through investigation.

The second step is format selection. The format is designed with reference to the 2013 curriculum, using C4–C6 level HOTS questions. The layout uses A4 paper, 2.45 cm margins, 1.15 spacing, and Times New Roman font for consistency and readability.

The third step involves the initial design. The cover, student worksheets and basic competency usage guide, indicators, learning objectives, reading materials, experiment targets, practicum objectives, experiment targets, experiment purpose, and observation tables are included in the initial design of the student worksheet, along with discussion or assignment sections. A light brown color is used for the student worksheets to make them simpler and less conspicuous, thereby reducing students' tension or intimidation toward the learning material.

3. Development Stage

This stage is aimed at obtaining improved student worksheets based on expert input. It includes validation by experts followed by revision, as well as simulation, which is the activity of implementing the learning design. The results of the development of HOTS-based student worksheets are presented in the following Figure 1.

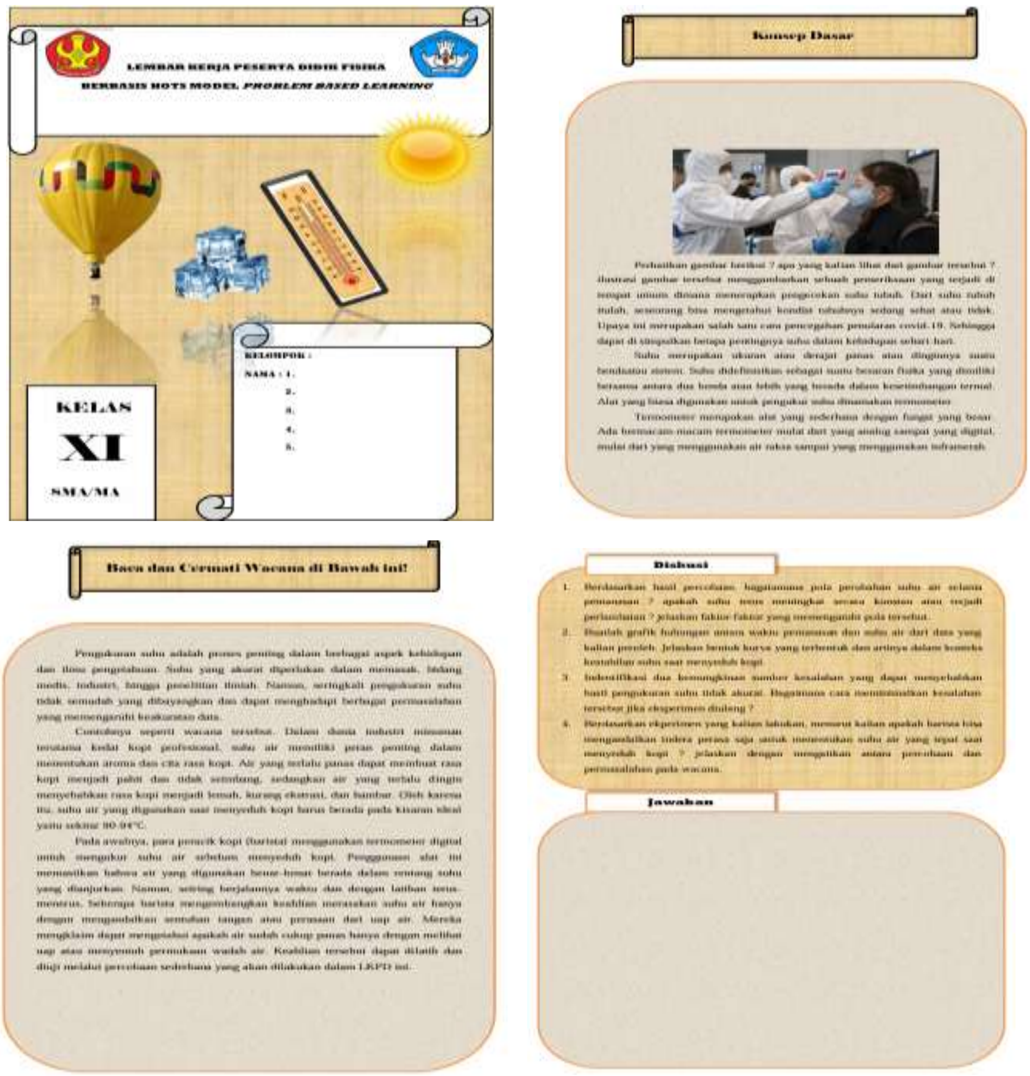

Fig 1. *Student Worksheets Display*

3.1 Media Expert Validition

The results of the media expert validation are presented in Table 6, which includes assessments of cover design and content design.

Tabel 6. Results of Media Expert Validition of Student Worksheet

Aspek	Persentase	Kategori
Cover design	91 %	Very good
Content design	88%	Very good

Experts assessed the student worksheets as interesting, consistent, and appropriate for high school students. Minor revisions were made to the font size and color to make it easier to read.

3.2 Expert Validation of Material per Aspect

The detailed results of the expert material validation can be seen in Table 7, which evaluates content suitability and language aspects.

Tabel 7. Result of Expert Material Validation

Aspect	Indicator	Percentage	Categori
Content suitability	Material relevance	70%	Suitable
	Accuracy of material	86%	Highly suitable
	Presentation & readability	95%	Very good
Language	Clear	90%	Very good
	Communicative	100%	Highly suitable
	Dialogic-interactive	80%	Suitable
	Language rules	92%	Highly suitable

In general, the student worksheets is, although improvements are needed in the learning indicators to make them more specific and operational.

3.3 Practicality Test

Student responses regarding the practicality of the worksheets are summarized in Table 8.

Tabel 8. Results of Student Respoense Qustionnaire Analysis

Indicator	Percentage	Categori
Student involvement	81%	Very practical
Concept understanding and mastery	83%	Very practical
Clarity of student worksheets	82%	Very practical

Students find the student worksheets easy to use, clear, and helpful in understanding the material through discussion and experimentation.

3.4 Effectiveness Test

The effectiveness of the worksheets, based on pretest and posttest scores, is presented in Table 9.

Tabel 9. N-gain Score Result

Statistic	Pretest	Posttest
Highest score	70	95
Lowest score	15	60
Average	43,33	78,70

The N-gain value is calculated as follows: g = 0.58 moderate category (0.3 g 0.7).

The validation results show that the student worksheets meets the category of highly feasible. This is in line with the theory that an effective student worksheets must be interesting, easy to use, and relevant to the material requirements [15] [16]. The integration of PBL syntax (problem orientation, organization, investigation, presentation, evaluation) strengthens the structure of the student worksheets so that it is more focused and contextual.

High practicality indicates that the student worksheets is easy for students to use. This is because it provides clear work steps, real-world problem discourse, simple experiments using tools available at school, and analytical questions that guide students' thinking patterns.

The N-gain value of 0.58 is in the moderate category, indicating a significant but not yet optimal improvement. The contributing success factors include the ability of the student worksheets to guide students in analyzing physical phenomena independently, the use of the PBL model that encourages discussion and active interaction, and the inclusion of HOTS tasks that stimulate critical thinking skills. Meanwhile, the factors limiting effectiveness include students needing time to adapt because they are not yet accustomed to HOTS questions, limited learning time for independent exploration, and limited laboratory equipment that causes some experiments to be carried out as demonstrations rather than individually.

The literature states that PBL-based learning outcomes usually improve gradually because they require an adaptation of mindset. Therefore, a moderate improvement category (0.58) is a reasonable and pedagogically valid result.

CONCLUSION AND SUGGESTION

This study successfully developed Higher Order Thinking Skills based Student Worksheets with a Problem Based Learning model using the 4 D development model. The validation results from media experts and subject matter experts showed that the was in the highly feasible category in terms of design, content feasibility, and language. This indicates that the structure of the student worksheets has met the standards required to support the physics learning process.

Practicality tests showed that the received positive responses from students, as indicated by high levels of engagement, conceptual understanding, and assessment of the student worksheets quality. In addition, the effectiveness of the student worksheets was proven through an increase in student learning outcomes with a moderate N-gain score (0.58). This improvement illustrates that the student worksheets is able to help students develop their analytical, evaluative, and problem-solving skills, particularly in the areas of temperature and heat, kinetic theory of gases, and thermodynamics.

Overall, HOTS-based student worksheets with the PBL model has been proven to be valid, practical, and effective in improving students' higher-order thinking skills and conceptual understanding. This student worksheets can be a relevant learning resource to support the achievement of 21st-century competencies, especially in physics learning, which requires a deep understanding of concepts and critical thinking skills.

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