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Development of Student Worksheet for Sound Waves Based on Project Based Learning Model to Improve Students' Science Literacy

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Abstract: Research and Development (R&D) research is included in this study using the 4D model developed by Thiagarajan. The product developed student worksheet sound waves. Data collection techniques used validation sheets, teacher learning implementation observation sheets, student response questionnaires and test instruments. This product was assessed for validity by three expert validators who are physics lecturers and three practitioner validators who are physics subject teachers. Its validity was obtained from the assessment results of expert and practitioner validators, which reached 91.67% and 94.70% respectively, indicating that the product was very valid. In addition, the reliability value also met the standard with an average of above 75%. Therefore, it can be said that this product is feasible to use. The practicality of this product was evaluated through observation sheets by teachers and questionnaires filled out by students related to the learning carried out. The assessment results show that this product is very practical, with the implementation sheet by the teacher reaching 94.56% and the response of students reaching 89.54%. In addition to validity and practicality, the effectiveness of this product was also assessed. The limited trial was conducted by measuring the increase in pretest and posttest scores using the N-Gain test. The analysis results show that this product is quite effective, with the acquisition of the N-Gain test for students' science literacy of 0.69, which is in the medium category. Based on the evaluation results, it can be concluded that the sound waves student worksheet produced is a feasible product, very practical, and quite effective in improving students' science literacy.

Keywords: Sound wave student worksheet; Project-based learning; Science literacy.

Introduction

Natural science is a branch of science that explores all events that occur in nature. Physics, as an important part of science, is a discipline that studies the most basic natural phenomena and events as they relate to the behaviour and structure of matter (Mahdalena et al., 2022). One of the efforts to improve students' understanding of physics concepts is through the application of quality learning tools, one of which is student worksheets (Sahidu, 2019; Yustina & Kapsin, 2017).

According to Mu'tashimah et al. (2020), student worksheet is a sheet of paper that contains a summary of the material, and instructions for carrying out student tasks in learning. The task is the obligation of students to do and the teacher's obligation to carry out the inspection (Mu'tashimah, 2020). The function of student worksheet is to minimise the role of educators, activate students to interact with the material provided, present tasks that can be done (Nisrina et al., 2020). This is in line with Yusuf et al. (2022), student worksheet can increase students' understanding of the material to be studied. In addition, in the context of physics learning, teachers are faced with demands to have creativity in designing and

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implementing a variety of interesting learning models and methods.

A learning model is a design in the form of a description of the learning process carried out by the teacher by transferring knowledge to students (Trianto, 2012). The project-based learning model is an innovative learning model that centres on students by focusing on constructing students' knowledge (Sakti et al., 2021; Hadi et al., 2023). According to Anggreni et al. (2020), the project-based learning model is a learning model that is focused on producing a scientific product that can improve science literacy.

PISA (2018), suggests that science literacy is knowledge related to science, which aims to recognise questions, acquire new knowledge, explain scientific phenomena, and make conclusions based on facts. Science literacy also involves an understanding of scientific characteristics and the application of science concepts in everyday life. According to Sya'ban and Wilujeng (2016); Ma'sumah & Mitarlis (2021), science literacy is the knowledge to recognise concepts, understand, explain, identify, communicate and apply science.

Based on the results of the PISA survey (2018) that Indonesia is in sixth position from the bottom or 74th place from other countries. The low science literacy experienced by students is due to the lack of maximum mastery of learning so that students' competencies are not achieved, the lack of seriousness of students in learning, facilities that do not support the learning process both in the classroom and outside the classroom, the unorganised science learning process so that students' science literacy is categorised as low (Adnan, et al., 2021; Bahtiar, 2022).

The results of observations that have been made by researchers at SMAN 1 Monta Bima Regency class XI MIPA 2 obtained the results that the teacher uses a package book provided by the government. In the learning process the teacher conveys the material and notes on the board using the lecture method and the teacher provides practice questions oriented to the ability to memorise physics formulas so that students only focus on the ability to memorise formulas from the material studied. Therefore, in the implementation of the learning process teachers tend to be more active than students.

The results of interviews conducted by researchers with teachers in class XI SMAN 1 Monta Bima Regency on 27 July 2022 that many students are passive in learning physics, because physics learning is considered difficult by students and the use of student worksheet teachers rarely implement in the learning process. This is because teachers have difficulty dividing their time in making student worksheet which takes quite a long time. In sound wave material the teacher has never applied or associated with gambo musical instruments.

In addition to teacher interviews, researchers also conducted interviews twith students. The results obtained that students do not know physics learning that uses Bima gambo musical instrument media into learning sound wave physics material and have never done a practicum or experiment in making gambo musical instruments. Therefore, there is a need for a project-based learning model-based sound wave student worksheet that can facilitate the needs of students to improve science literacy.

Method

Research and Development (R&D) research aims to produce a product that will be tested to assess its feasibility, practicality, and effectiveness. The product produced from this research is a project-based learning-based learner student worksheet. This research design uses the 4D model developed by Thiagarajan et al. (1974) which consists of 4 stages, namely define, design, develop and disseminate. However, the dissemination stage was not implemented due to time and cost constraints.

This research was conducted in class XI MIPA 2 SMAN 1 Monta, Bima Regency during the academic year 2022/2023. The data collection process was carried out through the use of several instruments, namely validation sheets, implementation sheets, response questionnaires, and science literacy test instruments given to students. The validation sheet was used to evaluate the feasibility of the product, including its validity and reliability. The validation process involved 6 validators, consisting of 3 expert and 3 practitioner validators. In addition, the implementation sheet and learner response questionnaire were used to assess the practicality of the product. Meanwhile, the test instrument was used to measure the effectiveness of the developed product.

The assessment of the validation sheet was carried out using a Likert scale consisting of numbers 1 to 4, with criteria 1 = invalid, 2 = less valid, 3 = valid, and 4 = very valid. The formula for calculating the percentage of product validity is as equation 1.

$$\text{Validity score} = \frac{\text{Sum of scores from validators}}{\text{Maximum possible score}} x\ 100\ \% \quad (1)$$

The scores from expert validators and practitioners can be calculated with the following equation formulated by Riduwan (2013) as equation 2.

$$\bar{x} = \frac{\text{Sum of scores from each validator}}{\text{Number of validators}} x\ 100\ \% \quad (2)$$

The criteria for the validity of the student worksheet on sound waves are determined in Table 1.

Table 1. Criteria for the percentage validity of student worksheet

Percentage (%)	Score
85.01 – 100	Very valid
70.01 – 85.00	Valid
50.01 – 70.00	Less valid
01.00 – 50.00	Invalid

(Riduwan, 2013)

Furthermore, the reliability will be tested using the equation formulated by Borich (1994) equation 3.

$$(\text{PA}) = \left[\, 1 - \frac{\text{A} - \text{B}}{\text{A} + \text{B}} \right] \text{X } 100\% \quad (3)$$

A is the highest score by the validator and B is the lowest score by the validator. To calculate the percentage of agreement (PA) is determined by combining the validation results of the three validators. The results of product validation can be said to be reliable, if the reliability value is obtained ≥75% (Makhrus et al, 2020). Analyses practicality using the following equation 4.

$$\% = \frac{\text{Sum of scores from the validatos}}{\text{Maximum possible score}} \; x \; 100 \; \% \quad (4)$$

The analysis of the data that has been obtained is then interpreted with the provision that the student worksheet for sound waves is said to be practical if the minimum assessment is in the practical category, namely an interval value of more than or equal to 61%. Practicality categories and intervals are determined in Table 2.

Table 2. Criteria for the percentage of practicality of student worksheet

Interval (%)	Classification
81 ≤ skor < 100	Very practical
61 ≤ skor < 80	Practical
41 ≤ skor < 60	Less practical
0 ≤ skor < 40	Not practical

(Riduwan, 2013)

The effectiveness analysis used the N-Gain test equation. The formula for calculating the N-Gain test is as equation 5.

$$\text{N} - \text{Gain} = \frac{\text{S}_{\text{post}} - \text{S}_{\text{pre}}}{\text{S}_{\text{maks}} - \text{S}_{\text{pre}}} \; x \; 100\% \quad (5)$$

Table 3. N-Gain criteria

Value g	Categories
$g \geq 0.7$	High
$0.3 \leq g < 0.7$	Medium
$g < 0.3$	Low

(Sundayana, 2014)

The N-Gain scores are further categorized in Table 3. The results of the average N-Gain score converted to percentage form are categorized into the interpretation of N-gain effectiveness as in Table 4.

Table 4. Interpretation of N-gain effectiveness

Percentage (%)	Interpretation
< 40	Not effective
40 – 55	Less effective
56 – 75	Moderately effectiv
> 75	Effective

(Solikha et al., 2020)

Result and Discussion

Define Stage

The initial stage aims to obtain information on problems that arise when implementing learning in the classroom, the curriculum used by teachers, learning materials, learning models, learning methods, and characteristics of students.

The define stage includes several steps namely examining the problems encountered when carrying out physics learning activities in the classroom. Information obtained at the initial analysis stage through initial observation activities and interviews conducted in class XI MIPA 2. Then conducted analysis of participants related to the science literacy skills of students is still categorized as low. Judging from the learning process the teacher conveys the material and notes on the board using the lecture method and the teacher gives practice questions oriented to the ability to memories physics formulas. Furthermore, the use of learning models applied by teachers rarely use project-based models.

Design Stage

The design stage is the stage of designing the initial draft of the project-based learning model-based sound waves student worksheet project (Setiawan et al., 2017; Suryawati et al., 2020). The snippet of the student worksheet product results for sound waves based on project-based learning can be seen in Figure 1.

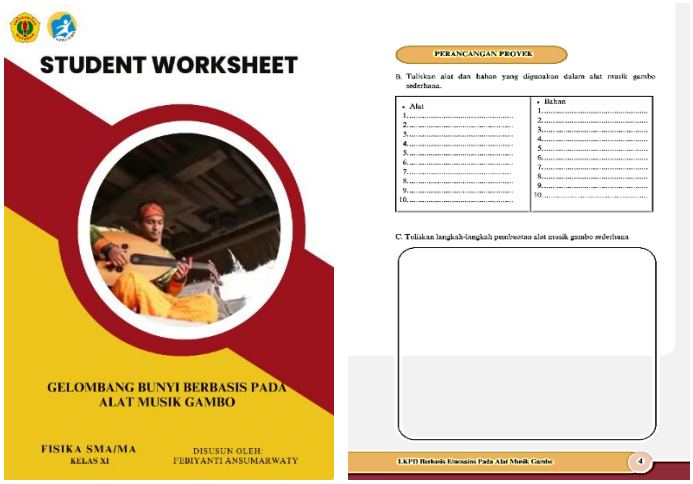

Figure 1. Excerpt of the product of the student worksheet.

Development Stage

The development stage is the stage to test the feasibility, practicality, and effectiveness. Student worksheet that have been developed in this study get an average assessment for the validity level from expert and practitioner validators of 91.67% and 94.70% respectively. Details of the assessment for each component in the student worksheet by expert validators and practitioners can be found in Table 5 and Table 6.

Table 5. Results of validation by expert validators

Aspects Assessed	Validator			Score	Validity (%)
	1	2	3		
Clarity of instructions	3	4	4	11	91.67
Harmony of colors, text, and images	4	4	4	12	100.00
Appropriateness of colours, text, and images	3	4	4	11	91.67
Appropriateness of the image in the question writing	3	4	4	11	91.67
Suitability of sound wave material with student worksheet	3	4	4	11	91.67
Appropriateness of the order of the subject matter with the level of science literacy skills	4	3	4	11	91.67
Materials can trigger science literacy skills	3	4	4	11	91.67
Student worksheet already contains the steps of the project-based learning model	3	3	4	10	83.33
Ease of sentences used	2	4	4	10	83.33
Ease of understanding the language used	3	4	4	11	91.67
Completeness of the required information sentence	4	4	4	12	100.00
Average					91.67
Criteria					Very valid

Table 6. Validation results by practitioner validators

Aspects Assessed	Validator			Score	Validity (%)
	1	2	3		
Clarity of instructions	3	4	4	11	91.67
Harmony of colors, text, and images	4	4	4	12	100.00
Appropriateness of colours, text, and images	4	4	4	12	100.00
Appropriateness of the image in the question writing	4	3	4	11	91.67
Suitability of sound wave material with student worksheet	4	4	3	11	91.67
Appropriateness of the order of the subject matter with the level of science literacy skills	4	4	4	12	100.00
Materials can trigger science literacy skills	4	4	4	12	100.00
Student worksheet already contains the steps of the project-based learning model	4	4	4	12	100.00
Ease of sentences used	4	3	4	11	91.67
Ease of understanding the language used	4	3	4	11	91.67
Completeness of the required information sentence	3	3	4	10	83.33
Average					94.70
Criteria					Very valid

Based on the Likert scale calculations in Tables 1 and 2, the average percentage value of the validation of student worksheet from expert validators and practitioners is 91.67% and 94.70% respectively, which is included in the very valid category. The very valid category obtained from the validation results does not make the student worksheet developed can be said to be perfect. This is because there are still some that need to be corrected, one of which is the equation on page 8 of the student worksheet, because the dimensions are not the same. These suggestions or comments are used as a reference in making improvements to get a better student worksheet. In addition, reliability calculations were carried out on the developed student worksheet. The results of these calculations show that the percentage of agreement of student worksheet from expert validators is 91.21% and from practitioner validators is 94.91% with an average of 93.06%. In accordance with the Borich method (1994), the student worksheet is categorized as reliable because it gets a percentage value of more than 75%. So, it can be said that the student worksheet of sound waves is feasible to use. The practicality of the developed sound waves student worksheet is known from the teacher's implementation sheet and the response questionnaire of students of class XI MIPA 2 at SMAN 1 Monta, Bima Regency. Table 7 and 8 are details of the assessment results from teachers and students:

Table 7. Percentage of implementation of learning activities by teachers

	Implementation of Learning			
	Meeting I	Meeting II	Meeting III	Meeting IV
Practicality score %	92.39	96.88	95.00	94.04
Average %				94.56
Practicality level				Very practical

Table 8. The results of the analysis of the students' response questionnaire

Statement	Number of learners			
	Strongly agree	Agree	Disagree	Strongly disagree
Learning activities using the project-based learning model make me active in learning	22	5	0	0
Learning activities using the project-based learning model can motivate me to learn about gambo musical instruments.	18	9	0	0
Student worksheet provide for writing learners' identities	19	8	0	0
The student worksheet contained interesting subject matter and increased my interest in reading.	9	17	1	0
Student worksheet contains subject matter that is easy to understand	17	8	2	0
The instructions in the student worksheet are easy to understand	13	14	0	0
The student worksheet requires me to cooperate with my friends	21	6	0	0
Student worksheet has group discussion activities that can train me to give my opinion about a problem.	11	15	1	0
The experiment increased my knowledge about Bima traditional musical instruments.	17	10	0	0
Experiments or group discussion activities can train me to easily conclude the material learnt	10	17	0	0
Average Percentage (%)	58.52	30.28	0.74	0
				89.54
Practicality Level				Very practical

Tables 7 and 8 show the average percentage value obtained from teachers and students respectively, namely 94.56% and 89.54% with a very practical category. From the students' response questionnaire, it is known that almost every statement obtained a category of strongly agree and agree, but there are still some who get an assessment in the disagree category. However, overall it can be concluded that the student worksheet of sound waves using the project-based learning model gets a positive response from students.

The stages of the sound waves student worksheet consist of 6 phases, namely determining fundamental questions, designing project plans, compiling activity schedules, monitoring students and project progress, testing results, and evaluating experiences experiences (Rapi et al., 2022; Yasir et al., 2022; Martawijaya et al., 2023). At this stage, students will be directed to design and make gambo traditional musical instruments and test the tools. Thus, a snapshot of the activities that have been carried out by learners is shown in Figures 2, 3, and 4.

Figure 2. Planning the gambo musical instrument.

Figure 3. Monitoring learners and the progress of the gambo instrument.

Figure 4. Testing the results of the traditional musical instrument from Bima regency.

Based on Figure 2. The learners design the project to be made, at this stage it will improve the science literacy of students on the indicator of explaining scientific phenomena because there are discussion activities carried out by students with their respective groups. In this discussion activity, learners can share knowledge, raise questions, and look for answers together. This allows learners to develop a better understanding of the science concepts associated with the project.

While Figure 3. learners will make gambo musical instruments that can improve science literacy on the indicator of identifying scientific issues. This is because learners will be challenged to think critically about the problems faced and find solutions based on scientific understanding and learners learn to see the relationship between science and the issues around them.

Furthermore, in Figure 4. learners will conduct tests on gambo musical instruments to determine the value of the speed of propagation of sound waves, through activities to collect data, conduct experiments, observe, and present scientific evidence systematically. This helps learners to develop science literacy skills on the indicator of using scientific evidence.

It can be concluded that the use of sound waves student worksheet based on the project-based learning model is very practical in learning, because the stages of the project-based learning model facilitate the improvement of students' science literacy. This is supported by the research of Izzania et al. (2021); Ma'sumah & Mitarlis (2021); Afriana & Permanasari, (2016).

The effectiveness of the project-based learning model-based product to improve science literacy with the N-Gain test. N-Gain calculation is based on pretest and posttest scores on science literacy skills. The pretest was carried out with the aim of knowing the initial knowledge of students on sound waves material. Furthermore, students were taught using the product that had been developed for 4 meetings. After the material is delivered entirely, a posttest is carried out to determine the increase in the science literacy of students who are taught using the project-based learning model-based sound waves student worksheet. The test

instrument used was 5 essay questions on sound waves material on Bima gambo musical instruments with the acquisition of minimum and maximum scores during the pretest, namely 13 and 46. Meanwhile, the posttest obtained minimum and maximum scores of 60 and 93. The acquisition of pretest and posttest scores of students can be seen in Figure 5.

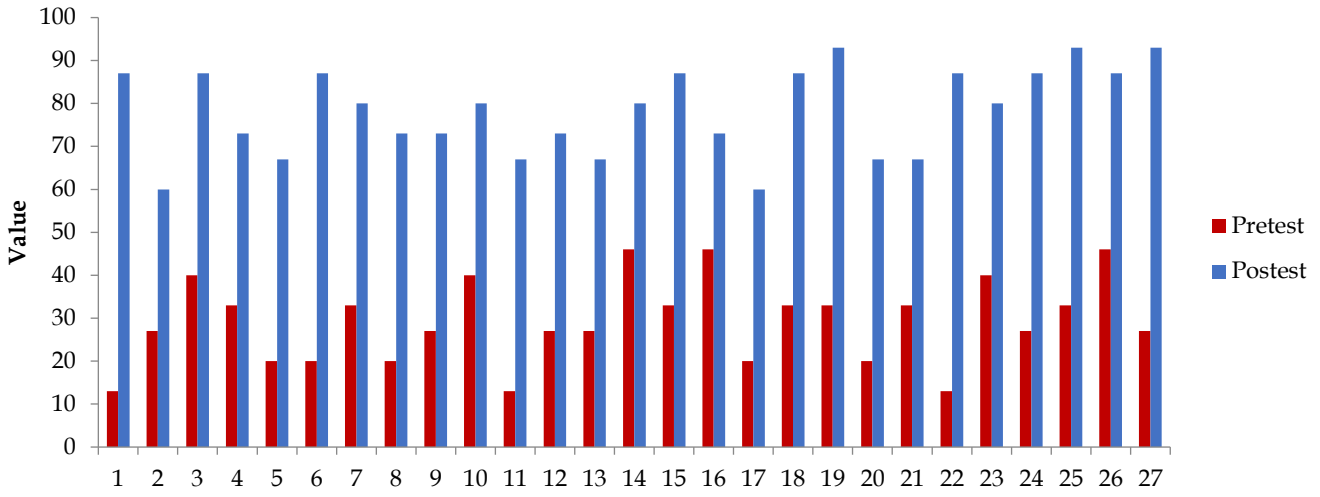

Figure 5. Pretest and posttest results of students' science literacy.

Furthermore, the N-Gain test calculation was also carried out to increase the science literacy of 27 students in class XI MIPA 2 and calculated the increase in science literacy per indicator which can be seen in Table 9 and Figure 6.

Table 9. N-Gain test results of students' science literacy

$\bar{X}$ Pre	$\bar{X}$ Post	$\bar{X}$ Post − $\bar{X}$ Pre	$X_{max} - \bar{X}$ Pre	N-Gain	Category
29.26	78.33	49.07	70.74	0.69	Medium

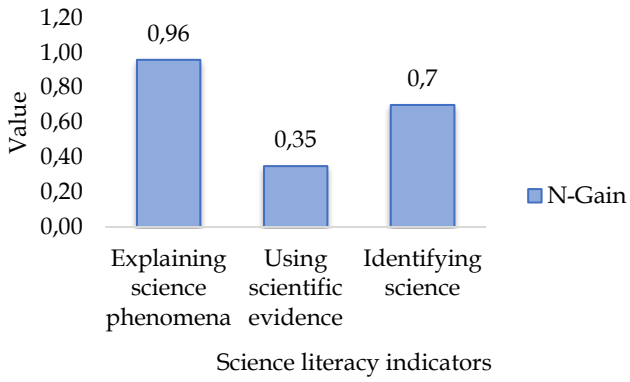

Figure 6. N-Gain diagram of science literacy per indicator.

Based on Table 9, it shows the average value of increasing the science literacy of students in class XI MIPA 2 which is 0.69 included in the moderate category. Then converted into a percentage form so that it is obtained by 69%. Based on the interpretation of the effectiveness of the sound wave student worksheet according to Solikha (2020); Fuadi et al. (2022), the N-Gain value of 69% obtained is classified into the moderately effective category. Furthermore, Figure 5 shows that the increase in science literacy of students of class XI MIPA 2 SMAN 1 Monta, Bima Regency from each indicator has a different average N-Gain value. This is because the questions presented in the test instrument used are adjusted to the science literacy indicators which have different levels of difficulty.

The indicator of explaining science phenomena obtained an N-Gain value with a high category, because the questions presented were related to material or basic theories related to sound wave material that was easy to remember such as the definition of gambo musical instruments, the notes produced by gambo. The material has also been discussed and obtained during practicum activities, so students easily answer the questions presented related to the indicators of explaining scientific phenomena. This is in accordance with research conducted by Junita et al. (2021); Farcis et al. (2022); Heliawati et al. (2022) that the use of student worksheet based on project-based learning can facilitate students in solving existing problems.

The indicator of using scientific evidence obtained a medium category N-Gain value with a value of 0.35. This is supported by research conducted by Siagian et al. (2022) because students have difficulty determining the

equation or formula used, so there are still students who cannot answer the question. Furthermore, the indicator of identifying scientific issues is categorized as high, this can be seen from the acquisition of the N-Gain value on the indicator which is 0.70. In line with the results of research conducted by Sakti et al. (2021) and Hikmawati (2021) that students' science literacy indicators can increase through a learning process that is not just a transfer of knowledge, but also emphasizes the learning process.

Conclusion

Based on the results of the research and discussion that has been described, it can be concluded that the project-based learning sound waves student worksheet is feasible with very valid and reliable criteria, and very practical, and quite effective. The project-based learning model provides opportunities for students to depend on the material through problem solving in the resulting project. In addition, this model can also increase students' insight into physics lessons by utilizing Bima culture.

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Authors Contribution
In this study, Febiyanti Ansumarwaty, served as the lead author. Her contributions included research planning, data collection and analysis. Jannatin 'Ardhuha and Hikmawati, provided valuable guidance and direction throughout the entire research process. In addition, Muh. Makhrus, played a role in reviewing the research results and providing critical feedback to improve the quality of the research.

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The funder is not involved in the entire research process, including design, data collection, analysis, interpretation, writing, and publication of results.

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