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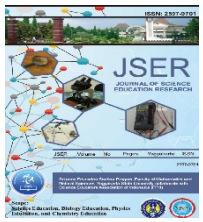

# Effect of Guided Inquiry Model by PhET Simulations Worksheet on Science Process Skills and Mastery of Concepts

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**Keywords**
Guided inquiry model, PhET Simulations student worksheet, rope waves, science process skills, concept mastery.

**Abstract**
This study aimed to (1) analyze the effect of the science learning of guided inquiry model assisted by PhET Simulations worksheet on science process skills and concept mastery on rope wave material at SMP Negeri 1 Sedayu and (2) analyze the effect of science learning through the guided inquiry model assisted by PhET Simulations worksheet on science process skills and concept mastery on rope waves material at SMP Negeri 1 Sedayu. This study was quasi-experiment research with a nonequivalent pretest-posttest control group design. The population was seven classes in grade VIII at SMP Negeri 1 Sedayu. The sample was 50 students who were selected by purposive sampling technique. Data collection techniques were observation and testing. Data analysis was performed using descriptive analysis, independent sample t-test, MANOVA test, and effect size. The results showed that (1) there was a significant effect of the guided inquiry learning model assisted by the PhET Simulations worksheet on science process skills and concept mastery on rope wave material (sig. 0.000). Second, the effect size value in the experiment class with the guided inquiry model assisted by the PhET Simulations worksheet on science process skills and concept mastery in rope wave material is relatively high (1.32 > 0.8).

## INTRODUCTION

Science in the 2013 curriculum is a discipline that is closely related to the environment. Science prioritizes understanding of nature that needs to be preserved and maintained from the point of view of biology, physics, and chemistry (Kemendikbud, 2018). Science learning should focus on the process of creating, not only emphasizing the final result (product). The implementation is facilitated through science process skills (Irawan & Yuliaritiningsih, 2017). Student's science process skills are low due to various triggers. Observations conducted in class VIII at SMP Negeri 1 Sedayu showed that the students were less skilled and only listened to the material being delivered by the teacher during the learning process. Then, the Science process skills should support the student's concept mastery of the subject material.

Observation at SMP Negeri 1 Sedayu shows the results of students' concept mastery, especially in science subjects, which need improvement. Concept mastery is a person's ability to master something scientifically, both in theory and practice in everyday life. Mastery of this concept is needed so the students can understand the material to continue to the next material (Salsabillah, Sudarti, & Supeno, 2018: 259). Students seem to have difficulties in understanding scientific concepts, which makes them unable to solve problems or questions asked by the teacher. The learning model applied should be able to develop and improve this. And, guided inquiry model can be used in implementation.

The guided inquiry learning model is a learning model where a teacher guides and directs students to carry out discussion activities to solve problems and draw conclusions independently (Hamiyah, 2014: 190). The guided inquiry model plays a role in encouraging students to be actively involved and have experience in conducting experiments (Shoimin, 2014: 85). Learning through the guided inquiry model is expected to help students integrate previous knowledge and concepts mastered through the events or problems they observe. The implementation of this guided inquiry

model can be achieved with the support of appropriate teaching media, such as the use of student worksheets.

Student worksheets are printed teaching media containing materials and instructions for completing tasks that refer to the goal of basic competencies (Prastowo, 2015). Students will be able to work like a scientist with student worksheets that are designed by adjusting the steps of the scientific method, for example in inquiry-based worksheets. An inquiry-based worksheet is expected to help activate students more and improve their concept mastery, especially in materials that have many concepts, such as rope wave material. Saprudin et al. (2022: 98) stated the results of observations made at a junior high school in the city of Tidore. He showed that "78% of students have difficulty in learning vibration and wave material due to the learning resources used in the form of textbooks and printed modules that are dominated by text and static images."

Aiming to facilitate students in studying rope wave material, the learning must use appropriate learning media, such as virtual simulation media of a PhET Simulation. Perkins (2020: 45) emphasizes that "PhET interactive simulation activities offer more to the way students learn physics in a way that intrigues the mind of learners with mouth-watering visualizations of abstract physics concepts; hence, they develop a deeper understanding of physics concepts." Students can use PhET Simulation to learn certain materials directly. The features of PhET can support students' concept mastery in achieving achievable goals. PhET simulation can help students concepts mastery in lessons. This PhET simulation has several advantages, such as explaining abstract concepts that cannot be explained in words (Wieman, et al., 2010: 228). The study aimed to analyze the effect of science learning guided inquiry model assisted by PhET Simulations worksheet on science process skills and mastery of student concepts on rope wave material at SMP Negeri 1 Sedayu and analyze the effect of science learning guided inquiry model assisted by PhET Simulations worksheet on science process skills and concept mastery on rope wave material at SMP Negeri 1 Sedayu.

## RESEARCH METHOD

The study used a quasi-experiment with a nonequivalent pretest-posttest control group design. Winarni (2018: 57) explains that "experimental research is systematic, logical, and thorough research to control conditions." Sugiyono (2015: 114) emphasizes that a "quasi-experiment is a research design that has a control group but cannot function fully to control external variables that affect the implementation of the experiment." This research was conducted at SMP Negeri 1 Sedayu in January, March, and April 2023. The subjects were 25 students in each class. Students of VIII D played as the experiment class and students of VIII E played as the control class. The object was the guided inquiry model assisted by LKPD PhET Simulation on science process skills and concept mastery of rope wave material. The design was a nonequivalent pretest-posttest control group design. This research design is presented in Figure 1.

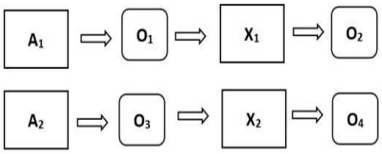


**Figure 1.** Research Design

Description:

| | |
|---|---|
| $A_1$: Experiment class | $O_3$: Control class pretest results |
| $A_2$: Control class | $O_4$: Control class posttest results |
| $O_1$: Experiment class pretest result | $X_1$: Guided inquiry learning assisted by LKPD PhET |
| $O_2$: Experiment class pretest results | $X_2$: Direct instruction learning |

The data include learning implementation, science process skills, and concept mastery. Data was obtained through observations made by observers. Data on science process skills were obtained through observation during the learning using an observation sheet instrument containing indicators of science process skills. Concept mastery data was obtained by conducting a pretest and posttest using test instruments in the form of multiple choice.

Data analysis techniques used descriptive statistics, hypothesis tests, and effect size tests, which are used to provide an overview of the collected data. The learning implementation analysis was carried out using the percentage formula with the following Interjudge Agreement (IJA) equation.

$$IJA = \frac{A_Y}{A_Y + A_N} \times 100\%$$

The lowest value, maximum value, mean value, and standard deviation of the science process skills and concept mastery data from the pretests and posttests were calculated using descriptive statistics. SPSS version 25 was employed in this research. The data on science process skills were examined to ascertain the proportion of each

student's science process abilities, and the outcomes grouped referring to Table 1.

**Table 1.** Science Process Skills Achievement Category

| Achieved Percentage | Predicate |
|---|---|
| 81 - 100% | Very good |
| 66 - 80% | Good |
| 56 - 65% | Enough |
| 40 - 55% | Less |
| 30 - 39% | Very Less |

(Arikunto, 2013: 281)

Prerequisite tests including normality and homogeneity tests are needed before the hypothesis test. The hypothesis test was the independent sample t-test and MANOVA test using the SPSS version 25 program. The independent sample t-test was carried out by looking at the sig. (2-tailed) value, while the MANOVA test looks at the sig value. And, an independent sample t-test to test the differences between the two classes. The effect size test was conducted on the results of science process skills and concept mastery to determine the effect of a variable on another variable. The results obtained were interpreted based on Table 2.

**Table 2.** Criteria for Effect Size Value

| Effect Size | Category |
|---|---|
| $d < 0.2$ | Low |
| $0.2 < d < 0.8$ | Medium |
| $d > 0.8$ | High |

(Yuberti & Antomi, 2017: 102).

## RESULT AND DISCUSSION

The effect of the guided inquiry learning model with the PhET Simulations worksheet applied to students' knowledge of science concepts and process skills was studied using a non-equivalent pretest-posttest control group design. To assess the student's conceptual mastery, the study collected data in the form of learning implementation observation sheets, science process skills observation sheets, and pretest-posttest results. Descriptive statistics, a hypothesis test of an independent sample t-test and a MANOVA test, and an effect size test were all employed in data analysis.

Analysis of the learning implementation was performed in both the experiment and control class. Table 3 presents the proportion of learning implementation in both classes.

**Table 3.** Percentage of Learning Implementation

| Class | Observer (%) | | | | | Average (%) |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | |
| Experiment | 90 | 85 | 90 | 90 | 90 | 89 |
| Control | 89 | 89 | 83 | 94 | 94 | 90 |

The percentage score of learning implementation was 89% in the class using the guided inquiry model, while 90% in the class with the direct instruction model. Both results were >75% so the learning was declared well implemented. The weakness of the learning implementation in both experiment and control classes is that there is no learning review. Wati et al. (2018: 129) state that "the guided inquiry model can be an effective solution to make students active to conduct exploration, observation, investigation that can improve students' mastery of science concepts."

Analysis of observations made in both experiment and control classes on indicators of science process skills. Then, it found differences in results between the experiment and control classes. The indicators of science process skills were adopted from Tawil & Liliasari (2014: 37-38). The indicators include "observing skills, formulating hypotheses, planning experiments, conducting experiments, analyzing data, and making conclusions." The observation sheet is used to measure students' science process skills. A Likert rating scale is used to measure the success of guided inquiry model learning which measures a person's attitudes, opinions, and perceptions related to several phenomena (Sugiyono, 2017: 93). The mean percentage obtained by the science process skills of experiment class students was 71.17% in the category good, while the control class value of 50.25% was classified as less. The average value of each indicator can be seen on Figure 2.

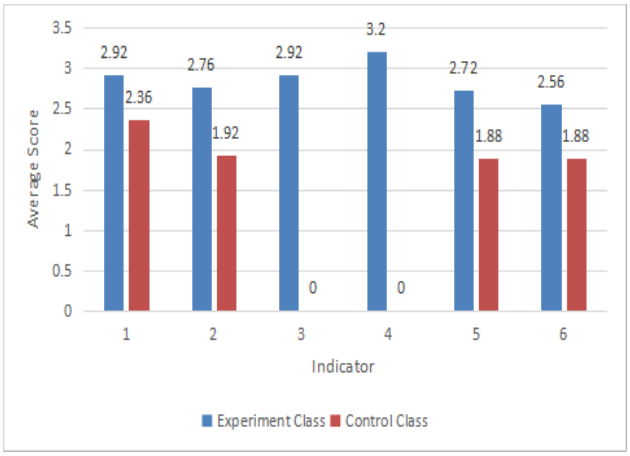


**Figure 2.** Science Process Skills Indicator Meab Score

Based on Figure 2, the mean value of students' science process skills in each indicator is different, in both the experiment and the control class. The fourth indicator is conducting experiments with the highest score in the experiment class which shows students' skills in conducting experiments using PhET simulations that have met the requirements. The third and fourth indicators in the control class showed zero because there were no experimental activities so it could not measure the indicators for planning experiments and conducting experiments. Science process skills can build students' thinking process and develop scientific attitudes because, in the learning process, students use their skills to build their knowledge (Turiman, et al., 2012: 114). This finding shows that the guided inquiry learning model in the experiment class is effective in improving students' process skills. These results are in line with research conducted by Jehadan, Nur, & Supardi (2020: 847) that "learning with physics-guided inquiry developed is classified as very valid, practical and effective for training students' science process skills."

Descriptive statistical analysis was conducted to determine the mean value, highest and lowest values, and standard deviation of the results of students' science process skills and concept mastery. The results of this analysis are presented in Table 4.

**Table 4.** Results of Descriptive Statistics Analysis

| | N | Min | Max | Mean | Std. Deviation |
|---|---|---|---|---|---|
| KPS Control | 25 | 5 | 11 | 8.04 | 1.594 |
| KPS Experiment | 25 | 12 | 21 | 17.08 | 2.565 |
| Pretest Experiment | 25 | 40 | 80 | 59.40 | 12.949 |
| Posttest Experiment | 25 | 53 | 100 | 76.48 | 13.254 |
| Pretest Control | 25 | 33 | 73 | 57.08 | 11.251 |
| Posttest Control | 25 | 53 | 87 | 69.60 | 9.046 |
| Valid N (listwise) | 25 | | | | |

The descriptive statistics analysis produces the mean value of the pretest of 65.00 for the experiment class and 41.08 for the control class. The mean posttest of the experiment class was 76.48, while in the control class was 71.72. Both classes had the same different results but were not significant. The results showed the post-test score was higher than the pretest. Concept mastery may defined as the students' ability to understand some of the material. Students not only remember a concept but also can explain and apply into every day (Widia et al., 2020: 469). The question instrument was in the form of multiple choice with four choices. Permana (2019: 19) stated that "a multiple choice test is an objective test where each test is provided with more than two possible answers and only one of these choices is correct or the most correct." This shows that there is an increase in students' mastery of concepts in rope wave material before and after applying the guided inquiry learning model. The difference between students in mastering the concepts of the two classes is presented in Figure 3.

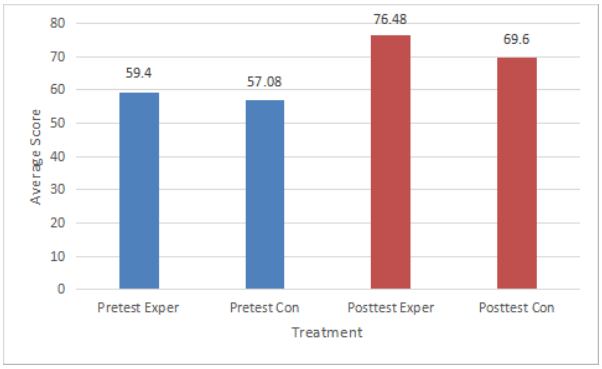


**Figure 3.** Average Score of Students' Concept Mastery

The mean value of the experimental class is higher than the control class. It means that the level of concept mastery of the experiment class is higher than the control class. Also, the guided inquiry model successfully had a positive effect on improving students' mastery of concepts. Similar to the research Putri, Serevina, & Budi (2019: 138) that "LKPD equipped with PhET influences the learning outcomes of participants, namely a gain value of 0.4 in moderate interpretation." Research by Amala, Indrawati, & Wicaksono (2020: 85) that "learning science in junior high school using the PhET application is quite effective in improving student learning outcomes and the average student learning activity is good." The guided inquiry learning model supported by the PhET simulation LKPD provides a new learning atmosphere for students because PhET simulation media has not been widely used. Learning by applying the guided inquiry model builds students to be more active when questioned and asked to ask and express opinions.

The hypothesis test using the independent sample t-test on the student concept mastery score shows a sig. (2-tailed) value of 0.000. These results may be interpreted that there are differences in student learning outcomes on rope wave material with guided inquiry models. The effect of the guided inquiry learning model on the two dependent variables used, namely science process skills and mastery of student concepts, can be determined by conducting a MANOVA test to determine the effect of both. This MANOVA test was conducted with the help of SPSS version 25 with the results of the analysis which is presented in Table 5.

**Table 5.** MANOVA Test Results

| Effect | | F | Sig. |
|---|---|---|---|
| Intercept | Pillai's Trace | 1090.040b | 0.000 |
| | Wilks' Lambda | 1090.040b | 0.000 |
| | Hotelling's Trace | 1090.040b | 0.000 |
| | Roy's Largest Root | 1090.040b | 0.000 |
| X | Pillai's Trace | 16.112b | 0.000 |
| | Wilks' Lambda | 16.112b | 0.000 |
| | Hotelling's Trace | 16.112b | 0.000 |
| | Roy's Largest Root | 16.112b | 0.000 |

Based on the MANOVA test, especially the results of Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root tests, all have a significance value of 0.000, so H0 is rejected. These results indicate that there is a significant influence between the guided inquiry learning model assisted by LKPD PhET Simulation on science process skills and mastery of student concepts on rope wave material. The findings of this study are in line with research by Widyawati, et al. (2019) that "understanding of concepts and science process skills obtained a value of 0.000 < α (0.05). It concluded that the application of the question-based guided inquiry learning model to understanding science concepts and science process skills is very effective."

This effect size test is used to determine the effect of a variable on another variable. The variables targeted in this test are science process skills and concept mastery. The test results obtained are presented in Table 6.

**Table 6.** Effect Size Test Results

| Class | Science Process Skills | Concept Mastery | Effect Size |
|---|---|---|---|
| Experiment | 2.56 | 12.17 | 1.32 |
| Control | 1.60 | 9.10 | 0.98 |

The results of the analysis presented in Table 6 show that students' science process skills and concept mastery were analyzed using the effect size test, which showed the results in both classes were high (d> 0.8). The experimental class has an effect size value of 1.32, and the control class has values of 0.98. The results show that the guided inquiry learning model assisted by LKPD PhET Simulation has a significant effect on science process skills and mastery of science concepts on rope wave material when compared to the direct instruction learning model.

## CONCLUSION

Based on the data analysis and discussions, it concluded that the guided inquiry model assisted by the PhET Simulations worksheet (1) has a significant positive effect on science process skills and concept mastery on rope wave material, (2) the effect on science process skills and concept mastery on rope wave material at SMP Negeri 1 Sedayu is in the high category.

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