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Development of Student Worksheets Based on Guided Discovery Learning Assisted by Tracker Video Analysis on Mechanical Energy Conservation Material

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Abstract

Student worksheets based on guided discovery learning assisted by a tracker video analysis on mechanical energy conservation materials were developed to provide experience in learning physics on conservation material mechanical energy. This research aims to produce a product in the form of the student worksheets based on guided discovery assisted by tracker video analysis. Studying this is research and development (R&D), using the ADDIE model, which consists of 5 stages: analysis, design, development, and implementation. This study uses quantitative data and qualitative data. Quantitative data results from the validation sheet and questionnaire responses of students and teachers. Then, qualitative data will be collected as suggestions, comments, and criticism from the validator regarding the development of the student worksheets. Data collection techniques using interviews and observations. The instrument used is a validation sheet for three validators: media, material, and language experts. This research was held at the Riyaluul Ulum High School. The research subjects were physics teachers and students of class X MIPA. The sample consisted of 130 students who were taken using simple random sampling and two teachers. Data analysis technique using descriptive statistics to determine validity and practicality. The results showed that the average value of media validation was 83% and categorized as very valid, material validation was 82% and categorized as very valid and language validation was 77% and categorized as valid. The results of the practicality assessment by students is 80% with the category of practical, and by the teacher is 86% very practical. The results of this study state that it can be used and implemented in the learning process.

Keywords: guided discovery; the student worksheets; video tracker

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INTRODUCTION

The optimization of the science learning process is dependent on the provision of sufficient infrastructure. One of the facilities that support the learning process is teaching materials. This teaching material is any form of method used by the teacher in the implementation of learning activities. Furthermore, the acquisition of scientific knowledge enables students to develop a capacity for comprehending many practical concepts, including those applicable to daily life (Darling-Hammond et al., 2020; Hardini et al., 2013). Teaching material is a form of learning material teachers use to facilitate the classroom learning process. This instructional material can be used in both print and digital formats. This instructional material is also a collection of learning materials that refer to the curriculum to attain predetermined competency standards (Risda et al., 2023; Nurdyansyah, 2018).

Based on the results of interviews with two physics teachers at SMAT Riyadhlul 'Ulum, it was determined that the availability of teaching materials in the form of worksheets for students was so limited that the learning process was severely constrained, so they only used the school-supplied textbooks. In addition to the learning book provided by the school, teachers should also have worksheets created by the students to supplement the learning process and prevent students from becoming bored. Teachers have used worksheets as teaching materials, but their use is uncommon, so they only use worksheets found on the internet. In addition, the worksheets used during the learning process are created individually with very basic concepts, so the school's physics teaching materials are severely deficient. A treasury of student worksheets that can supplement learning materials is required to solve this issue.

The limitations of teaching materials are not an excuse to carry out the learning process, but their existence will make it simpler for teachers to transform their knowledge in the classroom. According to Sadjati (2012), teachers are less trained in developing teaching materials and frequently utilize commercially available materials during this time. Teachers must, therefore, be able to create their instructional materials for use in the learning process. Utilizing instructional materials created by the teacher will create confidence in the learning process, allowing it to effectively and efficiently transform science and technology for students in the classroom. However, the creation of this instructional material continues to adhere to established rules, such as core and fundamental competencies (Mulyadi et al., 2016; Nadia et al., 2021). Various groups have developed instructional materials, including research instructors, government agencies, and private companies. Therefore, researchers intend to create worksheets to aid the school learning process. For the physics learning process to be more meaningful, the learning material must be directly applicable to real-world situations.

According to Hernawan et al. (2008), in the general guidelines for developing teaching materials, student activity sheets are sheets comprising assignments students must complete. These worksheets are usually in the form of instructions and steps to complete the tasks and problems provided. These tasks and issues must align with the competencies that must be attained. The purpose of using student worksheets in the learning process itself is to provide knowledge, attitudes, and skills that students must possess, assess the level of student comprehension of the presented material, and develop and apply difficult-to-communicate material during the learning process (Asmirani et al., 2013; Budi et al., 2021; Misbah et al., 2018).

The development of science and technology will encourage educators to

utilize novelty in teaching and learning. Educators must increase their creativity to develop and create learning media or instructional materials that will be utilized in the learning process (Pahrudin etal., 2021; Rezeki & Ishafit, 2017). There are three basic principles in educational technology that are used as a reference in its development and utilization, namely, the system approach, orientation, and resource utilization. The principle of the system approach itself is that its implementation must be designed using a system approach.

Its design requires several procedural steps, including problem identification, situation analysis, objective identification, learning management, method selection, and learning evaluation media selection. This orientation principle states that students' characteristics, interests, and potential should be considered when designing learning experiences. Source utilization implies that students should be able to access the necessary knowledge and skills by utilizing learning resources (Lau et al., 2018; Riyana & Pd, 2008).

This student worksheet requires creativity and interest, as well as an innovative approach. This worksheet requires students to think creatively and critically so that they become acclimated to solving common problems in the future. Educators must possess the creativity necessary to make student worksheets interesting, and they must be able to implement a variety of innovations in order for students to grasp physics concepts rapidly. In other words, the guided discovery learning model can be used to create this student worksheet. Students are expected to gain a comprehension of physics concepts from worksheets based on the guided discovery learning model in the Law of Conservation of Mechanical Energy material. According to Deboer (2011), the conservation of mechanical energy is the most difficult concept for students in high school. Students strain since they are unable to determine the correct energy graph for describing the motion of objects along a specific trajectory influenced by external forces. The guided discovery learning model emphasizes student activity in knowledge discovery under the guidance of peers and instructors. Guided Discovery Learning derives from J. Bruner's discovery theory, which asserts that the essence of learning is how we select, retain, and transform knowledge. The guided discovery learning model is a model that engages students in the learning process so that they can subsequently use their mental processes to discover a concept or theory.

In this application of science and technology, student-supporting learning materials in the form of worksheets can be incorporated into an application. Students require assistance with tracker video analysis to discover and convert the physics-based knowledge they have acquired into the material for the Law of Conservation of Mechanical Energy. Tracker video analysis software is a video analyzer based on an open-source Java framework (Artiningsih & Nurohman, 2020; Fitriyanto & Sucahyo, 2016). Students are expected to be able to activate their process skills with this software by making observations, taking measurements, and calibrating them. The results of this software's analysis are presented as graphs and tables of data to conclude from the statistics generated by the software by monitoring students.

Previous research conducted by Sucipta et al. (2018) explained that guided discovery learning can improve students' critical thinking skills and increase learning effectiveness compared to conventional learning models. The Discovery Learning method, which is able to motivate students and modernize by elevating the level of critical thinking, subsequently resulting in interaction between instructors and students, also

guides the learning process. Risa et al. (2021) concluded that the student worksheet they constructed with tracker video analysis was highly valid and that most student responses to the worksheets fell into the category of "agree." The researcher intends to conduct a study with a type of renewal, specifically in the student worksheet, where there is a stage arranged in accordance with the syntax of the guided discovery learning model and also in combination with tracker video analysis, which can encourage students to think critically. According to the research conducted by Pratiwi and Yulkifli (2019) on dynamic fluid material, the experimental class yielded a value of 78.62. Then, 70.10 for the control class. The use of discovery-based student worksheets improves the engagement and concentration of each student in the learning process. This guided discovery-based student worksheet can be used in various science lessons, including teachings on inheritance (Desimaris et al., 2022). If the researcher's validation results were deemed highly valid to use, then the evaluation of the class test was categorized as highly feasible.

METHOD

The research approach is a means of obtaining reliable data. According to the ADDIE model, researchers would use the development method (Research and Development), which includes analysis, design, development, implementation, and evaluation (Pribadi, 2009). The nature of this applied research was to develop a product, so this research and development had the objective of finding something new, not only that it could develop but also validate the products developed (Sugiyono, 2017).

Analysis

Preliminary research was conducted to identify the occurrence of problems and propose solutions. The researcher conducted a curriculum analysis at the time. This curriculum analysis was used to evaluate the fundamental design competencies. Next, the researcher conducted a requirements assessment. During the requirements assessment phase, researchers conducted observations. Observations were made by interviewing two physics teachers regarding learning requirements and commonly used physics learning tools in schools. The researchers then conducted interviews with representative students from each class regarding the learning process, the instructional materials utilized, and the inventiveness of the teacher.

Design

The design phase of the development of student worksheets conducted by researchers was compiled based on the findings of the analysis phase. This phase was also used to translate the requirements of the product that the researcher would develop and represent the design as a product that would be executed later. To facilitate the production of products, researchers engaged in a number of activities, including the creation of storyboards and the collection of materials.

Development

This phase of development is where the product design will be realised. Developed products will be implemented in multiple phases.

Validity Test by Expert

During the testing phase of validity, the data was separated into qualitative and quantitative data sets. The quantitative information was acquired from the validation sheet. Furthermore, it was converted into quantitative data using a Likert scale (5) to determine the product's feasibility, validity, and applicability: 5 (very good), 4 (good), 3 (good enough), 2 (less), and 1 (very little). There are columns of opinions and suggestions for

media experts, linguists, and material experts who evaluate this information.
Method for determining Validity:

$$The\ percentage = \frac{f}{N} \times 100\% \quad \ldots (1)$$

where:
P = Number of percentages
f = Total score
N = Maximum score
After obtaining the validation percentage's value, it is classified from the criteria in Table 1.

Table 1 Criteria for product validity

Achievement Level (%)	Categories
81 – 100	Very valid
61 – 80	Valid
41 – 60	Moderately Valid
21 – 40	Less Valid
0 – 20	Not Valid

(Riduwan, 2007)

Implementation
The following phase involves implementing the products designed for students and teachers. Learners and teachers were instructed to first review the worksheets created for students and then complete a questionnaire to determine the level of applicability of the products created by the researchers. This implementation was conducted for teachers and students who had or were studying materials on mechanical energy conservation.

$$The\ percentage = \frac{f}{N} \times 100\% \quad \ldots (2)$$

where:
P = Number of percentages
f = Total score
N = Maximum score
After obtaining the practicality percentage, it is classified as criteria in Table 2.

Table 2 Criteria for product practicality

Achievement Level (%)	Categories
81 – 100	Very Practical
61 – 80	Practical
41 – 60	Moderately Practical
21 – 40	Less Practical
0 – 20	Not Practical

(Riduwan, 2007)

Evaluation
In this study, the evaluation phase was omitted because only the validity and usability tests of the developed product were conducted.

RESULTS AND DISCUSSION

Students' worksheets were used to teach physics in this study. They were made using the ADDIE development model, which has steps like Analysis, Design, Development, Implementation, and Evaluation. Here is an explanation of the steps that were taken to carry out all of the stages in this study:

Analysis
Curriculum Analysis
The 2013 curriculum is used at SMAT Riyadhlul Ulum. This mechanical energy conservation material refers to the basic competencies of Permendikbud Number 37 of 2018.

Requirement Analysis
The results of interviews with physics teachers of class X MIPA SMAT Riyadhlul Ulum indicate that the only teaching materials used are school-supplied textbooks, while student worksheets are only used a few times due to limited time for learning and none are used for learning outside of the classroom. The results of interviews with students found that students did not comprehend physics learning in class because learning was only fixated on one book. Due to the real-world application of physics concepts learnt in class, students favour laboratory-based instruction. In order to assist students in overcoming learning tedium, it is necessary to provide them with engaging and easily understood instructional materials so that they have a unique classroom experience.

Design
The design stage is the planning stage of the student worksheet, which is developed by compiling material,

images, questions, and answers to create a learning framework.

Material Preparation

The student worksheet used energy material, which consisted of effort by conservative forces, conservative and non-conservative forces, the relationship between conservative forces and potential energy, and constant gravitational potential energy. The material was sourced from class X high school physics books and other reference books.

Collection of images, cover, and background

The worksheet's background originates from Microsoft Word's toolbar, while the images come from websites such as orami.co.id, pngtree.com, kompas.com, canva.com, and istockphoto.com. After gathering the necessary materials, the product was created using Microsoft Word. Microsoft Word is a word-processing application. This application can also insert photographs and create an attractive book layout, but it has a simplistic design.

Product design in the form of a storyboard

This storyboard contains the student worksheet's design and product description in images, materials, and guided inquiry learning model stages. This storyboard is also used to summarise the developed learner worksheets.

Development

At this stage, each phase of the student worksheet will be described, using the independently developed video analysis tracker and the revisions that were made. The following is a description of the product created prior to expert validation.

Product Design Results of Student Worksheets Assisted with Tracker Video Analysis

The Cover Page

The cover page was designed to be as attractive as possible to attract learners to open and read to the next page. The black roller coaster image showed that students would analyse the ball's motion on the roller coaster track. Then, the Siliwangi University logo indicated that this worksheet was created and approved by Siliwangi University. The revised 2013 curriculum logo indicates that the material compiled in this student worksheet is in accordance with the revised 2013 curriculum. The book title on the cover page was "Worksheet for Students of Mechanical Energy Conservation Law Based on Guided Discovery Learning Aided by Tracker Video Analysis".

Starting Page

After the cover page, there would be an introductory page with the introduction, table of contents, worksheet usage instructions, learning competencies, and concept map.

Material Page

This page explains the material Effort by Conservative forces, Conservative and Non-conservative forces, the Relationship between conservative forces and Potential Energy, and Constant Gravitational Potential Energy.

Validity Test

Results of Media Expert Validity Test

A media expert validated the product by describing the product's results on a worksheet for students, which included a video analysis tracker. In addition, media expert validators evaluate the developed products by completing a 10-item questionnaire. The results of each media expert validator's data are depicted in the following diagram in Figure 1.

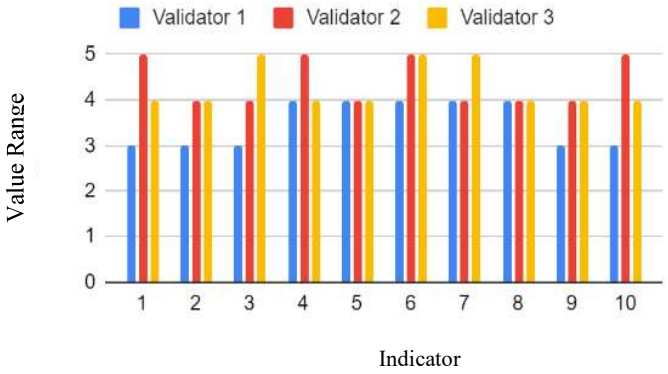

Figure 1 Percentage of media expert validity test

The maximum number of validation scores from media experts was 41. These results were evaluated based on the ten presented indicators. So, the obtained results were 82%. According to the product validity criteria table, these results were interpreted. According to this table, the worksheet for students assisted by the video analysis tracker is deemed "Very Valid" for instructional material.

Results of Material Expert Validity Test

This material expert validation aimed to determine whether the material presented in the learner worksheet was consistent with the fundamental and core competencies. The material presented in this student worksheet was attempted by conservative forces, conservative and non-conservative forces, the relationship between conservative forces and potential energy, and constant gravitational potential energy. Three validators conducted material expert validation. In addition, material expert validators evaluated the developed products by completing a questionnaire with ten indicators. The data from each material expert validator is depicted in the following diagram in Figure 2.

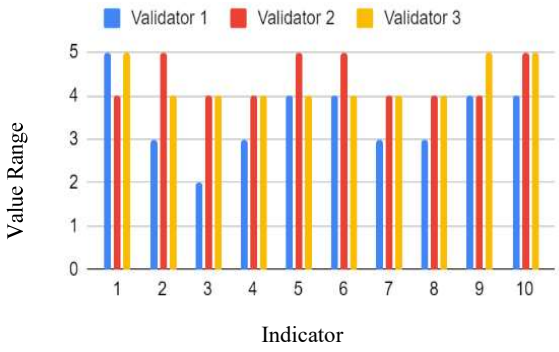

Figure 2 Percentage of material expert validity test results

The number of material expert validation scores from the maximum score was 41. These results were assessed using the ten indicators that have been presented. The results obtained were 82%, which were interpreted based on the product validity criteria table. In accordance with this table, it could be concluded that the student worksheet assisted by the video analysis tracker was

declared "Very Valid" to be used as teaching material.

Results of the Linguist Validity Test

The technical validation of linguists consisted of requesting the availability of three linguist validators, just as it did for material experts and media experts. Furthermore, linguist validators assessed the products that had been developed by filling out a questionnaire comprised of six indicators. The resulting data from each material expert validator is depicted in the following diagram in Figure 3.

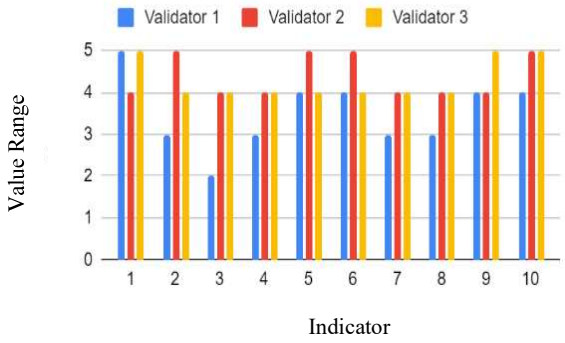

Figure 3 Percentage of linguist validity test results

The number of linguist validation scores from the maximum score was 23. These results were assessed using the six indicators that have been presented. so that the results obtained were 77%, these results were interpreted based on the product validity criteria table. In accordance with this table, it could be concluded that the student worksheet assisted by the video analysis tracker was declared "valid" to be used as teaching material.

Implementation

This phase is the product testing phase conducted on a sample of 130 students from a population of 193 comprising 7 X MIPA classes and two physics instructors at SMAT Riyadhul Ulum. The sample's population members were deemed identical, so simple random sampling was utilised to select the data sample. The physics teacher was then selected from a population of two individuals. The evaluated product had been validated by media specialists, material specialists, and linguists. The product's usefulness is determined by the responses to the questionnaire given to students and teachers following the trial.

Practicality Test by Students

The product trial was conducted in the computer centre of SMAT Riyadhul Ulum from October 17 to October 25, 2022. Students attempted the worksheet assisted by the video analysis tracker that had been developed, and then they were asked to provide an assessment through the questionnaire that had been provided by checking the available value levels. The results of the practicality examination for students are summarized in Table 3.

Table 3 Assessment of practicality by students

Aspects	Indicators	Total Average	Categories
The use of Student worksheets	The sentences used in the student worksheet are clear	4	Good
	The linkage between commands and usage learner worksheet using Video tracker.	4	Good

Aspects	Indicators	Total Average	Categories
	The language used is in accordance with EYD	4	Good
	The selection of size, font, and spacing on the student worksheet is easy to understand and read.	4	Good
	Student worksheets is easy to use as a learning tool	4	Good
	Accuracy of Sentence Structure	4	Good
	Accuracy of background colour selection and writing colour in student worksheet	4	Good
	The attractiveness of the contents of the student worksheet	4	Good
	Suitability of commands for filling in answers with videos or tables	4	Good
	Total	36	
	Maximal Score	45	Practical
	Final Score	80%	

The results of the practicality test showed that the average score was 36 out of a maximum score of 45, so it gets an 80% percentage. Furthermore, these results were interpreted against Table 3.7. In accordance with the table, it can be concluded that the worksheet for tracker video analysis students is declared "practical" and will be used as teaching material.

Teacher Practicality Test

The class X teacher of Riyadlul Ulum SMAT administered the praxis examination for teachers. The practicality questionnaire is appended in Appendix 6. The teacher's practicality evaluation results are depicted in Table 4.

Table 4 Teacher Practicality Assessment

No	Teacher Name	Total	Maximum Score	Final Score
1	Teacher 1	39	45	85.56
2	Teacher 2	38		
	Total Score	77	45	85.56 %
	Average Score	38.5		

The average score on the practicality examination was 39 out of a maximum of 45, achieving a percentage of 86%. In addition, these results are interpreted in light of Table 3.7. According to this table, it can be concluded that the video analysis tracker-assisted student worksheet qualifies as "very practical" teaching material.

Evaluation

This research was conducted until the implementation stage. It did not include an evaluation phase because it focused solely on verifying the validity and practicability of the products developed by researchers.

Based on the results of the validity test assessed by three experts, it was stated that the worksheet of students assisted by video analysis trackers that had been developed was in the valid category as teaching material. The arrangement that had been presented in this worksheet was in accordance with the learning needs of the material, the model arrangement, and the words arranged systematically so that it was easy for students to read. According to Prastowo (2016), the student worksheet is one of the printed

learning resources containing summary material and some implementation instructions for the learning process to be carried out by students. Making this student worksheet must require innovation to provide something interesting (Rezeki & Ishafit, 2017). In addition, the products that researchers develop are in accordance with the preparation and characteristics of student worksheets, according to Suwartaya et al. (2020) which consist of a foreword, Table of Contents Introduction (contains an analysis and list of learning objectives and achievement indicators); Chapter 1 contains material from the subject matter; worksheets contain various questions or assignments that students will do; and Chapter 2 contains a summary of the material from the subject matter, worksheets, and bibliography.

According to Habibbulloh (2014), this video analysis tracker indicates that student learning skills have improved in measuring, observing, conducting an experiment, and communicating. Similarly, Fitriyanto and Sucahyono (2016) found that the analysis results using pre-test and post-test question sheets completed by students increased their skills and their responses to learning using video analysis trackers met extremely high standards. According to research conducted by Agraini (2020), assessing the effectiveness of the learning outcomes evaluation on worksheets based on guided discovery learning met the effective criteria.

The researchers' worksheets were well-received by students, instructors, and validators. When validating the worksheets, the validation results from the media experts indicated that they were very valid, with a score of 82%. In terms of the model's organisation and the worksheets' presentation, it is possible to state that the worksheets created are high quality.

While the material validator's validation results indicate a very valid category with a score of 82% and the language validator's validation results indicate a valid category with a score of 77%, the student worksheet developed in the valid category can be utilised in the classroom learning process.

According to the outcomes of the product's usability test data analysis, the final score was 86%. The evaluation results of the physics teacher of grade ten indicate that the material presented in this worksheet is well-organized and highly engaging for use in the learning process. Then, the students' practicality examination results revealed a score of 80%. These results indicate that students are very conversant with the worksheet's presentation of theory and explanation. Based on the questionnaire evaluation of the students' practicality test, the highest average score is attained in the linguistic aspect. Thus, it can be stated that the developed product employs simple language, allowing students to comprehend the concept of motion in mechanical energy conservation material. Therefore, it can be stated that the worksheet based on guided discovery 93 learning assisted by a video analysis tracker on mechanical energy conservation material can be used practically in the learning process after going through revisions based on validators' suggestions and comments.

CONCLUSION

Based on the results of the conducted research, the following conclusions can be drawn: (1) Student worksheets based on guided discovery learning assisted by video analysis trackers on mechanical energy conservation material are valid or feasible to use as teaching materials in class. The results of the study obtained an average validation value given by three validators: media experts were 83% with a very valid category, material experts were 82% with a very valid category and linguists were 77% with a valid category; (2) Students' worksheet based on guided

discovery learning assisted by a video analysis tracker on mechanical energy conservation material is valid or feasible to use. The practicality test was conducted by students and teachers. The results of the practicality test for students were 80% in the practical category, and for teachers, 86% in the very practical category.

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