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Development of Learning Media for Wave Ripple Tanks with the Implementation of Guided Inquiry Models on Students' Mastery of Concepts and Scientific Creativity

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Abstract: The purpose of this study was to develop learning media for wave ripple tanks with the implementation of guided inquiry models on the conceptualization and creativity of students in physics subjects in class XI with the material of mechanical wave characteristics. The wave ripple tank learning media is used as a tool in the learning process that can improve students' mastery of concepts and creativity. This study uses the Research and Development method with a 4D design (Define, Design, Development, Disseminate). At the defining stage, the initial analysis was carried out, namely examining the background behind the emergence of researchers' ideas. The design stage is carried out by designing the wave ripple tank learning media with the implementation of guided inquiry models. The development stage is a development activity as well as an assessment of the experts which includes the validation test of the development results of the device, media ripple tank learning, and assessment instruments. The last stage is the dissemination stage, where the results of this study are distributed to schools to be used as a model that can be used.

Keywords: Learning media of wave ripple tank; Guided inquiry model; Concept mastery; Scientific creativity.

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Introduction

Studying physics emphasizes a meaningful learning process that is able to develop the ability to understand the natural surroundings scientifically (Nurussaniah et al., 2017). Not only limited to memorizing activities but must understand (Maesaroh et al, 2016). Meaningful learning can take place in the laboratory so that students have the opportunity to manipulate equipment and materials in the surrounding environment to build knowledge based on phenomena and the relationship between scientific concepts (Susilawati et al., 2015; Sundari et al., 2017). The laboratory is one of the means to bring students to understand the real subject matter which provides a meaningful learning experience directly (Wang et al, 2015; Susilawati et al., 2019).

The teaching and learning process contains elements that are important to note, namely the learning model and learning media. The two elements are mutually exclusive; the use of certain learning models has an influence on the type of learning media used (Anam et al., 2015; Susilawati et al., 2020). The lack of research in the field of physics on mechanical wave material at the high school level so that students have difficulty understanding the basic concept of mechanical waves (Lazonder et al., 2016; Jannah et al., 2016). The learning media referred to in this study is the wave tank ripple on the mechanical wave material of senior high school (SMA) students are required to be able to carry out one experiment, for example, a ripple tank, which is

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a special tool used to investigate the motion of waves on the surface of the water (Wahyudi, 2016).

The guided inquiry model is a learning model that guides students to find and develop knowledge close to life through a hypothetical process so as to increase students' understanding of the concept of participants (Hermanto et al., 2016). The results showed that the guided inquiry model was obtained by classes using the inquiry learning model better than those using conventional learning models (Nurmayani et al., 2018).

Applying a laboratory-based guided inquiry model involves students to actively seek and find solutions to the questions given (Rahmat et al., 2019). The inquiry model has the largest average compared to the conventional model on the science process skills of students (Setyawati et al., 2014). The delivery of mechanical wave material using the wave ripple tank learning media with the implementation of the guided inquiry model is realized in the form of the wave ripple tank learning media as a tool that functions to facilitate students' understanding of the wave material.

Problems that are difficult to solve in the world of education, namely, the tendency of students to consider physics subjects difficult and abstract and also the lack of learning media and practicum tools available in schools. The teacher's ability to apply learning strategies that seem monotonous is also a factor, where learning activities are not enriched with new things. The involvement of students in learning activities should be prioritized so that students do not only accept and memorize lessons without knowing the relationship between the knowledge gained and its application in real life. So far, the achievement of the objectives of learning physics in schools has not achieved the results as expected.

This study focuses on developing the wave ripple tank learning media with the implementation of the guided inquiry model is made as a solution in the physics learning process and makes it easier for educators to convey abstract mechanical wave characteristics material with the wave ripple tank learning media so that students have mastery of concepts and increased creativity in the material of mechanical wave characteristics.

Method

General Background

This research is research development (Research and Development) which uses the development model of Dick and Carey (2001). The product developed was a wave ripple tank learning media to improve concept mastery and scientific creativity of XI grade high school students on the characteristics of mechanical waves.

Sample / Participants / Group

Limited-scale trials in this study were conducted in 2 classes at XI grade in SMAN A Mataram, totaling 64 students, and 2 classes at XI grade in SMAN B Mataram, totaling 80 students.

Instrument and Procedures

This study uses a research and development (R&D) approach with a 4D model stage. Research and Development Methods are research methods used to produce certain products and test the effectiveness of these products (Sugiyono, 2017). The research steps with the 4D model stages are as follows:

a) The definition stage (Define) is carried out, the preliminary final analysis examines the background of the emergence of the researchers' ideas, then the task analysis is carried out by detailing the task content of the subjects in the form of an outline, then concept analysis is carried out by identifying the main concepts to be taught, compiling systematically and detailing relevant concepts, and specification of learning objectives based on concept analysis and task analysis so that they can be more operational and expressed by observable behavior.
b) The design stage is carried out in the device preparation stage in the form of a device design that will be developed, namely Lesson Plan, Student Worksheets, learning media for wave ripple tank, and test instruments in the form of concept mastery questions and creativity questions.
c) Development stage, this stage is an assessment activity from experts which includes a feasibility test for the results of device development and a development test in the form of a test on the use of the results of device development applied in learning. Expert validation is in the form of an assessment of the preparation of tools by expert lecturers/experts to validate the presentation of content, language, time, and indicators of Revision I carried out based on the results of validation by expert lecturers. This revision is carried out once and then it is consulted by an expert. The revised results that have received the fit-for-right approval from the experts are then tested on a limited scale, namely one class XI at SMAN Mataram. Trials of learning tools that have been tested on a limited scale are then revised II and presented in a broad scope. The wide-scale trial was carried out in two XI classes at SMAN Mataram.
d) The dissemination stage of the wave ripple tank learning media with the implementation of the guided inquiry model on the mastery of the concepts and creativity of students that have been developed are spread with journal publications.

Data Analysis

The data collection technique was carried out by observation, distributing questionnaires (product validation questionnaires, validation questionnaires for wave ripple tank learning media with the implementation of the guided inquiry model and test question validation questionnaires), and the final data collection through pretest-posttest. The instrument for collecting data is validated by an expert validator in accordance with its field. The validity of this instrument is determined using the formula for calculating Content Validity (V), which is Aiken's V formula, namely:

$$V = \frac{\sum s}{n(c-1)} \qquad \text{.............................. (1)}$$

Where s is the number given by the validator minus the lowest scoring number, n is the number of validators who filled out the questionnaire, and c is the highest scoring number. Quantitative data were analyzed using the percentage formula as follows:

$$P = \frac{\sum x}{\sum x_i} \times 100\% \qquad \text{.............................. (2)}$$

The practicality test was carried out to determine the practicality of the device that had been developed from the observer's assessment in the form of a learning implementation questionnaire which was analyzed using the average percentage formula:

$$\%average = \frac{\text{the total score of the rater}}{\text{the maximum score}} \times 100\% \qquad \text{...... (3)}$$

The effectiveness test was conducted to determine the increase in student learning outcomes from the results of the pretest and posttest that had been done. The learning outcomes of students in the form of pretest and posttest values were analyzed using the following equation (Sugiyono, 2017):

$$\text{Gain (g)} = \frac{\text{postest} - \text{pretest}}{\text{the maximum score of pretest}} \qquad \text{.....(4)}$$

Result and Discussion

This research is a research development (Research and Development). The main products produced from this development are a wave ripple tank and a learning device developed using a guided inquiry model. The learning tools developed consisted of a syllabus, lesson plans, student worksheets, and an evaluation instrument for concept mastery and Scientific Creativity. The material in this study is the mechanics wave characteristics. The limited-scale trial in this study was conducted at two schools in Mataram.

The learning media for the wave ripple tank that has been developed is tested for its feasibility by being validated by 3 validators, media experts, and material experts. The material expert validator validates the syllabus, lesson plans, and student worksheets. The media expert validator validates the learning media of the wave ripple tank on five aspects, namely: shape, size, completeness, the suitability of the applied wave concept engineering, and practicality in operating the learning media. The evaluation of the material expert validator shows that the syllabus, lesson plans, and student worksheets are in the very feasible category. These results can be seen in Tables 1, 2, and 3.

Table 1. Summary of syllabus validation results.

Assessment Aspects	Score (%)
Conformity between indicators and basic competencies	100.00
The suitability of the subject matter with indicators	100.00
The suitability of learning activities with the subject matter	100.00
The suitability of the assessment with learning activities or learning experiences	86.67
The suitability between the allocation of time and the assessment	93.33
Match between learning resources and time allocation	86.67
The language used is communicative and easy to understand	93.33
The language used is in accordance with the conditions of the object or target user	86.67
Completeness of syllabus components	100.00
Learning activities are in accordance with the guided inquiry model syntax	100.00
Average	94.67
Criteria	Very feasible

Table 2. Summary of lesson plan validation results.

Assessment Aspects	Score (%)
Formulation of Learning Objectives	95.56
Contents served	96.00
Language	82.22
Time	100.00
Average	99.26
Criteria	Very feasible

The media expert validator validates the learning media of the ripple tank on five aspects, namely: shape, size, completeness, the suitability of the applied wave concept engineering, and practicality in operating the learning media. The results of the media expert's validation show that the wave ripple tank developed is in the feasible category as shown in Table 4.

Table 3. Summary of student worksheets validation results

Assessment Aspects	Score (%)
Contents Presented	
Student worksheet is presented mathematically	100.00
Is an essential material/task	93.33
The problem raised is in accordance with the level of cognition of students	93.33
Each activity presented has a clear purpose	100.00
The activities presented can foster the curiosity of students	93.33
Student Worksheet presentation is equipped with pictures and illustrations	100.00
Language	
Use of language according to Enhanced Spelling	86.67
The language used is in accordance with the level of cognitive development of students	86.67
The sentences used are clear and easy to understand	93.33
Clarity of instructions or directions	100.00
Average	94.67
Criteria	Very feasible

Table 4 shows that the results of the media expert's validation of the wave ripple tank developed are in the feasible category. The validator added that the learning media developed was an innovation to attract students' interest in learning. Innovative learning media are tools for conveying learning messages by utilizing technology and information so that students are able to understand the material presented by the teacher well (Kartini et al., 2019; Khasanah et al., 2019). The innovation from the development of this learning media is to take advantage of objects and equipment that are around us and the development of technological science. The wave ripple tank being developed has several advantages including visualizing the process of wave formation and the interactions that occur between several waves that are formed. The existence of this wave ripple tank can help students understand the concept of waves better, and increase the creativity of students.

Table 4. Presentation of the results of media expert trials.

Validator	Percentage Eligibility (%)	Criteria	Level of Validity	Criticism and suggestions
Media Expert 1	84	Very good	Very valid	• The media size is not very large • Use a transparent vessel so that water waves are observed • Include instructions for using the media
Media Expert 2	79	Good	Valid	• Ensure that the ripple tank container does not vibrate when the vibration source is turned on • Do not use a dark-colored container
Media Expert 3	80	Good	Valid	• The steps in the operation of the ripple tank media must be appropriate • Label the names of each component of the wave ripple tank
Average score	81	Good	Valid and feasible with recommended revisions	

Table 5. Summary of educator and student response results to lesson plan.

Responder	Average (%)	Criteria
Educator	92.22	Very good
Students of SMAN A	85.16	Very good
Students of SMAN B	86.64	Very good
Average	88.01	Very good

Table 6. Summary of educator and student response results to student worksheets.

Responder	Average (%)	Criteria
Educator	89.09	Very good
Students of SMAN A	87.27	Very good
Students of SMAN B	90.22	Very good
Average	88.18	Very good

Table 7. Summary of educator and student response results to the wave ripple tank.

Responder	Average (%)	Criteria
Educator	92.22	Very good
Students of SMAN A	87.47	Very good
Students of SMAN B	90.47	Very good
Average	90.05	Very good

Table 8. Recapitulation of observation results of lesson plan implementation

No	Meeting	SMAN A		SMAN B	
		Observer		Observer	
		I	II	I	II
1	First	85.71	90.48	88.52	90.48
2	Second	90.91	90.91	90.48	90.91
3	Third	95.45	95.45	95.45	95.45
4	Fourth	90.91	95.45	90.91	90.91
5	Fifth	100.00	100.00	100.00	100.00
Average		92.60	94.46	93.07	93.55

Analysis of the practicality of media and learning tools that have been developed using teacher response questionnaires, student response questionnaires, and learning implementation observation sheets assessed by two observers. The following is a table of the results of the analysis of the practicality of media and tools that have been developed based on the opinions of educators and students for SMAN in Mataram as research subjects.

The media that have been developed are then used in learning by using a guided inquiry model. To assess the practicality of the wave ripple tank learning media used observation sheets, teacher and student response questionnaires containing questions, opinion columns, and suggestions related to the media and learning devices used. The use of learning devices supported by the wave ripple tank media in learning received a positive response from both educators and students from two high schools in Mataram. They stated that the learning media used were very interesting, so they got new and fun learning experiences. In addition, the very simple way of using the media makes the media developed easy to use but still has a modern element.

In a teaching and learning process, the mastery of mathematics would support students in learning physics (Retnawati et al., 2018). Thus, the concept of the material being studied must be mastered properly so that it can support mastery of the concept in the next material. This research also examines the students 'mastery of the concept of the mechanical wave characteristics material in order to support students' mastery of the next material. The results of the students' mastery of the concept of the mechanical wave characteristics in this study are shown in Figures 1 and 2.

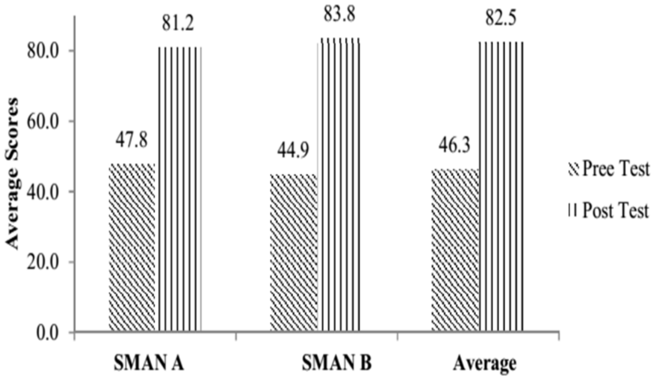

Figure 1. Graph of concept mastery pre-test and post-test values.

Figure 1 shows the average pre-test and post-test scores tested at the school that was the subject of the study, namely the two high schools in Mataram. The graph shows that there is a very significant increase between the pre-test and post-test scores. This shows that the wave ripple tank and the device developed using the guided inquiry model are effective in increasing the students' mastery of concepts at the schools that are the research subjects. Figure 2 shows that the average conceptual mastery in the two schools that were the research subjects was in the medium category, namely 0.7. In accordance with the N-Gain Table, SMAN A is in the medium criteria, while SMAN B is on the high criteria.

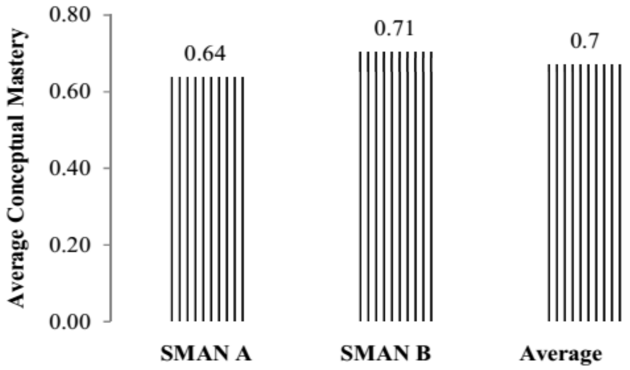

Figure 2. Graph of the concept mastery n-gain value

In the learning process using a wave ripple tank, students conduct experiments directly so that they can practice the scientific creativity of students. Creativity is undoubtedly an important factor in science. Therefore, many science educators emphasize that students need to have creativity in working scientifically (Park, 2011).

Figure 3 shows that the device developed effectively increases the scientific creativity of students. This can be seen from the increase in the average pre-test and post-test scores of students in the two research subject schools. Figure 4 shows that the scientific creativity of students in the two schools that were the research subjects was in the medium category because the N-Gain scores obtained were 0.39 and 0.41. The score is in the range 0.3 to 0.7 according to the N-Gain Table, this range is in the medium criteria.

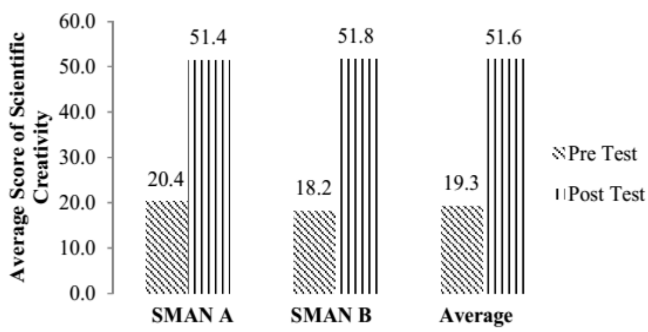

Figure 3. Graph of pre-test and post-test average score of scientific creativity.

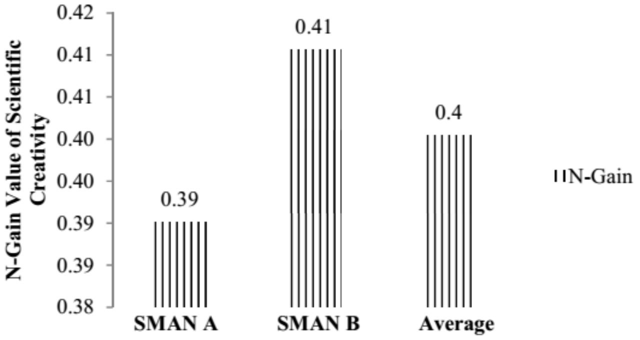

Figure 4. Graph of pre-test and post-test average score of scientific creativity.

Broadly speaking, learning tools developed with the guided inquiry model can effectively improve students' mastery of concepts and scientific creativity. The same result has been gained from Wicaksono on his research that the use of media in learning improved the student's scientific creativity and concept mastery (Wicaksono et al., 2017).

Conclusion

The wave ripple tank learning media and the guided inquiry model learning tools have valid characteristics with the category very feasible to use, very practical, and very effective in improving the conceptual understanding of students of SMAN Mataram on the material of mechanical wave characteristics.

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