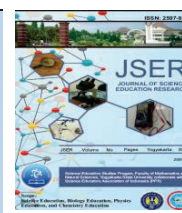




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Development of Student Worksheet Based on Guided Inquiry Assisted by Phet Simulation to Improve Concept Comprehension

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ABSTRACT

Keywords:

Concept
Comprehension,
Guided Inquiry
Model, PhET
Simulation,
Science Student
Worksheet

This study aimed to develop a product in the form of student worksheet based on the guided inquiry assisted by PhET simulation media on Vibration and Wave materials that was feasible according to validators, practical according to science teacher and student responses, and effective to improve student's concept comprehension. This study was a research and development (R&D), which was adapted from Thiagarajan's 4D model. The main field-testing was conducted at SMPN 2 Sukoharjo via online upon 12 students of class VIII H. The design of the main field-testing was one group pre-test-post-test design. The analysis technique included the mean score, Meltzer's standard gain test and Cohen's effect size test. The results show that (1) the obtained student worksheet product based on guided inquiry assisted by PhET simulations was feasible according to the material and media experts with an excellent category, (2) the practicality of the student worksheet used by science teacher was in an excellent category and obtained good responses from the students, and (3) the effectiveness of the developed student worksheet was able to improve concept comprehension with a gain score in the moderate category and the effect size was categorized as a strong effect.

INTRODUCTION

A new policy in the field of education in 2021 was set by the Ministry of Education and Culture in order to adjust the conditions of the Indonesian nation due to the impact of the Covid-19 pandemic, namely about study from home (SFH) policy with the aim of ensuring the fulfillment of students' rights to obtain educational services. The method of implementing SFH is carried out with distance learning (DL) via Internet network (online), which is carried out to provide a meaningful learning experience for students.

The demands of DL also apply to Science subjects. Natural Sciences can literally be referred to as the science of nature and events that occur in nature. Based on the results of observations, science learning at SMPN 2 Sukoharjo is carried out via online using the Google Classroom platform, which has been going on since March 2020. The use of this platform is seen as less interactive because in

reality learning activities are only one-way (asynchronous). The science learning outcomes of students at SMPN 2 Sukoharjo still do not fulfill the school's minimum completeness criteria (MCC) as seen from the science learning outcomes at PTS even semester 2021.

In addition to the decreasing in students' mastery scores and a lack of active interaction, practicum activities cannot be carried out in schools during the pandemic. Therefore, supporting media is needed, namely a simulation that can give students an idea of science concepts, such as the PhET interactive simulations. PhET simulation brings the invisible to life through the use of graphics and intuitive controls such as click and drag manipulation, cylinders and radio buttons (Sumargo, 2014). Science learning presented using PhET simulation media certainly makes it easier for students to understand valid and practical experimental concepts.

The use of worksheets needs to be optimized and supported by a learning model that is aligned with the objectives of the worksheets. The learning model used in here is the discovery or inquiry learning, which is one of the three main learning models in PERMENDIKBUD No. 103 of 2014. Guided inquiry offers an integrated, planned, and guided inquiry by educators to help students gain and develop a better understanding of the concepts of knowledge and skills needed to be used in everyday life (Kuhlthau *et al.*, 2007). The use of the inquiry model needs to be carried out in a guided manner as a form of adjustment in helping students to carry out learning activities as in the syntax of the guided inquiry model. The result of the study by Putri (2019) that is based on the guided inquiry worksheets-equipped with PhET simulations show that the concept mastery of students are increased quite effectively.

METHOD

The type of research used was research and development (R&D), which used the 4D model by Thiagarajan. The stages in the 4D model include: define, design, develop, and disseminate. A development research with small-scale trials was carried out at SMPN 2 Sukoharjo in the even semester of March 2021. The population and sample in this study were 12 students of class VIII H.

The product trial design in this study used the one-group pretest-posttest design by Sugiyono (2013). This is given in Figure 1 where O₁ was the pretest value (before treatment) and O₂ was posttest value (after treatment).

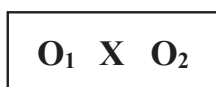


Figure 1. One-Group Pretest-Posttest Design

Data collection instruments with non-test techniques were validation sheets, practicality sheets, student response questionnaire sheets, learning implementation sheets, and test techniques with pretest-posttest sheets for concepts comprehension.

Analysis of the feasibility, practicality, and student response to the worksheets used the formula as follows:

$$\bar{X} = \frac{\sum x}{n}, \tag{1}$$

where X is the mean score, $\sum x$ is the total score, and n is the number of validators. Reference to

change the score to a scale of 5 used the following reference formula, i.e.:

$$X_i = \frac{1}{2} (\text{max score} + \text{min score}), \tag{2}$$

and

$$SBi = \frac{1}{6} (\text{max score} - \text{min score}). \tag{3}$$

where max score is given by the criteria item \times highest score and min score is the criterion item \times lowest score. The scoring criteria were determined by a conversion according to Table 1 (Widyoko, 2009).

Table 1. Conversion of 5 Scale Score

Interval	Category
$X > X_i + 1,8 SBi$	Excellent
$X_i + 0,6 SBi < X \leq X_i + 1,8 SBi$	Good
$X_i - 0,6 SBi < X \leq X_i + 0,6 SBi$	Enough
$X_i - 1,8 SBi < X \leq X_i - 0,6 SBi$	Not Enough
$X \leq X_i - 1,8 SBi$	Very less

Implementation of learning was analyzed using the calculation of the interjudge agreement (IJA) as follows:

$$IJA = \frac{A\gamma}{A\gamma + AN} \times 100\%, \tag{4}$$

where $A\gamma$ is the activities carried out and AN is the activities not carried out (Pee *et al.*, 2002). If the value of IJA exceeds 75% then the prepared lesson plan was said to be implemented.

The increased of concept comprehension can be seen through the improvement of learning outcomes in the pretest-posttest results. This was analyzed using the standard gain with the following formula:

$$g = \frac{\text{posttest score} - \text{pretest score}}{\text{ideal score} - \text{pretest score}}, \tag{5}$$

where g is the standard gain and ideal score is the maximum value (Meltzer, 2002). The interpretation of standard gain is presented in Table 2.

Table 2. Interpretation of Standard Gain

Gain Score	Interpretation
$g > 0.7$	High
$0.3 < g < 0.7$	Moderate

$g < 0.3$ Low

The value of the effect of the worksheets in increasing the concept comprehension was analyzed using the effect size formula (Cohen in Bowles, 2020):

$$\text{Effect Size} = \frac{\text{posttest} - \text{pretest average}}{\text{standard deviation}} \quad (6)$$

The results of the effect size were interpreted in Table 3.

Table 3. Interpretation of Effect Size

Size	Interpretation
0 – 0.20	Weak Effect
0.21 – 0.50	Modest Effect
0.51 – 1.00	Moderate Effect
> 1.00	Strong Effect

RESULTS AND DISCUSSION

The development research used was the 4D model by Thiagarajan. The stages of the 4D model include define, design, develop, and disseminate. The define stage includes 5 activities, namely initial analysis, student analysis, task analysis, concept analysis, and specification of learning objectives. The design stage includes 4 steps, namely the preparation of test standards, media selection, format selection, and initial design of learning tools. The develop stage has 2 steps, namely expert assessment and product testing. The stage of disseminate consists of product distribution, which is limited to the science teachers of SMP N 2 Sukoharjo.

The assessment of the feasibility of the guided inquiry-based worksheet products is carried out by material and media experts. Assessment of the practicality of the guided inquiry-based worksheet products is carried out by science teachers and students through response questionnaires. The level of effectiveness of the guided inquiry-based worksheet products in improving concept comprehension is seen from the increase in learning outcomes through the *pretest* and *posttest* results. The feasibility assessment by the material expert, i.e.: lecturers include aspects of content feasibility, stages of inquiry, linguistics, systematics, content truth, interests, and curiosity of students. The diagram of the results of the assessment by material experts can be seen in Figure 2. The figure shows the results of the feasibility assessment of the worksheets in terms of material, which is included in the very feasible category by obtaining an average percentage of 91%.

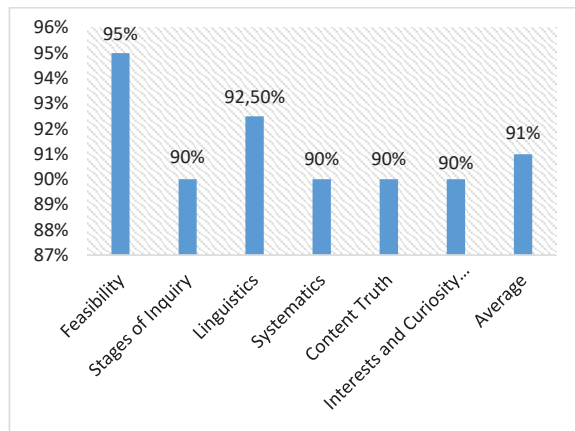


Figure 2. Material Validation Results

The results in terms of the material are very feasible because the form of the worksheets contain what must be done by students, including conducting, observing, and analyzing as the worksheets function as a learning guide, as well as presenting the appropriate material as in the components of the feasibility of the contents of the worksheets.

The assessment of the feasibility of the worksheet-based inquiry guided by media experts consists of the aspects of format, font size, color, visual and image appearance, space adequacy, and layout. The diagram of the results of the assessment by media experts is presented in Figure 3.

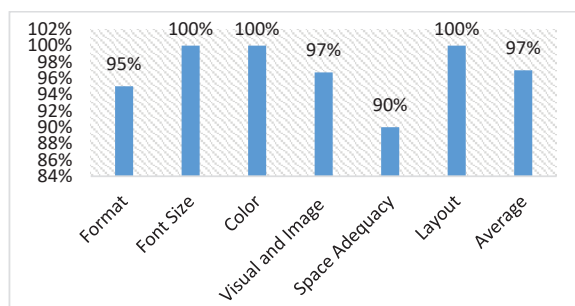


Figure 3. Media Validation Results

Figure 3 shows that the feasibility of the worksheets in terms of media is included in the very feasible category with an average percentage of 97%. The results obtained are very feasible because the worksheet meets the requirements for graphic components such as the design of the skin and content according to the BSNP (Muljono, 2007).

The assessment of the practicality of the worksheets was carried out by science teachers and students through the response questionnaires. Aspects of the science teacher assessment include content, language, presentation completeness,

practicality, interests, and curiosity of students. The results of the assessment by science teachers are presented in Figure 4. The average percentage of practicality by the science teacher is 91% and is categorized as very practical.

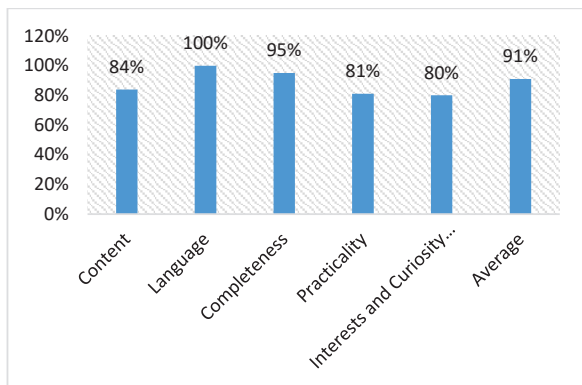


Figure 4. Science Teacher Assessment

The practicality and implementation of the use of the worksheets through the student response questionnaires cover the aspects of content, language, appearance, and implementation. The results of the student response questionnaire are presented in Figure 5. The figure shows the results of obtaining a student response questionnaire with an average percentage of 81.7% and is included in the good category.

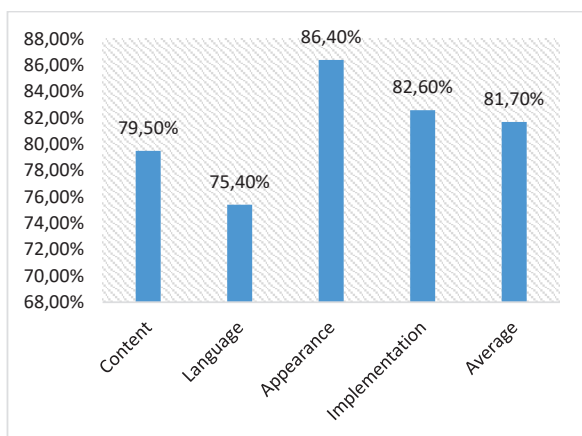


Figure 5. Student Response Results

The overall practicality assessment of the use of the worksheets by science teachers is in the very practical category and by students is in the practical category. This shows that the prepared worksheet is appropriate in terms of practicality and implementation so that it is practical to be used in learning.

Furthermore, the worksheet product is tested on a small scale of 12 students in learning. The implementation of the learning with the guided

inquiry model obtains an average of 96%, so the lesson plans that have been prepared can be said to be very well implemented.

The improved concept comprehension is observed through the learning outcomes of the pretest and posttest results. The average scores of the pretest and posttest of students are presented in Figure 6.

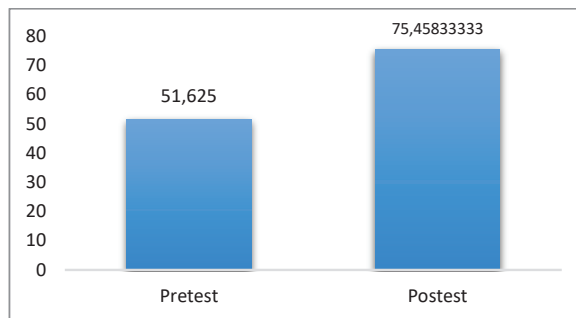


Figure 6. Average of Pretest and Posttest

Based on Figure 6, the average pretest and posttest values are 51.62 and 75.46, respectively. Furthermore, the value of the improvement is analyzed using the standard gain, which produces an n-gain value of 0.48, which is in the $0.3 < g < 0.7$ interval and included in the medium category. The small number of subjects in the product trial affects the results of the n-gain analysis. Based on the results of the effect size analysis, which is used to determine the value of the effect of the guided inquiry worksheet products in improving concept understanding, a value of 1.86 is obtained where the interpretation is > 1.00 and included in the strong effect category.

Based on the results of the overall research, the guided inquiry-based worksheet product developed is able to improve students' concept comprehension. This improvement is supported by the guided inquiry model and the PhET simulation media that is integrated with the product. This is in accordance with the opinion of Kuhlthau *et al.* (2007), which state that guided inquiry offers an integrated, planned, and guided inquiry by educators to help students develop a better understanding of the concepts of knowledge and skills needed to can be used in everyday life.

CONCLUSION

The guided inquiry-based worksheets assisted by PhET simulation are declared feasible by material and media experts with average percentages of 91% and 97%, respectively, and are categorized as very good. The practicality of using the guided inquiry-based worksheets assisted by the PhET simulation by science teachers obtains an

average percentage of 91% in the very practical category and the students' response questionnaire obtains a percentage of 81.67% in the practical category. The effectiveness of the guided inquiry-based worksheets assisted by PhET simulation to

improve students' concept understanding based on the standard gain obtains a value of 0.48, which is included in the medium category and the effect size is $1.86 > 1.00$ with a strong effect category.

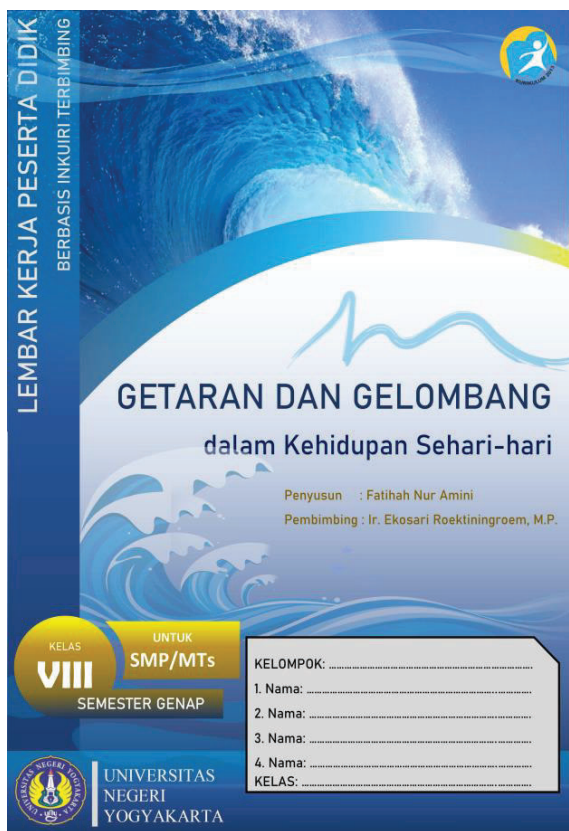


Figure 7. Display of the Cover of the Worksheet



Figure 8. Display of Student Activities

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