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Research Article

Development Of Low-Cost Technology-Based Learning Aids For Heat Radiation Material

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ABSTRACT

This study aims to develop low-cost technology-based learning aids in physics, specifically on heat radiation, using Student Worksheets (LKS). The Suyanto method of research and instructional media development was employed, including internal testing and variance similarity testing of the learning aids. The results consist of physics learning aids and LKS that have been internally validated, in line with theoretical expectations. The LKS validation yielded a score of 3.14, indicating suitability for use, while the external test using a One-Shot Case Study showed a student learning outcome score of 3.61, signifying good learning quality. Assessment of the appeal of the learning aids and LKS yielded a score of 3.32, and ease of use scored 3.17, indicating positive reception. Improvements were made before the production stage, which only involved prototyping.

Introduction

Science is divided into several branches of knowledge, one of which is physics. Physics is the most fundamental science because it deals with the behavior and structure of matter. In supporting physics education, especially for better concept delivery, the availability of supporting tools is crucial, one of which is teaching aids that align with the physics subjects to be taught to students.[1]

In the process of physics education at schools, physics teaching aids can help clarify the delivery of messages and information about the physics subjects presented by teachers.[2] These physics teaching aids are specially made tools for specific physics lessons, such as electrical and magnetic teaching aids for electricity and magnetism[3], optical teaching aids for optics, and mechanical teaching aids for mechanics. The use of physics teaching aids helps students better understand abstract physics concepts.[4]

Observations were conducted at SMP Negeri 4 Metro and SMP Negeri 1 Trimurjo, both schools already have science laboratories.[5] The laboratories in these schools are used for physics, chemistry, and biology practical sessions.[6] However, in physics education, teachers often deliver lessons through textbooks and practice questions, while practical sessions are only conducted for specific topics.[7] This limitation arises because there are several physics topics that do not have teaching aids, such as the topic of heat radiation, where there are no teaching aids used for learning.[8] One of the roles of teaching aids is to concretize abstract concepts, such as in the topic of heat radiation in physics, where the process cannot be directly observed by humans.[9]

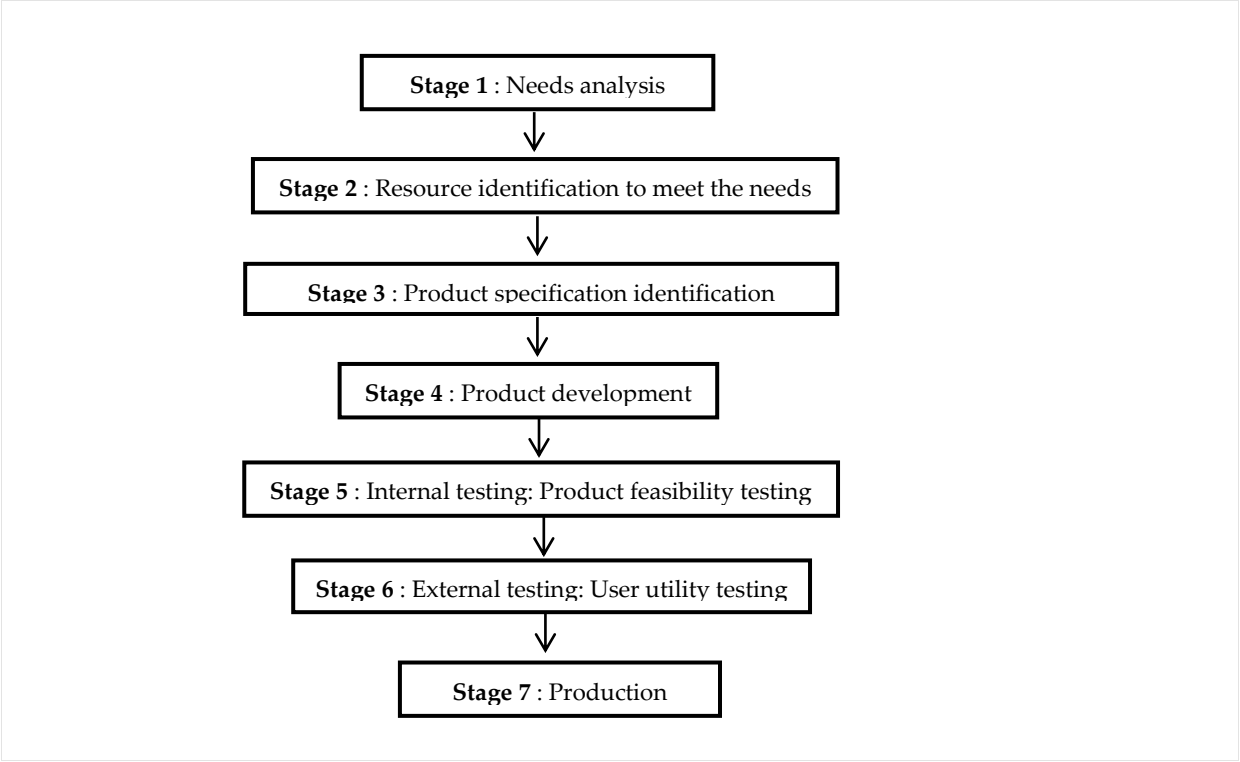
Therefore, efforts to concretize the concept of heat radiation need to be undertaken, one of which is by creating teaching aids, so that the abstract concept of heat radiation can be directly observed by students.[10]

Methodology

Participant

The field tests for the development of this heat radiation teaching aid were conducted at SMP Negeri 4 Metro, SMP Negeri 1 Trimurjo, and SMP Negeri 2 Kalianda.

Research design



Instrument

	Assessment Items	Examiner	
		student	teacher
1. Visual aids	Suitability of experiment results with the use of visual aids to the theory	√	
	Quality of visual aids	√	
	Attractiveness of visual aids	√	√
	Ease of operation of visual aids	√	√
	Practicality of using visual aids	√	√
2. LKS	Accuracy of indicators in the Student Worksheets (LKS) with the learning material	√	
	Alignment of learning objectives in the Student Worksheets (LKS)	√	
	Suitability of pictures/illustrations in the Student Worksheets (LKS) with the learning material	√	
	Clarity of pictures/illustrations in the Student Worksheets (LKS)	√	√

	Suitability of introductory questions in the Student Worksheets (LKS) which are examples from daily life with the learning material	√	√
	Alignment of guidance on conducting experiments using visual aids in the Student Worksheets (LKS)	√	√
	Experiment procedures in the Student Worksheets (LKS) presented as systematic guidance	√	√
	Questions posed in the Student Worksheets (LKS) guide students towards drawing conclusions	√	√
	Pertanyaan-pertanyaan yang diajukan dalam LKS mengarahkan siswa kepada penarikan kesimpulan	√	√
	Readability of the writing in the Student Worksheets (LKS)	√	√
	Sentences used in the Student Worksheets (LKS) are easily understood	√	√
	Sentences used in the Student Worksheets (LKS) adhere to the rules of Indonesian grammar (EYD)	√	√

Results and Discussion

The main outcome of this development research is the heat radiation learning aid with accompanying worksheets containing experimental guidelines for its use. Here are the results from each stage of the development procedure. The main outcome of this development research is the heat radiation and hydrostatic pressure learning aids accompanied by worksheets containing experimental guidelines for their use. The results from each stage of the development procedure are as follows.

I. Analysis of Development Needs
II. Identification of Resources
III. Identification of Product Specifications
IV. Product Development
V. Internal Testing
VI. External Testing
VII. Final Product

In this discussion, an overview of the revised development product is presented, including the alignment of the produced product with the development objectives, as well as the strengths and weaknesses of the developed product.

Alignment of Produced Product with Development Objectives

The aim of this development research is to create low-cost technology-based heat radiation learning aids with accompanying worksheets, teaching the concept of heat radiation, and assessing the effectiveness of the heat radiation learning aids and worksheets as learning resources for junior high school students. The development procedure used in this study adapted the learning media development model by Suyanto (2009). The learning aids and worksheets were developed to achieve mastery of each indicator in the heat radiation material. The material developed in these worksheets is the heat radiation material. The systematic presentation of the worksheets includes (a) cover, (b) initial information on the material to be learned, (c) learning objectives, (d) pre-knowledge assessment, (f) prediction before conducting experiments, (g) conducting experiments, (h) analyzing experiment results, and (i) formulating

conclusions.

The appropriateness of the learning presented in the worksheets (corresponding to the learning aids) was assessed in the product feasibility test by subject matter/content experts and instructional media design experts. The operability of the learning aids and worksheets to achieve learning objectives was tested on students from SMP Negeri 4 Metro, SMP Negeri 1 Trimurjo, and SMP Negeri 2 Kalianda. The results were based on the external evaluation of students (assessment results of the operability of prototype II products) and the established Minimum Completeness Criteria (KKM). Based on the KKM set for these three schools, which is a passing score of 75, the achievement of learning objectives using the learning aids and worksheets is as follows:

- Completeness in the cognitive aspect.
- Completeness in the affective aspect.
- Completeness in the psychomotor aspect.

Based on the evaluations and revisions conducted, the objectives of this development have been achieved: the production of low-cost technology-based learning aids for physics, specifically on the topic of heat radiation, accompanied by worksheets. The method of teaching the concept of heat radiation using the developed aids is known, and the effectiveness of the learning aids in teaching heat radiation has been established. These findings are in line with the views of Sanjaya (2011), who stated that the learning objectives using the developed practical kits and worksheets were achieved. Furthermore, the products of this development can be used as a learning guide for students individually or in groups, achieving completeness in the cognitive, affective, and psychomotor aspects. This is supported by the research by Fadila (2011), which stated that the use (operability) of the practical kits and worksheets to achieve learning objectives has been successful in terms of cognitive, affective, and psychomotor aspects.

Strengths and Weaknesses of the Developed Product The product of this development can be used as a learning guide for students individually or in groups. Another advantage of the developed product, the heat radiation learning aids and worksheets, is that they provide clarity to students, enabling them to determine factors that affect the amount of heat radiation received by an object, establish the relationship between the radiation received by an object and the wavelength of visible light, and investigate heat transfer by radiation. Based on internal and external testing results, it is known that the learning aids and worksheets can be used as an evaluation tool to assess the level of mastery of the heat radiation material, including its cognitive, affective, and psychomotor aspects. Moreover, the cost needed to create these learning aids is relatively low because they are made using inexpensive tools and materials readily available in the surrounding environment.

A weakness of the developed product is that the heat radiation learning aids can only be used when the sun is not obscured by clouds and it is not raining.

The main result of this development is a heat radiation teaching aid and student worksheets on heat radiation.

	Operational Component	**Score**	Statement of Quality	Suggestions for Improvement
1	attractiveness	3,33	very interesting	1. The layout design should be more appealing to students' interests. 2. It is advisable to use slightly bright and striking colors.
2	Convenience	3,04	easy	-
3	learning outcomes	77,9	complete	-

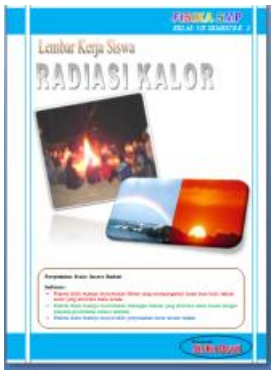


Figure 1 & 2. Is the final product image of teaching aids and student worksheets (LKS) for the material Low-Cost Technology-Based Learning Aids For Heat Radiation Material

Conclusion

The conclusion of this developmental research has resulted in affordable technology-based physics learning aids with accompanying worksheets for the topic of heat radiation, investigating the effects of color and cross-sectional area on heat absorption through radiation. These learning aids are deemed suitable for use based on internal testing aligning with established theories, and the worksheets meet the standards set by BSNP. The concept of heat radiation can be effectively taught through direct experimentation using the developed aids, providing clarity to students. Field test results from SMP Negeri 4 Metro, SMP Negeri 1 Trimurjo, and SMP Negeri 2 Kalianda have shown excellent student learning outcomes. The operational testing of the products has demonstrated the effectiveness of the heat radiation and hydrostatic pressure learning aids with the worksheets, achieving highly effective learning objectives in the cognitive, affective, and psychomotor aspects, serving as an alternative learning resource for the field test groups of students.

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teachers, and schools who have collaborated and granted permission for this research to be conducted.

Conflicts of Interest

"The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results"

Author Contribution

Siska Dewi: Research idea, research planning, Methodology, data analysis, Data curation and testing. Lucky Maulana Hakim: Data curation, Writing – original draft, Writing – review & editing

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