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Development of guided inquiry learning tools combined with advance organizer to increase students' understanding of physics concept

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Abstract. The combination of guided inquiry learning models combined with advanced organizers is needed to facilitate students who have diverse initial abilities so that they can participate in inquiry activities well. The purpose of this study is to produce a physics learning device in a guided inquiry model that is combined with an advance organizer, who has valid, practical, and effective criteria in improving students understanding of the physics concept. The learning tools testing phase was carried out in class X in one of the high schools in the Mataram, using one group pre-test post-test design. Observation and concept understanding tests do data collection. The results of the study show that: Learning tools developed are valid; The practicality of learning tools was tested through the implementation of physics learning by the guided inquiry model combined with advance organizer, and the effectiveness of the learning tools can increase student understanding of physics concepts. These results indicate that the learning device developed has valid, practical, and effective criteria to increase student' understanding of the physics concept.

1. Introduction

The essence of science consists of four elements, namely science as a process, product, attitude, and application. The essence of science can be developed through physics learning. Physics is a part of science that focuses on the study of matter, energy, and the relationship between the two [1]. Physics includes facts, laws, principles, and concepts, both concrete and abstract. Physics as a science process is a scientific activity to integrate prior knowledge with new knowledge. In learning physics, understanding concepts are essential to build students' thinking processes in understanding simple to complex problems. Moreover, physics tends to be considered as a difficult subject, especially for high school students.

The difficulty which students got on learning physics when they have to master the different representations (experiments, graphics, conceptual or verbal information, formulas, pictures, diagrams, and graphs) simultaneously and manage changes among these representations [2]. In addition, students find it difficult to understand physics because they do not experience what is learned, so the learning outcomes and activities of students are not optimal [3-5].

The difficulties experienced by students towards physics certainly lead to the achievement of learning outcomes, namely, the inability of students to understand and use physics concepts in various situations. According to [6], understanding concepts is one of the abilities that must be mastered by students because understanding concepts is the basis for formulating principles. Understanding the concept refers to the ability of students to understand scientifically, both the theory and application of everyday life. Students who understand the concept will be able to solve the problems presented in various forms of settlement. Understanding of physics concepts are obtained from theoretical and empirical understanding through experimental activities, so students can record and transfer some information to be used in problems solving, analyzing, and applying in everyday life.

Learning physics cannot be separated from scientific activities. A learning model that is effective and efficient is needed in conducting investigations. Learning that involves students actively in investigative activities to provide direct experience to students in solving problems related to those learned. The learning model that involves students actively in the investigation activity is a guided inquiry learning model. According to [7], Guided inquiry model is a learning activity that starts with the teacher giving a problem then the students complete it through investigative activities but still under the guidance of the teacher. Guided inquiry learning will occur smoothly if the teacher has well planned, and students have good readiness. This means that students must at least have a good prior knowledge of the material being studied and already familiar with inquiry-based learning. Based on observation, implementation of physics learning in school is tends to be one-way (teacher center) so that students do not have inquiry-based learning experiences.

Advance organizer model can activate students' prior knowledge. An advance organizer is model that can stimulate prior knowledge and can be integrated with the new knowledge [8]. An advance organizer is a learning model that emphasizes the organization of initial knowledge which aims to strengthen the cognitive structure of students [9]. Guided inquiry learning model combined with advance organizer has eight stages of learning namely 1) advance organizer presentation, 2) presenting questions, 3) formulating hypotheses, 4) designing experiments, 5) conducting experiments, 6) analyzing data, 7) strengthening cognitive structures and 8) make conclusions. The aim of combination guided inquiry model with an advance organizer that students whose lack of prior knowledge to be facilitated by the presentation of advance organizers in the form of concept maps and videos.

2. Method

This type of research is research and development. The model of the study used a 4-D model (define, design, develop, and disseminate). At the stage of development consists of two activities, namely expert validation and trial of the product. Expert validation was conducted to test the feasibility of the learning tools. The expert validators are three lecturers Master of Science education Universitas Mataram. Validation data were analysed by interpreting the average score scale with the categories in Table 1 [10].

Table 1. Category for Results of Feasibility Assessment

Average Score Range	Category
$4{,}2 \geq VS \leq 5{,}0$	Very High
$3{,}4 \geq VS \leq 4{,}2$	High
$2{,}6 \geq VS \leq 3{,}4$	Medium
$1{,}8 \geq VS \leq 2{,}6$	Low
$1{,}0 \geq VS \leq 1{,}8$	Very Low

*VS = Validation Score

Whereas in the trial activities carried out in one of Senior High School in Mataram for the determined practice of implementation of the learning model. Data were analysed by interpreting the value of the average score scale observers with the categories in Table 2 [10].

Table 2 Practical Category

Average Score Range	Category
4,2 ≥ PS ≤5,0	Very High
3,4 ≥ PS ≤ 4,2	High
2,6 ≥ PS ≤ 3,4	Medium
1,8 ≥ PS ≤ 2,6	Low
1,0 ≥ PS ≤ 1,8	Very Low

*PS = Practical Score

Subjects of the trial phase were students of class X in semester 2 of the 2018/2019 academic year. The subjects were 32 students with an age range 15-16 years old. The subject consisted of 16 male and 16 female students. The design of the trial is one group pre-test post-test design [11]. Pre-test and post-test are the same tests, which is in the form of a multiple-choice test of 20 questions. Pre-test and post-test were analysed with normalized gain scores based on [12] to determine the improvement of each indicator of conceptual understanding.

3. Result and Discussion

This research produced physics learning tools with guided inquiry model combined with an advanced organizer. Learning tools developed in accordance with constructivism learning theory that includes four aspects, namely learning that builds students' understanding, learning by developing prior knowledge, the process of social interaction and meaningful learning where all is achieved through investigative activities.

The learning tools produced consist of the syllabus, lesson plans, student worksheet, teaching materials, and concept understanding tests. The results of the validation of learning tools are presented in Table 3.

Table 3. Validation Result of Learning Tools

No	Assessment Aspect	Expert Validator			Mean	Percentage	Category
		1	2	3			
1	Syllabus	4.00	4.00	4.11	4.04	81%	Valid
2	Lesson Plan	4.00	3.85	4.15	4.00	80%	Valid
3	Student Worksheet	3.80	4.12	4.12	4.01	80%	Valid
4	Concept Understanding Test	4.13	3.88	3.88	3.96	79%	Valid

Table 3 shows results of the learning tools validation in each aspect. Overall, every aspect with the valid category. This means that the learning tools developed are worthy of being tested in schools. However, before being tested, revisions were made in the form of input and suggestions from experts, such as aspects of concept understanding tests, the validator suggested that the language used was not ambiguous so students could understand the purpose of the problem. Learning tools have been revised according to the advice and input of experts. So that research can be carried out to the next stage, namely testing the products developed.

Trial of learning tools was carried out with four meetings. Every meeting was observed in the implementation of learning. Observations were carried out by two observers. Observations were made to see the feasibility of the learning tools developed. In addition, to determine the response of students to the guided inquiry learning model combined with an advanced organizer. The results of observations on the implementation of learning at each meeting are presented in Table 4.

Table 4. Results of Observation on the Implementation of Physics Learning

Meeting	Observer		Mean	Percentage	Category
	1	2			
I	3.79	3.71	3.75	75%	Practical
II	3.67	3.75	3.71	74%	Practical
III	4.38	4.21	4.29	86%	Very Practical
IV	4.46	4.29	4.38	88%	Very Practical

Table 4 shows the results of observations on the implementation of physics learning. At the first meeting, there were stages of learning that were less optimal. It is the stage of the advance organizer presentation took much time, because of when the teacher proposed a question as a stimulus to generate students' prior knowledge, there were still many students who felt confused. Also, in the experimental activities, students are still having difficulty in formulating problems, hypotheses, and experiment procedural. The amount of time spent on preliminary activities and experiments causes the presentation stage of the experimental results for each group was not optimally. These obstacles are caused by students first experience learning with guided inquiry model combined with an advance organizer. Constraints at the first meeting were improved with good readiness from the teacher so that the learning stages were well at the next meeting.

The application of a guided inquiry model combined with an advance organizer also produces data on effectiveness in the form of data on understanding students' concepts in simple harmonic motion material. Understanding the concepts measured includes six indicators of understanding according to [13], namely 1) interpreting, 2) exemplifying, 3) comparing, 4) explaining, 5) inference and 6) generalizing. The results of understanding the concepts of students are shown in Figure 1.

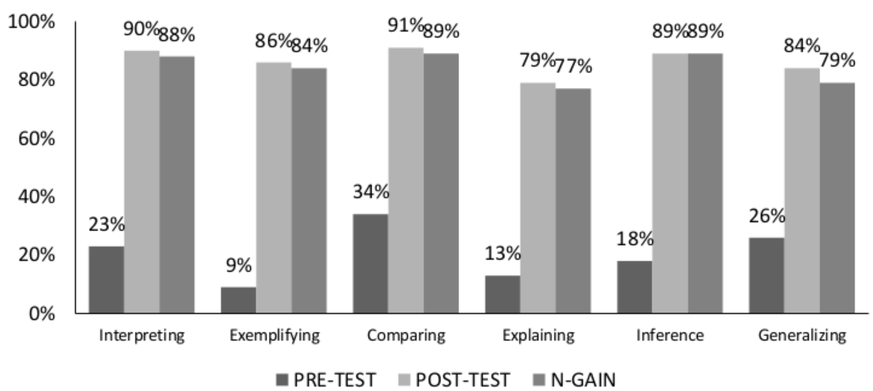

Figure 1. Average Pre and Post Tests for each Indicator of Conceptual Understanding

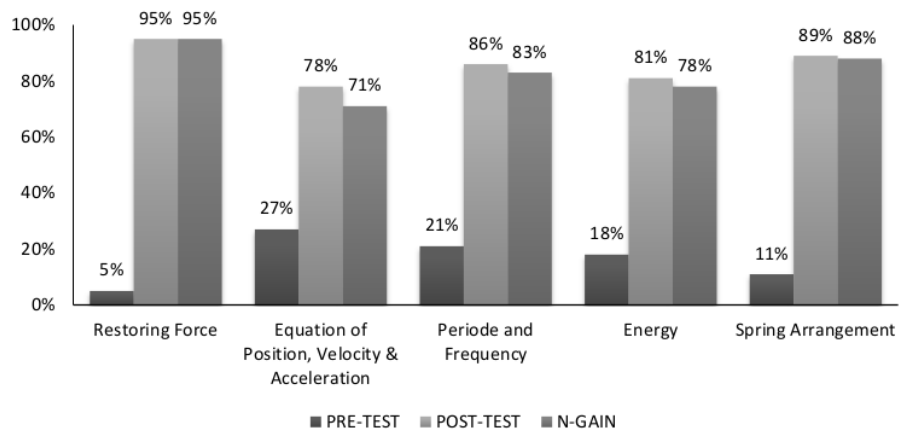

Figure 2. Average Pre and Post Test for Each Sub Material

Figure 1 shows that understanding the concepts of student's increases after being given a guided treatment of guided inquiry models combined with an advance organizer. The result of the N-gain understanding of the concept of each indicator is above 70%. This means that each understanding indicator is included in the high category, or it can be said that the guided inquiry learning model is combined with an advanced organizer effective on each indicator of understanding the concept. Also, the average analysis of each concept understanding indicator, Figure 2 shows the results of pre-test and post-test and n-gain on each sub-material. Sub material in simple harmonic motion consists of five concepts, namely restoring force, position equation, velocity and acceleration, period and frequency, energy in harmonic motion, and spring arrangement. Overall, the average n-gain of each sub is above 70%. The lowest n-gain score on sub material equation of position, velocity, and acceleration. It causes, students must at least master the derivative and integral mathematical concepts. Most students do not understand the concepts of derivatives and integrals. However, the average n-gain in each sub-material is included in the high category. This means that guided inquiry model learning is combined with an advanced organizer effective in improving students' understanding of concepts. This is in accordance with the research [14-15] that implementation media that appropriate in learning model was proven to improve understanding of physics concepts and critical thinking skills, especially in concluding. This is in line with research [16-17] that learning using advance organizers has a positive effect on student learning outcomes. Besides having a positive effect on student learning outcomes. The guided inquiry learning model has several advantages, among others, effective for improving learning outcomes, enthusiasm of students in following practical activities, and attitudes of students during the learning process [18]. In addition, the implementation of guided inquiry model can improve student understanding concept and students' science process skills in physics, especially in hypothesizing, practicing, and communicating [19-21]. The investigation activity in the form of practicum gives motivation to students to find physics concepts [22]. Guided inquiry learning combined with an advance organizer has been proven to be able to improve student' critical thinking skill [23].

4. Conclusion

This research has succeeded in developing learning tools in guided inquiry models that are combined with advance organizers. Physics learning tools that have been developed are included in the category of valid, practical and effective in improving the understanding of students' concepts of physics. Researchers recommend to teachers and other researchers to apply guided inquiry learning combined with advance organizers on other physics material and test it on students' thinking skills.

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