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Development of Student Worksheets Based on a Multi-Representation Approach to Improve Students' Mastery of Sound Wave Concepts

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Abstract: This development research aims to produce a product in the form of student worksheets based on a multi-representation approach to improve students' mastery of the sound wave concept that is valid, and effective. The product developed is student worksheets. The research design used is a 4D model consisting of Define, Design, Develop and Disseminate. Data collection techniques used validation sheets and concept mastery evaluation tools. Device validity data were analyzed using a Likert scale. Product effectiveness data were analyzed using Gain standards. Product validity was assessed by three expert validators and three practitioner validators. The assessment by the expert validator is 3.50 and by the practitioner validator it is 3.70 with valid criteria. The average result of the N Gain test for mastery of Sound Wave concepts is 0.73 in the high category. So, it can be concluded that student worksheets based on a multi-representation approach to improve students' mastery of sound wave concepts are valid and effective.

Keywords: Student Worksheet; Multi-Representation Approach; Concept Mastery.

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Introduction

Physics is a branch of science that studies real and abstract natural phenomena. Real natural phenomena can be seen such as the movement of the airplane's trajectory, the movement of the wind, the trajectory of the parabolic kicker of the ball and so on. An abstract natural phenomenon is found in the movement of electrons in atoms, the jump of electrons in the semiconductor process. This phenomenon is formed from various physical quantities and develops through scientific steps in the form of observation, problem formulation, hypothesis formulation, hypothesis testing through experiments, drawing conclusions (Ismet, 2013; Trianto, 2012).

Analysis of abstract physical phenomena requires high reasoning power in studying physics, this is what causes students to find difficulties in learning it. To understand concrete and abstract phenomena requires representational skills in the form of visuals, animations, pictures, inventions, mathematical data presentation, experiments, graphs, conceptual, diagrams and equations (Mahardika, 2013; Doyan, 2018; Mahardika, 2020; Mahardika, 2021).

In studying physics, the emphasis is on understanding a concept so that knowledge is formed through discovery activities, mathematical presentation of data, and certain other rules (Trianto, 2012). To understand physics requires different representational abilities. This is what makes students have difficulty in learning physics. Physics learning in schools is still conventional, innovations in learning have not yet developed such as quantum learning, problem base

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learning, creative thinking (Doyan, 2015; Hardiansyah, 2019; Rizaldi, 2021).

Physics lessons have a lot of material, one of which is sound wave material. Sound waves are mechanical waves that are classified as longitudinal waves with their propagation through the medium. In this material, many students do not understand in depth the concept of the sound wave itself. The ability of students to master the concept of sound wave material is very low because it is still far below the minimum completeness criteria. This is because students are less active and creative when receiving learning takes place. This means that students are passive in class, in other words, only teachers who are active in learning activities or learning are still conventional so that communication during learning takes place only in one direction. Students tend to just listen without analyzing and thinking about what is obtained through the teacher's exposure (Nofriati, 2016).

The facts on the ground show the ineffectiveness of the teaching and learning process in schools. One of them is the teaching and learning process which is still conventional so that students have limitations in learning actively and creatively. The limitations of the learning process during this pandemic resulted in teachers having difficulty in developing learning tools so that it had an impact on students' interest in learning and difficulties in understanding the subject matter. Students have difficulty understanding the subject matter because the teacher cannot control the learning process optimally (Majid, 2008).

Learning is a complex thing that can happen to a person throughout his life. Learning is a lasting change in behavior resulting from practice or other forms of experience. Education requires adequate facilities and infrastructure to create highly competitive learners. Some of them are learning tools such as student worksheets that are able to support students to master teaching materials or materials easily. (Schunk, 2012).

The multi-representation approach is an approach that uses various representations to convey concepts in the learning process. In multi-representation science learning, describing the same problem or process in different situations, including verbal, graphic or numerical formats (Tytler, 2013).

The multi-representation approach has three main functions. First, multi-representation functions to provide complementary information or help complement cognitive processes. Both representations are used to limit the possibility of errors in interpreting the other representations. Furthermore, multi-representation encourages students to build an in-depth understanding of a problem (Irwandi, 2015).

De Jong (2012) divides the forms of Multi Representation into four categories. First, Multi-representation in human reasoning, multi-representation can support the formation of one's understanding of information. Where everyone has their own multi-intelligence so they need different skills from the information they get to make it easier to understand.

Second, Multi Representation in learning that is specifically used in physics learning has three ways. The three ways are (a) as a tool that describes the problems that occur when students make or draw sketches of physical situations and complete the information, (b) as the subject matter when students are explicitly asked to make graphs or find the value of a physical quantity using a graph. , (c) as a step when students are asked to draw a free-body diagram as one of the first steps to solving problems (Astuti, 2013).

The third is Multi Representation in teaching can use multiple representations to explain abstract concepts by converting the concept into a visual representation. So that students can understand the meaning of the concept.

Fourth is Multi Representation in problem solving, in the form of successful representation in directing students to understand information and knowledge to provide convenience for students to solve various problems.

In solving physics problems, one of the students is given a worksheet. Student worksheets are sheets that contain tasks that must be completed by students. This worksheet contains the steps used by students in completing tasks, where in each task it is clear the competencies to be achieved. Student Activity Sheet is a student guide that is used to carry out research or problem solving activities. The student worksheet contains a set of basic activities that students must do to maximize understanding in order to develop basic multi-representation abilities according to the indicators of achievement of learning outcomes that must be taken. (Majid, 2008; Trianto, 2012).

Method

The research used is research and development research. In this case, what was developed was a learning device, namely the Student Worksheet and testing the effectiveness of the product. This development model refers to the development model proposed by Thiagarajan, also known as 4-D (definition, design, development, dissemination) (Sugiyono, 2014).

The research subjects in this study were 25 students of class XI MIPA 2, SMAN 3 Mataram. The instruments used in this study were validation sheets, student response questionnaires and tests for understanding the concept of sound waves.

The technique of collecting data for validity is using a validity test by 6 validators with an assessment

using a Likert scale. Then the effectiveness data obtained from the results of the N Gain test. The data analysis technique on validity uses a Likert scale and the effectiveness of learning devices is analyzed using N Gain, it can be seen in equations 1 and 2.

$$\text{N} - \text{gain} = \frac{S_{post} - S_{pre}}{S_{max} - S_{min}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Information:
S_{post} : Post Test Score
S_{pre} : Pre Test Score
S_{max} : Maximal Score
S_{min} : Minimal Score

Based on the results obtained using N-Gain, the effectiveness categories are grouped according to Table 1.

Table 1. Interpretation of the N-Gain Index.

No	Interval	Criteria
1.	g > 70	High
2.	30 ≤ g ≤ 70	Medium
3.	g < 30	Low

$$P = \frac{f}{N} \times 100\% \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Information:
P = Percentage Number
f = Score obtained
N = maximal Score

The questionnaire response to the use of the product has four choices according to the content of the question. Changing the assessment results from letters to scores with provisions using the Rating Scale scale which can be seen in Table 2.

Table 2. Assessment Score Against Answer Choices

No	Answer Choices	Score
1	Very Good	4
2	Good	3
3	Enough	2
4	less	1

(Latifa, 2016)

Validation questionnaire and response using four choices according to the content of the question. The percentage data obtained is then converted into the criteria for the validity of the learning devices listed in Table 3.

Table 3. Validity Criteria

No	Persentase (%)	Validity Criteria
1	85 - 100	Very Valid
2	70 - 85	Valid
3	50 - 70	Quite Valid,
4	0 – 50	Invalid

Result and Discussion

The definition stage aims to obtain information about the condition of students, problems that arise when learning, learning methods used by teachers, supporting media and curriculum studies used. At this stage, an initial analysis was carried out by conducting interviews with physics teachers at SMAN 3 Mataram to find out the initial state. Then determine the content in the lesson plan by detailing the task of teaching material content, Core Competencies and Basic Competencies as well as indicators developed from Basic Competencies. The material developed in this research is Sound Waves. Furthermore, the formulation of learning objectives is carried out.

The design stage is the stage of making the initial draft of the learning device used in learning the sound wave material. The resulting draft is in the form of a Student Worksheet.

The development stage is the stage to produce a development product which is carried out by testing the validity and effectiveness of the product developed using a validation sheet and a sound wave concept mastery test instrument. The results of the validity of the product developed were assessed by 3 expert validators and 3 practitioner validators and can be seen in Table 4.

Table 4. Obtaining the validity of the Student Worksheet

No	Validator	Persentage (%)	Categories
1.	Expert validator	91.5	Valid
2.	Practitioner Validator	90.5	Valid

Based on Table 4 above shows, the developed student worksheets obtained a percentage of validity by the expert validator 91.5% and by the practitioner validator obtained 90.5% with a valid category. However, the developed student worksheets received criticism and suggestions from the validator so that minor revisions were made so that the developed student worksheets became better. Learning devices that have met the criteria for validity can be used in learning. This is also in accordance with Fitriani's opinion (2019), that a product that is developed if it meets the criteria for validity can then be used in learning. The developed product is then tested on students. The average gain of N-Gain for students can be seen in Table 5.

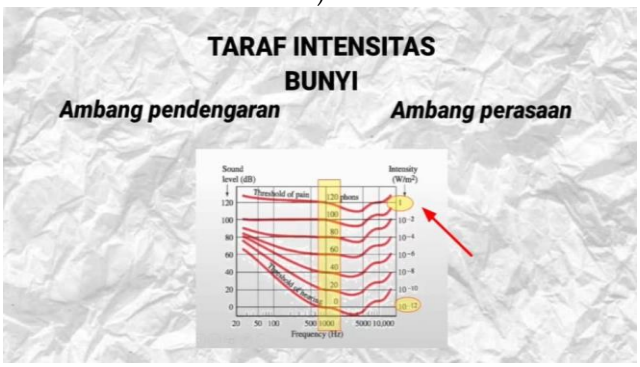
Table 5. The average acquisition of the concept mastery test with the N-Gain Test

$\bar{X}$ Pretest	$\bar{X}$ Posttest	N-Gain	Category
31.2	81.6	0.73	High

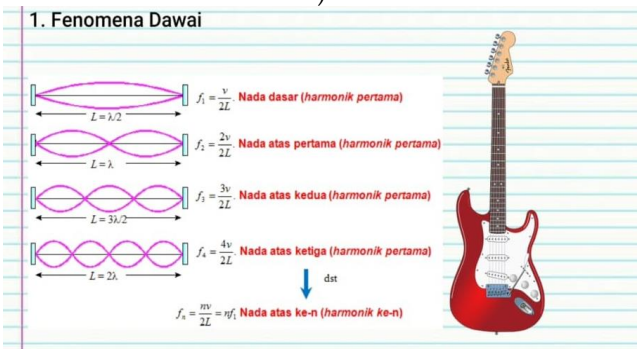
Table 5 above shows the increase in mastery of concepts for students of class XI MIPA 2 in the high category with an N-Gain of 0.73. The Student Worksheet

based on the multi-representation approach that was developed looks like Figure 1 (Latifa, 2016, Kosim 2019).

a).



b).



c).

d).

Figure 1. Student Worksheets based on a multi-representation approach: a). Verbal language, b). Diagrams, c). image, d). Mathematics

To find out the achievement of increasing the highest concept mastery indicator, the following describes the results of the N-Gain test for each indicator which can be seen in Table 6.

Table 6. Average Gain per Concept Mastery Indicator with N-Gain Test

Indicator	$\bar{X}$ Pre	$\bar{X}$ Post	N-Gain	Categories
Presenting the concept	24.03	98.66	0.98	High
Classifying objects	46.00	86.00	0.74	High
Connecting concept	28.02	69.36	0.57	Medium
Modeling the concept	32.00	70.00	0.56	Medium

Table 6 shows that the indicators of concept mastery for the value of N-Gain are in the medium and high categories. In addition, the increase in mastery of concepts for 25 students of class XI MIPA 2 in Table 5. shows an N-Gain value of 0.73 in the high category. So it can be said that there is an increase in the concept mastery of students in class XI MIPA 2. Furthermore, from 25 students it is known that the highest increase in concept mastery is experienced by 16 people, then 9 people are in the medium category and no students are in the low category. The details of the data can be seen in Table 7.

Table 7. Specifications Category mastery of concepts with N-Gain Test

Score N-Gain	Categories	Number of Students	Persentage (%)
0.70<g<1.00	High	16	64.00
0.30<g<0.70	Medium	9	36.00
0.0<g<0.30	Low	0	0.00

Table 7 above shows the percentage increase in mastery of concepts with a high category of 64%, a medium category of 36% and a low category of 0%. Based on these percentages, it can be said that the developed student worksheets can improve students' mastery of concepts in class XI MIPA 2. The dissemination stage is carried out by publishing research results into e-journals and distributing products that have been developed to the class and to other schools.

Conclusion

Based on the results of the research and discussion, it can be concluded that the development of multi-representation-based student worksheets is effective for increasing mastery of concepts.

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