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# High School Physics Student Worksheets Assisted by Augmented Reality: Enhancing Problem Solving Skills

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## Abstract

Practicum is a component of physics learning which is important in increasing the literacy of students in high school. This article describes the results of research and development of students physics worksheets with problem-solving stages equipped with AR (Augmented Reality) media. The research method used is a research and development method with the Dick and Carey approach. The resulting Physics Student worksheet is presented with stages to train students' problem solving skills. Activity components in Student Worksheet: short theory, videos with the help of AR (Augmented Reality) technology, practicum data, tables, graphs, graphic interpretation, analysis of practicum concepts for each topic presented in the practicum. The stages of problem solving in Student Worksheet: (a) describe an initial problem and a brief theory; (b) ask questions related to the problems given earlier; (c) describes the analysis of practicum data, and (d) explains the analysis of the physics concept of the practicum results. The results of this study have been validated by Student Worksheet media experts, physics concept material experts, and learning experts. To fulfill all aspects, it can be shown that a proper Student Worksheet is used to train the problem solving skills of high school students.

**Keywords:** physics student worksheet, augmented reality, problem solving

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## INTRODUCTION

In physics learning, student worksheet is one of the most important materials for achieving the objectives of learning activities (Kaymacki, 2012). Student worksheet itself is a learning tool that can be used to explore the teaching and learning process carried out (Gagne, 1975) and can also be used as a tool to support active learning (Lee, 2014). Because basically student worksheet is printed teaching material that is used to help students gain education, skills, and values by providing useful statements learning objectives they want to obtain (Kaymacki, 2012). Learning with a scientific approach can build attitudes,

knowledge, and skills among students in the classroom. Experimental learning or practical activities in the laboratory can help shape and train the students' own soft skills. Practical activities can also develop students' scientific attitudes and skills so that the learning process can train cognitive aspects, affective aspects, and psychomotor aspects (Zaghloul, 2001). With practicum activities, students can play an active role in the learning process and can train the students' own learning independence. To further support the success of relevant student worksheet according to the demands of the learning process, student worksheet is needed that has learning stages (Astutik et al., 2017). Learning stages that are in accordance with the demands of the learning process in the 2013 curriculum, one of which is the Problem-Solving learning model (Kemendikbud, 2014). Basically, problem-solving is an ability that is given in the learning process in order to create critical and comprehensive learning (dunleavy et al., 2009). In the Problem-Solving learning model, students play a more active role in the learning process (Kemendikbud, 2014). Creative thinking skills and problem-solving skills in students can be trained through learning activities (Duban, 2019), but in realizing this the implementation of technology is also very necessary (Cambridge International, 2018). In experimental or practical learning, media is needed that is integrated with technological developments. Augmented Reality (AR) is one of the appropriate learning media applications to be developed (Billinghurst, 2012). The use AR (augmented reality) media in the form of videos experimental activities in the laboratory can improve the development of students' laboratory skills. In AR videos can make it easier to complete laboratory activities in a shorter time so that there is more time to experimental results (Akçayır, 2016). Researchers also state that the use of technology in learning can save time (Nadelson, 2015). This article describes the results of research and development of student worksheet, which is equipped with media assisted by augmented reality technology to train problem-solving skills in high school.

## METHOD

### Research Design

This research design uses the Dick and Carey model approach, where there are nine stages consisting of:

1. Research design
   Research and development using the Dick and Carey approach is used to produce worksheets that train problem-solving skills in practical activities in high school. The stages of research and development activities carried out are:
   1.1. Identify Instructional Goals
   Activities to identify physics learning objectives in high school.
   1.2. Conduct Instructional Analysis
   Analyzing practical activities that are relevant to basic competencies in physics learning in high school.
   1.3. Analyze Learners and Contexts
   Analyzing the competencies that will be formed in students in practicum activities in high school. Analyzing physics practicum material that is relevant to attitudinal, cognitive, and psychomotor competencies based on basic physics learning competencies in high school. Create a practical map to achieve basic physics learning competencies in high school.
   1.4. Write Performance Objectives
   Write down the objectives of physics practicum activities in the attitudinal, cognitive, and psychomotor domains that train problem solving abilities.
   1.5. Develop Assesment Instruments
   Developing instruments to measure learning outcomes for physics practicum activities that train problem-solving skills in high school.

1.6. Develop Instructional Strategy
Developing strategies for physics practicum activities that train problem solving skills in high school.
1.7. Develop and Select Instructional Materials
Develop practical activity worksheets that are relevant to the basic competencies of high school physics learning, with stages of practicing problem-solving skills.
1.8. Design and Conduct Formative of Instruction
Designing a formative evaluation instrument for the feasibility of practicum activity worksheets that train students' problem-solving abilities in high school.
1.9. Revise Worksheet
Revise worksheets based on formative evaluation by material experts, media experts and learning experts. Revisions are carried out until the expert's state that the worksheet is suitable for use for practical activities that train problem-solving skills.

### Research Instrument

The assessment instrument used in this research is in the form of a questionnaire to test the feasibility of research results on the development of class X physics worksheets. The assessment instruments include media suitability questionnaires, materials and pedagogy.

### Data Analysis

This research data was obtained from experts' assessment instruments on practicum worksheets. The assessment given uses a four continuum scale based on media, material and pedagogy.

**TABLE 1.** Continuum Scale

| No | Alternative Answers | Score |
|---|---|---|
| 1. | Very Good | 4 |
| 2. | Good | 3 |
| 3. | Bad | 2 |
| 4. | Very Bad | 1 |

The assessment results obtained by experts are processed and calculated using techniques for determining score ranges and presenting scores.

$$\text{IS} = \frac{\text{maximum score} - \text{minimum score}}{\sum \text{category}}$$

$$\text{Persentage Score} = \frac{\sum \text{score}}{\sum \text{maximum score}} \times 100\%$$

The results of obtaining percentage scores are then measured using score interpretation and percentage scores for the continuum scale, with the scale range obtained based on the continuum scale range, namely 1 to 4, so that the formula can be used : $R_s = \frac{4-1}{4} = 0.75$, then the scale range used is 0.75.

**TABLE 2.** Interpretation Score

| Scala | Score Intepretation | Interpretation |
|---|---|---|
| 1 ≤ IS < 1.75 | 25% ≤ PS < 43.8% | Low |
| 1.75 ≤ IS < 2.50 | 43.8% ≤ PS < 62.5% | Moderate Low |
| 2.50 ≤ IS < 3.25 | 62.5% ≤ PS < 81.3% | Moderate Good |
| 3.25 ≤ IS < 4.00 | 81.3% ≤ PS < 100% | Good |

## RESULTS AND DISCUSSION

This student worksheet is structured in three stages, consisting of: the preliminary or initial stage, the practicum stage, and the post-practicum stage, which is structured using a problem-solving model where in the initial stage of the practicum students are given a problem contained in the augmented reality (AR) video stimulation.

### Research Results of Student Worksheet Products

First Stage

In the initial stage, this worksheet consists of worksheet cover, introduction, list of practical activities, practical objectives to be carried out, stimulation in the form of videos related to practical material integrated with AR, preliminary questions related to the stimulation video, as well as related short theory. with practicum.

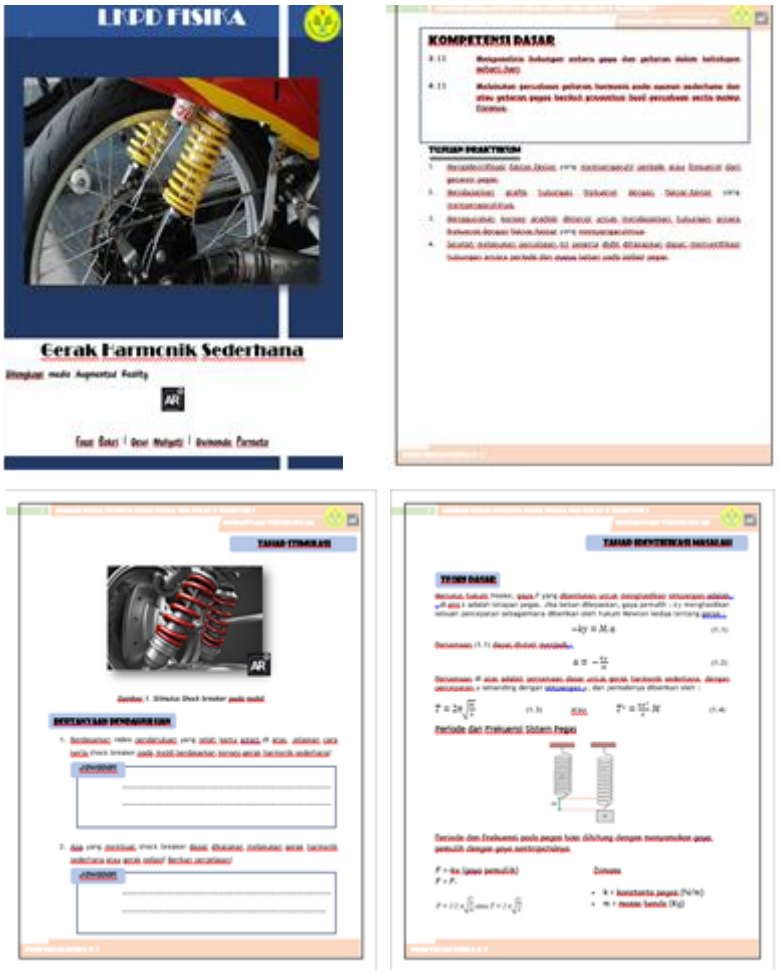


**FIGURE 1.** Initial Stage Display of student worksheet

Practicum Stage

This stage consists of tools and materials needed in the practicum, procedures or stages of operation of practicum tools and materials as well as work steps contained in the AR video, observation tables, data processing tables, graphs and their interpretation.

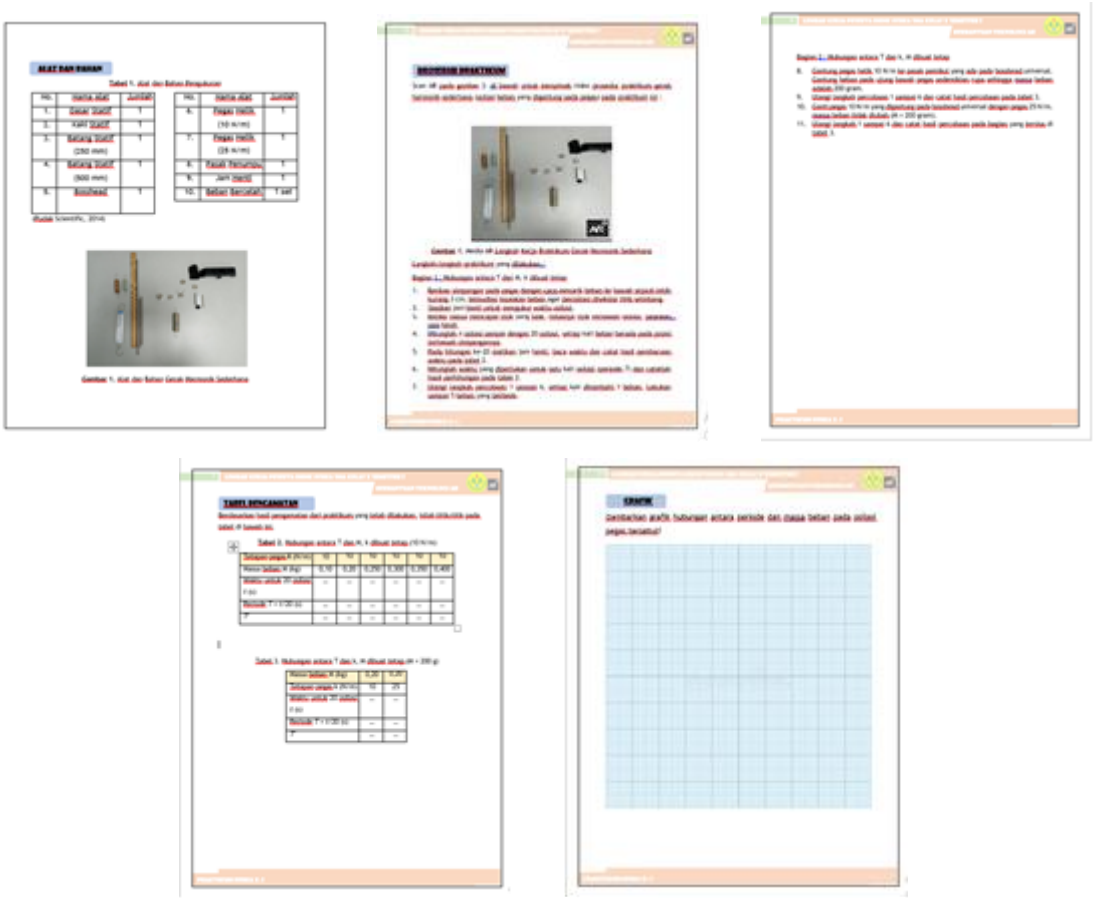

**FIGURE 2.** Practical Stage Display

Post-Practicum Stage

This stage consists of analysis and discussion of physics concepts from practicum results, questions measuring the achievement of practicum objectives, as well as conclusions from practicum results.

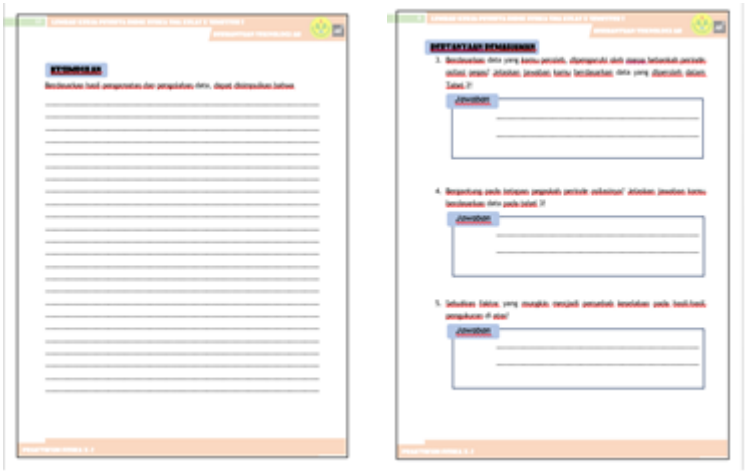

**FIGURE 3.** Post-Practicum Stage Display

On the worksheet, there are several figures with the AR a symbol to support practical activities, where the figures contain videos of physical stimulation and videos of practical work steps as well as explanations of material tools. This practical worksheet application has menu sections found in AR applications, including about panel, hint panel, scan panel, and exit panel. This application was created with the help of Unity, which can then be installed on Android with a minimum version 4.1 (Android Jelly Bean).


**FIGURE 4.** Menu Design Display in AR Application on Smartphone

## Results of Formative Evaluation of Student Worksheet Research Results

Based on the results of the formative evaluation of the student worksheet that has been carried out, the percentage of suitability of media, materials and product are obtained as follows:

**TABLE 1**. Feasibility of AR Assisted Student Worksheet Media

| Aspect | Result |
|---|---|
| Design of practical activities on Student Worksheet | 87% |
| Quality of physics practicum Student Worksheet media | 89% |
| Quality of augmented reality media supporting practical activities on worksheets | 91% |

**TABLE 2**. Feasibility of Student Worksheet Content

| Aspect | Result |
|---|---|
| The relevance of practical material to basic competencies | 91% |
| Accuracy of problem-solving steps in practical activities | 89% |
| Feasibility of the practical stage in preparing physics concepts | 86% |
| Feasibility of language in physics practical worksheets | 89% |

**TABLE 3**. Feasibility of Student Worksheet Learning Activities

| Aspect | Result |
|---|---|
| Stages of practical activities on the worksheet | 87% |
| Accuracy of problem-solving stages on the worksheet | 86% |
| The accuracy of the practical stages in forming physics concepts | 88% |

## Discussion of Research Results

Based on the literature, as technology develops, the world of education also requires developments in the learning media used. In this research, an even semester class X high school physics worksheet was developed using augmented reality technology to train high-school students' problem-solving skills. It is

hoped that this student worksheet can train students' problem-solving abilities. By being equipped with stimulation videos contained in AR media that relate to problem phenomena in the real world, it is hoped that students can apply the knowledge they gain through these stimulations to the real world and can carry out practical work independently and with direction.

## CONCLUSION

It can be concluded that this research produced a product in the form of a physics worksheet for class. The resulting product (student worksheet) has been declared suitable for use by high-school students based on media validation, material validation, and learning validation.

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