World Journal of Advanced Research and Reviews

eISSN: 2581-9615 CODEN (USA): WJARAI

Cross Ref DOI: 10.30574/wjarr

Journal homepage: https://wjarr.com/

(Research Article)

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Developing a PhET- AIDED Ryleac model learning device to augment eighth graders' science process skills in vibration and wave materials at SMP Negeri Tangagah

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World Journal of Advanced Research and Reviews, 2023, 17(03), 232–241

Publication history: Received on 20 January 2023; revised on 01 March 2023; accepted on 04 March 2023

Article DOI: https://doi.org/10.30574/wjarr.2023.17.3.0346

Abstract

The research aims to develop a PhET-aided Ryleac learning model device that is valid, practical, and effective for elevating students' science process skills in vibration and wave materials. The research type was the 4-D (Define, Design, Develop, and Disseminate) model development research with a limited test on ten students and an extended one on 20 students (class A) and 19 students (class B). All students were eighth graders at SMP Negeri Tangagah in the academic year of 2021/2022. The results exhibited that:

- According to the experts, the PhET-aided Ryleac learning model device developed was valid,
- The learning device was practical, as featured by the mean score of learning implementedness and students' positive responses to learning,
- The learning device was effective, as indicated by:
  - Student activities were good and excellent,
  - Based on the observation results, student science process skills in the indicators of observing, predicting, data-interpreting, communicating, and concluding were good, and
  - The science process skill test scores acquired from limited and extended tests were 0.71 and 0.65, considered low and medium, respectively, indicative of the effectiveness of the PhET-aided Ryleac learning model device.

Keywords: Learning Device; Ryleac Model; PhET; Process Skill

1. Introduction

As regards process skills in 21st-century learning, students should acquire both training and education in learning. Science process skills are critical for being cultivated in education as it is a basic competency to develop scientific attitudes, problem-solving skills, and self-development in order to be creative, critical, innovative, and competitive students prepared for confronting global competitions in the community (Indah, 2018:3).

Based on our science observation at SMP Negeri Tangagah, Bolaang Uki, Bolaang Mongondowo Selatan, the learning devices deployed had neither been developed nor modified. Associated with the learning process, most methods applied were lecturing, questions-answers, discussion, demonstration, and scheduled assignments using experimental methods. Meanwhile, the learning approach used was the scientific one, but lecturing was the most frequently used one. Practicums were rare as a result of practicum tool constraints in laboratories, and if any, most of them were damaged. Accordingly, students lacked process skills as they were only exposed to theories without hands-on experiences. As such, their process skills, e.g., observing, formulating hypotheses, formulating problems, and expressing exploring results in front of the class, were considered low.

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Students' cognitive learning results were also relatively low. It was demonstrated by their learning achievement results, in which 45% of eight graders did not achieve the Minimum Completeness Criteria.

Students still maintained that physics was difficult to learn because it had formulas and abstract concepts to study. The abstract characteristics led students into adversity when learning physics, especially when employing physic concepts in their daily lives (Surapranata, 2004).

Difficulties interpreting abstract concepts make physics one of the lessons hard to apprehend. Hence, in the physic learning process, teachers must develop learning devices that can create real-life conditions. One of such learning devices is PhET simulation-aided learning. It allows students to comprehend physics concepts and ideally carry out experiments where they cannot exert the real tools.

Building on the literature review, we found the solution to the in-class problems by developing a learning device aligned with science material characteristics to train students' process skills. One of the learning models exploited was Ryleac.

One of the Ryleac model analyses was conducted by Abdjul (2019) and titled The Development of Inquiry by Learning Cycle (Ryleac) Model on Electricity and Magnetic Concept to Increase Science Process Skill and the Academic Achievement of Students*.* The research bred a valid, practical, and effective Ryleac learning model product.

Predicated on the explanation, we were interested in doing research titled "Developing a PhET-aided Ryleac Model Learning Device to Augment Eighth Graders' Science Process Skills in Vibration and Wave Materials at SMP Negeri Tangagah".

2. Material and methods

The research leveraged the Research and Development (R&D) method. The model used was the 4D development model by S. Thiagarajan (1974:5). The model comprised four key stages, i.e., Define, Design, Develop, and Disseminate.

2.1. Data Analysis Technique

2.1.1. Validity Test

The expert team gave scores of 1-4 to each component on the validation sheet using the following formula.

$$\bar{x} = \frac{\sum x_i}{n}$$

Where:

$\bar{x}$: mean score

xi : score earned

n : the number of question items

Based on the learning device assessment scoring, we elicited the learning device's validity criteria interval, as shown in Table 1.

Table 1 Learning Device Validity Criteria

Mean Score	Category
4.00-3.75	Very valid
3.75-3.00	Valid
3.00-2.25	Acceptable
2.25-1.50	Poor
1.50-0	Very Poor

(Azwar, 2012:134)

2.1.2. Product Practicality Test

Response Questionnaire

The formula applied in student response questionnaires was (Azwar, 2012: 134):

$$\% \text{ student responses} = \frac{acquired\ score}{maximum\ score}\ x\ 100\%$$

The categories for student response percentages are featured in Table 2.

Table 2 Student Response Classification

Attained Percentage (%)	Predicate
86-100%	Very good
76-85%	Good
60-75%	Acceptable
55-59%	Poor
≤54%	Very poor

Learning Implementedness Observation

The results of learning implementedness observation were calculated using the following formula (Ngalim, 2002:103).

$$\text{Percent implementedness} = \frac{\text{implemented item frequency}}{\text{total items}} \text{ x } 100\%$$

Referring to the formula, a device was considered practical by learning implementedness if the percent implementedness was above 75%.

2.1.3. Product Effectiveness Test

Student Science Process Skill Observation

Student accomplishment in science process skills was analyzed using the following formula (Suharsimi Arikunto, 2012:235).

$$\% \text{ KPPS} \quad = \frac{\text{X}}{\text{N}} x\ 100\%$$

Description:
% KPPS : Science process skill accomplishment
X : Total indicator scores gained by students
N : Total indicator scores

The assessment scale was manifested in Table 4 (Ngalim, 2002:103).

Table 3 Category of Science Process Skills

Attained Percentage (%)	Predicate
75% < score ≤ 100%	Very good
55% < score ≤ 75%	Good
40% < score ≤ 55%	Acceptable
Score ≤ 40%	Poor

Student Science Process Skill Test

The test results were analyzed using the following formula, classically quantifying percent learning completeness.

$$P = \frac{F}{N} x\ 100\%$$

Description:
P : Percent classical completeness
F : The number of completing students
N : Total number of students

Assessment criteria by Ngalim Purwanto (2002:103) are pointed out in Table 5.

Table 4 Categories Science Process Skills

Attained Percentage (%)	Predicate
86-100%	Very good
76-85%	Good
60-75%	Acceptable
55-59%	Poor
≤ 54%	Very poor

The product developed was considered reliable by the effectiveness aspect when the achieved percent completeness was at least in the good criterion.

To get student learning results using the device developed, pretest and posttest data were analyzed to glean gain data. According to Hake (1999), the formula to calculate the normalized gain index (g) was:

$$g = \frac{Posttest\ score - Pretest\ score}{Maximum\ score - Pretest\ score}$$

The gain index interpretation, as argued by Hake (1999), was presented in Table 6.

Table 5 Gain Index Interpretation

Gain Index (g)	Criteria
g > 0.7	High
0.3 > g > 0.7	Medium
g ≤ 0.3	Low

Student Activity

Student activities in learning processes were analyzed using the following formula.

$$\%\ \text{student activity} = \frac{\text{acquired score}}{\text{maximum score}} \text{ x } 100\%$$

3. Results

3.1. Model Development Results

The development results of the PhET-aided Ryleac model learning device using the 4D (Define, Design, Develop, and Disseminate) development model by Thiangarajan and Semmel (1974) were as follows

3.1.1. Define Stage

The stage covered five main steps, i.e., initial-end analysis, student analysis, task analysis, concept analysis, and learning objective formulation.

Initial-end Analysis

Building on observation and interviews, student process skills, e.g., observing, formulating hypotheses, formulating problems, and expressing exploration results in front of the class, were poor.

Student Characteristic Analysis

The targets of using the PhET-aided Ryleac model learning device were eighth graders in the second semester with heterogenous competencies falling into high and medium categories.

Task Analysis

Tasks administered were executed in groups predicated on achievement analyses as regards the concept learned and pervaded activities of observing, formulating problems, formulating hypotheses, communicating results, elaborating, and concluding.

Concept Analysis

The analysis was aimed at defining the content of the concept developed. In vibration and wave materials, several concepts should be fathomed by students.

Learning Objective Formulation

The analysis was performed to formulate the results of task and concept analyses into learning result achievement objectives associated with psychomotor competencies.

3.1.2. Design Stage

Test Standardization

Test standardization was based on learning objective specifications and student analyses.

Learning Media Determination

The media deployed was stylized to science materials and student characteristics described building on the define stage results. Three learning media employed were LKPD, LCD, and PhET simulation.

Format Determination

Format determination in learning device development focused on designing learning contents and defining learning strategies, approaches, methods, and sources.

Initial Design

The initial design embraced the design of all learning devices which should be completed before testing. The learning devices were syllabuses, lesson plans, learning materials, LKPD, and assessing instruments.

Test Problems

In the stage, research instruments, namely test problems, were assembled to examine student process skills.

3.1.3. Develop Stage

The development stage brought about the learning device draft or Draft 1, which was revised henceforth predicated on validator lecturers' suggestions. After validation, a test in the limited class and a field test was carried out.

3.1.4. Disseminate Stage

Disseminate was the last stage of all development research stages. In the stage, we disseminated by packaging and distributing the device to science teachers on a limited scale.

3.2. Quality of the PhET-aided Ryleac Model Learning Device

In the development research, tests for developed product quality encompassed tests for validity, practicality, and effectiveness. The following are the test results of the PhET-aided Ryleac model learning device quality.

3.2.1. Validity

Table 1 shows the results of the validators' assessment.

Table 6 Results of Validators' Assessment

No.	Validated Device	Mean	Assessment Category
1	Syllabus	4.00	Very valid
2	Lesson plan	3.91	Very valid
3	Learning material	3.83	Very valid
4	LKPD	3.89	Very valid
5	Process skill test	3.95	Very valid
6	Process Skill Observation Sheet	3.89	Very valid

Based on Table 8, the learning device developed was very valid, showing off that the test was reliable to employ.

3.2.2. Practicality

The analysis results of learning implementedness and student response questionnaires were as follows.

Learning Implementedness

Table 1 shows off the results of the implementedness of learning by teachers using the PhET-aided Ryleac model learning device on eighth graders from classes and B in the academic year of 2021/2022.

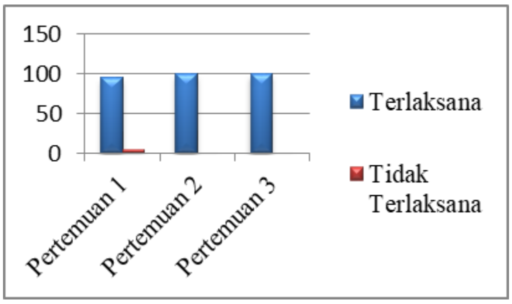

Figure 1 Percent Learning Implementedness of Class A

Building on Figure 1, the mean of learning implementedness in meetings 1, 2, and three was 98.5%, which was then considered very good. Figure 2 signifies the learning implementedness of class B.

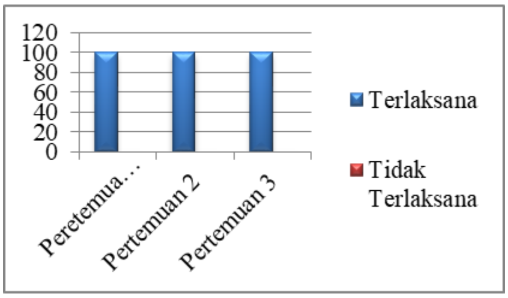

Figure 2 Percent Learning Implementedness in Class B

In Figure 2, the mean of learning implementedness in class B from meetings 1-3 was 100%, which was also considered very good.

Student Responses

Predicated on the analysis results, the mean of student responses is suggested in Figure 3.

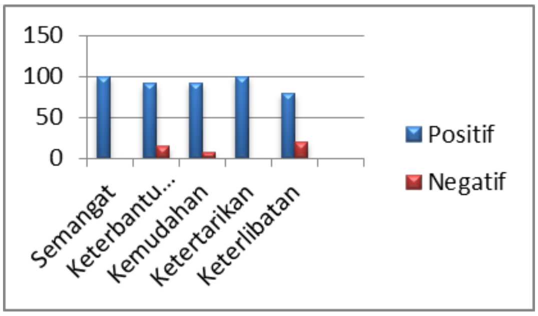

Figure 3 Class A Student Responses to the Learning Device

Based on Figure 3, 88% of students afforded positive responses. Moreover, their responses to the PhET-aided Ryleac model learning are demonstrated in Figure 4.

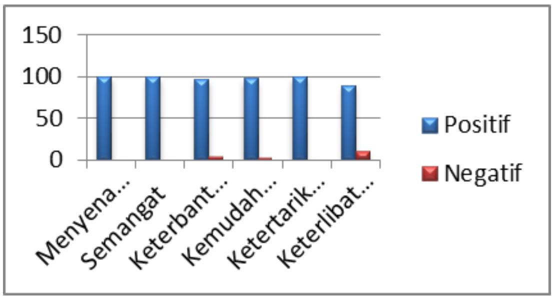

Figure 4 Class B Student Responses to the PhET-aided Ryleac Model Learning

Referring to Figure 4, 96.4% of students conferred positive responses to all indicators.

3.2.3. Effectiveness of the PhET-aided Ryleac Model Learning Device

Figure 5 exhibits the analysis results of student learning activities in classes A and B.

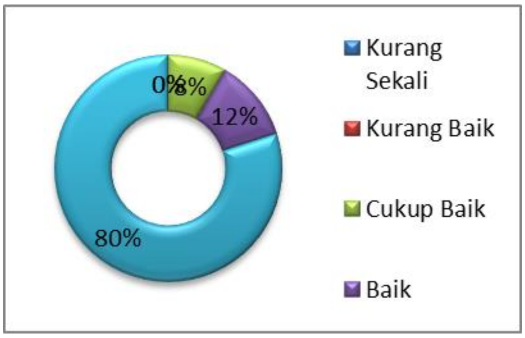

Figure 5 Category of Student Learning Activity in Class A

Based on Figure 5, in meetings 1, 2, and 3, 80%, 12%, and 8% of students in class A featured very good, good, and acceptable activities, respectively. Meanwhile, the analysis results of student activities in class B are indicated in Figure 6.

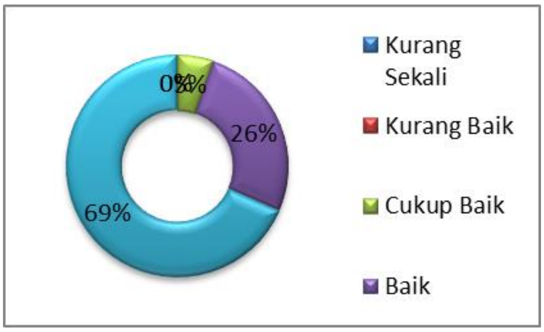

Figure 6 Category of Student Learning Activity in Class B

As manifested in Figure 6, in meetings 1, 2, and 3, 69%, 26%, and 5% of students pointed out very good, good, and acceptable activities, respectively.

Process Skill Observation

The observation results of student science process skills, building on the extended tests in classes A and B during learning, are presented in Figure 7.

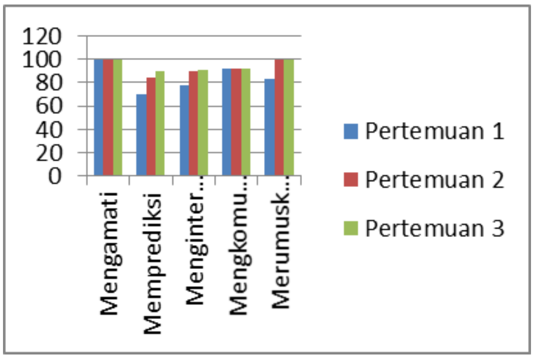

Figure 7 Observation Results of the Science Process Skill Aspect in Class A

As seen in Figure 7, all science process skill aspects exhibited increases from meetings 1-3 for all indicators.

Process Skill Test Results

In addition to learning activities and process skill observation, the effectiveness indicator of the learning device was also indicated from the results of process skill tests. Figure 8 manifests the results of student science process skill tests from classes A and B based on the extended test.

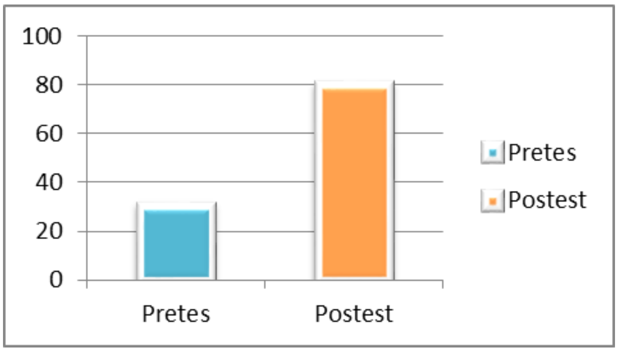

Figure 8 Chart of Pretest and Posttest Scores in Class A

From Figure 8, the mean score from the pretest was 30.7. Meanwhile, the mean score from the posttest was 80. In classical, 80% of 20 students participating in the posttest achieved completeness. Based on the N-Gain test, student science process skills scored 0.71, which was considered high. The results of science process skill tests are manifested in Figure 9.

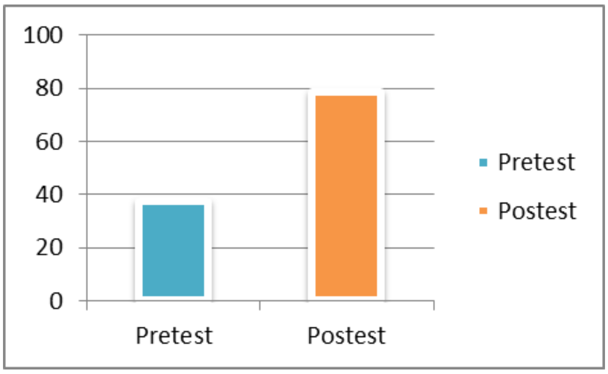

Figure 9 Chart of Pretest and Posttest Scores in Class B

From Figure 9, the mean scores from the pretest and posttest in class B were 37.5 and 80, respectively. In classical, 78.9% of students completed. Based on the N-gain analysis, student science process skills scored 0.65, considered medium.

4. Discussion

4.1. Quality of the PhET-aided Ryleac Model Learning Device

4.1.1. Validity

As demonstrated in Table 1, all assessment components were valid. Hence, the learning device was reliable after being revised by suggestions. It was aligned with the previous research by Abdjul (2019), that the Ryleac model learning device for the static fluid material was valid.

4.1.2. Practicality

Based on the previous research data, from the limited test class, the mean learning implementedmess using the PhET-aided Ryleac model was 91.3, whereas, from the extended test, classes A and B scored 98.5% and 100%, respectively. The limited and extended tests in meetings 1 and 2 were targeting student engagement, in which teachers identified student presence and delivered learning objectives.

Besides, building on the results of student response analysis in Figures 3 and 4, the PhET-aided Ryleac model learning device obtained positive responses. From the limited test class, the mean of student response questionnaire results was 87.4%, while in the extended test, classes A and B scored 88% and 96.4%, respectively, and as such, falling under the very good category. It was commensurate with Bahtiar (2016), that learning was effective were students active in the learning process.

Predicated on the response questionnaire analysis, students maintained an interest in learning from teachers, augmenting their learning motivation.

4.1.3. Effectiveness

Based on the data analysis results, the PhET-aided Ryleac model learning device elevated student activeness in participating in science learning by teachers. It was congruent with Rohani (2011:125), that learning processes emphasizing student activeness were crucial for learning as they could construct student understanding of new knowledge, and in so doing, optimizing their learning output.

Based on student science process skills aspects, the mean percentages of all aspects in all meetings were enhanced.

In the final stage, an effectiveness test of the PhET-aided Ryleac model learning device was carried out by distributing multiple-choice questions to students. Based on the data analysis of student process skills from the limited test class, ten students scored 80 in the posttest, and in classical, the percent completeness was 80% of all students participating in the posttest.

Furthermore, from the extended science process skills test, classes A and B scored 80 and 78.6, respectively. N-gains of 0.71 and 0.65 exhibited increases in process skill aspect achievement before and after vibration and wave learning using the developed device, namely the PhET-aided Ryleac learning model. In so doing, students had experienced a learning process, as conveyed by Morgan in his book titled Introduction to Psychology (Ngalim:2012), that learning was a constant behavioral change as the result of practices or experiences.

5. Conclusion

Based on data analyses and result discussion, we could conclude that:

- The learning device was developed using Thiangarajan's 4-D model including Define, Design, Develop, and Disseminate stages which were elucidated in detail as follows:
  - The Define stage covered initial-end analyses, student character analysis, task analysis, concept analysis, and learning objective formulation.
  - The Design stage covered test making, media determination, and determination of the format of the learning device developed.
  - The Develop stage covered initial design, expert validation, and limited and extended tests.
  - The Disseminate stage covered PhET-aided Ryleac model learning device distribution.
- The PhET-aided Ryleac model science learning device developed, from its validity, practicality, and effectiveness was reliable to use as it fulfilled the following criteria.
  - It was valid based on the validator assessment, which stated the very valid category.
  - It was practical based on the learning implementedness analysis with the percentage of 98.5% and the very good category and student positive responses, which scored 88% and 96.4% from classes A and B, respectively.
  - It was effective based on student activities, which fell under the very good category. The results of science process skill tests with N-Gains of classes A and B of 0.71 and 0.65 with high and medium categories. From the results of process skill observation analyses, aspects of observing, predicting, interpreting, communicating, and concluding procured a good category.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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