The impact of PhET virtual lab worksheets on student learning outcomes on sound wave materials

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Abstract. The need for students' worksheets is felt urgent and very necessary, especially when the covid-19 pandemic. Therefore, through this research a Student Worksheet (SW) will be developed and the application to increase the understanding of the Sound Wave concept in Middle School students. The development of SW uses a Research and Development approach through the ADDIE model. SW limited trials were conducted on high school students. This research was conducted in 2 cycles of 4 meetings, each of which consisted of 4 stages: planning, implementation, observation and reflection. In addition, the feasibility of the learning tools used, the feasibility of learning, classroom management and students' responses to learning were examined. Trials on limited samples, test student learning outcomes, teacher skills and student responses. Data analysis method used is descriptive method. Results that being analyzed with descriptive statistics it was found that the use of Lab Virtual PhET SW can improve student learning outcomes and teacher skills in the learning process in each cycle.

1. Introduction
Learning is a systematic, dynamic, constructive and organic process. Learning also occurs because of the drive needs and the goals to be achieved [1]. In learning activities, students are the subjects and objects of learning activities. Therefore, the teaching process is nothing but student learning activities in achieving a teaching goal. The aim of teaching of course will be achieved if students actively try to achieve it [2].

Poor learning process is a problem that is often faced in the world of education in Indonesia. The learning process that occurs at this time, students are less encouraged to develop thinking skills. The learning process in the classroom is directed at the student's ability to memorize, the student's brain to remember and accumulate a variety of information without being required to understand the information that is remembered to connect it with daily life [3,4].

During the Covid-19 pandemic, the learning process both in tertiary institutions and high schools used a lot of computer media, including using eduplasa media to reduce misconceptions [5], a media tracker to improve critical thinking skills [6], using e-learning media to develop diagnostic tests [7,8], use of internet media to increase understanding of concepts [9], use of smartphones to increase student interest in learning [10], and CLIS models based on computer simulations to improve understanding...
of physical concepts [11]. The use of computer media is that there are applications that run online and there are also run offline, but there are also applications that can be run in both conditions or online and also offline, one of which is the PhET simulation media.

PhET simulation application is an application that was created first by solid physicists, and then developed almost in all fields of science. Previous research related to PhET simulation is relatively very large, including the development of Students Worksheets for PhET simulations [12], the development of practicum modules with PhET simulations [13], comparison of the results of manual practicum and virtual practicums with PhET [14], the use of PhET simulations with the inquiry approach [15], the use of generative learning models using lab.virtual [16], the application of NHT learning models by utilizing lab.virtual [17], and the use of PhET simulations to improve mastery of physical concepts [18]. Based on the results of these studies it can be understood that the use of PhET simulation media so far has been widely used as an auxiliary media to develop other devices or also used PhET simulations as the main objective or media.

Based on the results of observations made by the author in a sample school, it was found that students at the school were very difficult to understand physics concepts, especially abstract concepts. This is due to the fact that physics material is rarely experimented in laboratories and very expensive equipment and the risk involved if there is an error in the experiment. Students are still awkward using the tools in the laboratory. In addition, the laboratory at the school is still relatively new, so teachers rarely use the laboratory in the learning process, especially in physics. In addition, the teachers in the sample schools have not mastered the use of laboratory equipment without any skilled technicians to guide during practice. So, it has an impact on student learning outcomes that do not reach Minimum Criteria for Completion (MCC).

Based on the data found in the field or in a sample school and also some of the advantages of the PhET simulation media from previous research results, it becomes very important and urgent to develop Student Worksheets (SW) for use in virtual practicum activities through the PhET simulation media. One of the goals developed by the SW lab.virtual is to improve student learning outcomes in sample schools. Besides that the PhET simulation is also very interesting and very easy to use. This application can be used online or offline so that it can be used anywhere and anytime. PhET interactive simulations are moving images (animated), interactive and made like a game where students can learn by doing exploration.

2. Methods

2.1. research approaches and types

The research approach used in this study is the Research and Development (R&D) approach. The R&D approach is a process used to develop educational products that can be scientifically justified. Basically, R&D research has the characteristics of the products produced from its research. The resulting product begins with an analysis of the needs of the research location. In the field of education, the products produced are generally in the form of learning media [19].

2.2. development method

Research product development, in this case Students Worksheets (SW), uses the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) [20]. The ADDIE model is one of the most widely used models by teachers or researchers for the development of learning tools and test kits [4,12,14,16,17,19]. This type of ADDIE model is relatively more complete in stages, compared to other models, starting from the analysis of the field situation to the evaluation of the results of product implementation. In detail the stages in the ADDIE model are shown in Figure 1.

The forms of activities and products produced at each step of the ADDIE model, as shown in figure 1, are as follows. Stages of Analysis. The initial stage of the ADDIE model is the situation analysis stage where a study or school sample is conducted. The analysis is carried out systematically and deeply, so that there are obstacles that are found in the place of research or in school samples. The analysis focused
on the level of product needs by the sample schools for the products produced. This includes analyzing the problem of product or device availability so far at the sample school, the constraints of using existing devices at the sample school, the readiness of HR to use learning products, and the weaknesses of the products available at the sample school so far.

**Design Stages.** The main activity at this stage is to design or design the product to be made. The design phase includes; (i) Preparation of practical learning media framework using Lab. Virtual based on PhET and (ii) Systematic determination of presentation of material, illustrations and visualization. The main data at the design stage is the product draft or initial product design.

**Development Stages.** At the product development stage, students’ worksheets (SW) are made which include an introduction to PhET, discussion of material in the form of pictures and videos as well as the steps in using the Lab. Virtual PhET based. The main data at the development stage is product design added with revisions from the results of expert assessments.

![The ADDIE model](image-url)

**Figure 1.** The ADDIE model [20]

**Stages of Implementation.** The implement phase is to use or use the learning package or product in learning activities. At this stage an evaluation is carried out to determine eligibility by looking at the teacher and student levels. In addition to knowing the effectiveness of these media, a Pre-test and Post-test will be carried out in a trial on a limited sample, that are students high school. The main data at this stage is feedback on the results of implementation from teachers, students and also colleagues.

**Evaluation Stages.** Evaluation is carried out in two forms, namely formative and summative evaluation. Formative evaluations are carried out at the end of each cycle. Evaluation results are used to provide good feedback to the users of the model/method. Revisions are made according to the evaluation results or needs that cannot be met by the model / method. The main data from the results of this evaluation is the level of effectiveness of the implementation of learning using products that have been developed. The level of effectiveness in terms of time, ease of use, achievement of learning objectives, student attractiveness and teacher responses.

2.3. **validity of SW**

The form of the product produced from this study is the Student Worksheet (SW) that can be used for the implementation of virtual laboratory practicum (Lab.Virtual) by using a PhET simulation. The two main aspects that will be used are the basis for expert validity, namely the content aspect and the display aspect. Therefore, the right SW validitor is done by 2 IT experts (display) and 2 physics material experts. Each validator is given a Display Validation Sheet and a Content Validation Sheet.

2.4. **pilot test strategy**

The intended trial is the same as the implementation phase at the time of product development. This trial has a research strategy with pre-experimental methods or there is only one class of trials. Before the trial, students are demonstrated or socialized the use of the SW Lab. Virtual version of the techniques. To get product effectiveness data, before testing it is first given a Pre-test and after the trial is given Post-
test to students.

2.5. collection of data
The method used in this study is a pre-experimental research method. The implementation is reviewed in 3 aspects, namely student learning outcomes, the ability of teachers to manage learning and student responses to the development of SW. To obtain data from these 3 aspects, data collection instruments are used in the form of (i) learning outcomes tests, (ii) Observation Sheets and (iii) Student Response Sheets.

2.5.1. test of learning outcome. To obtain SW effectiveness data, two tests were conducted, namely pre-test and post-test. The type of test used by researchers is a written test in the form of multiple-choice questions totaling 10 items arranged according to the indicators in the learning plan (RPP) of the sound wave syllabus.

2.5.2. observation sheet teacher ability. This observation sheet is used to obtain data about the teacher's ability to manage learning using the SW Lab. Virtual simulation of PhET on sound wave material. This observation was made by two observers.

2.5.3. student response sheet. This observation sheet is arranged to find out how students respond to the development of the SW Lab practicum. Virtual PhET simulation of sound material applied by the teacher during the learning activity. The data was collected using a questionnaire that was distributed to students in the final cycle.

2.6. data analysis
To find out student learning outcomes through SW Lab expectations. Virtual PhET simulations were analyzed using descriptive statistics, using individual and classical completeness values. Individual completeness is achieved if the student's score reaches the Minimum Criteria for Completion (MCC) value set by the sample school, which is 70. Students complete individually if the post-test score is \( \geq 70 \) [2]. Classical completeness is achieved when the proportion of students whose post-test scores reach \( \geq 85\% \) [4]. Classical completeness calculation uses equations of percentage [2,21,22]. Virtual simulation of PhET on sound wave material using data analysis based on the average score of observations. Furthermore, these values are converted into qualitative categories according to the range of values [23,24,25].

3. Result and Discussion.
Student learning outcomes carried out learning using the SW Lab. Virtual simulation PhET presented in table 1 includes pre-test and post-test scores as well as completeness information. Learning can improve student metacognition skills and learning interest[18,26]. Based on table 1, data on student learning outcomes are carried out using SW Lab. Virtual PhET simulation shows that there are 12 students completed individually. So, students are said to be complete individually if they reach the Minimum Criteria for Completion (MCC) \( \geq 70 \). While classical completeness as a whole is 92\%, namely from 13 students only 12 students who completed individually and completed classically. Based on the percentage value, the classical completeness condition has been achieved and the sound wave material has been understood by students in accordance with the indicators in the lesson plan. Besides completing student learning outcomes, the use of SW tools can also improve a number of other variables, including using a Jigsaw SW type can improve student creative skills [9,21], SW inquiry methods can improve students' generic science skills [8], SW COCOAER models can Overcoming students 'misconceptions [10,27], SW media tracker can improve students' critical thinking skills [11,15,20], SW scientific approach can improve student learning outcomes [12] and SW based on discovery.
Table 1. Pre-test and post-test results after using of the SW Lab. Virtual

| No | Students Code | Pre-test | Post-test | Individual completeness *) |
|----|----------------|----------|-----------|-----------------------------|
| 1  | 01             | 60       | 80        | Complete                    |
| 2  | 02             | 70       | 90        | Complete                    |
| 3  | 03             | 60       | 90        | Complete                    |
| 4  | 04             | 40       | 70        | Complete                    |
| 5  | 05             | 60       | 80        | Complete                    |
| 6  | 06             | 60       | 90        | Complete                    |
| 7  | 07             | 40       | 70        | Complete                    |
| 8  | 08             | 60       | 90        | Complete                    |
| 9  | 09             | 70       | 80        | Complete                    |
| 10 | 10             | 50       | 80        | Complete                    |
| 11 | 11             | 60       | 80        | Complete                    |
| 12 | 12             | 70       | 90        | Complete                    |
| 13 | 13             | 40       | 60        | Not Complete                |

*) Criteria of completeness is 70

Teacher skills in managing learning using SW Lab. Virtual PhET simulation is presented in Table 2. The data in Table 2 were collected using Observation Sheet by 2 observer teachers. The aspects observed included four parts, namely: (a) introductory (initial activity), (b) core activities, (c) closing (final activity) and (d) class atmosphere.

Table 2. Recapitulation of teacher skills using SW Lab. Virtual PhET simulation

| No | The observed aspect | Obs.1 | Obs. 2 | Means (x) | RPP 2 | Score | Criteria |
|----|---------------------|-------|--------|-----------|-------|-------|----------|
| I  | Preliminary         | 4     | 4      | 4         |       |       |          |
|    | Provide pre-test questions | 4 | 4 | 4 |       |       |       |          |
|    | Provide apperception, motivation and learning objectives | 4 | 4 | 4 |       |       |       |          |
|    | Shows the simulation media that will be used in learning | 4 | 4 | 4 |       |       |       |          |
| II | Core activities     | 2     | 3      | 2.5       |       |       |          |
|    | Directing students to discuss groups to study SW | 3 | 3 | 3 |       |       |           | Good    |
|    | Guide students to conduct experiments and assess students’ processes and attitudes during practicum | 3 | 3 | 3 |       |       |           | Very Good |
|    | Guiding students to process and analyze experimental data | 3 | 3 | 3 |       |       |           |          |
|    | Direct and assess the presentation of each group | 4 | 3 | 3.5 |       |       |           |          |
| III| Closing             | 3     | 3      | 3         |       |       |          |
|    | Give reinforcement material and guide students to make conclusions | 4 | 4 | 4 |       |       |           | Very Good |
|    | Give post-tests to students | 3 | 3 | 3 |       |       |           |          |
| IV | Class situation     | 3     | 3      | 3         |       |       |          |
|    | Enthusiastic students | 3 | 3 | 3 |       |       |           | Good    |
|    | Student-centered learning | 3 | 3 | 3 |       |       |           |          |
| Mean of total |                  | 3.38  |        | 3.38     |       |       |          |

Based on the data in Table 2 it can be understood that the teacher's skills in managing learning using SW Lab. Virtual simulation of PhET in the introduction (initial activity) obtained a score of 4 and categorized very well, core activities with the acquisition of a score of 3 are categorized good, closing activities (final) obtained a score of 3.5 with a very good category, and class atmosphere obtained a
score of 3 with categorized well. So overall the teacher's skills in managing learning using SW Lab. Virtual PhET simulation can be categorized very well with the acquisition of an average score of 3.38.

In this study Sound Wave material was chosen because it is rich in concepts and has many mathematical similarities and is abstract in nature. However, using SW Lab. Virtual simulation PhET was able to improve student activity and learning outcomes in sample schools. In addition, students' responses to SW Lab. Virtual PhET simulation is also very positive. This positive response shows that students are enthusiastic about the learning presented. This can motivate students to increase attention and get them involved in a fun and meaningful learning experience. This motivation encourages students to carry out learning activities as observed by observers. The high response of students indirectly can help students get a complete understanding of the concept. Some previous research also shows that teacher skills are not only focused on the use of SW, but are also skilled in developing questions [22,23,26,27], and teacher questioning skills [7]. Both of these skills contribute positively to the skills of teachers in using the SW Lab. Virtual PhET simulation.

Based on Table 3, it can be explained that students' responses to learning using the Lab. Virtual PhET simulations tend to be positive, where 100% of students stated that they were happy with this learning, 100% of students stated that they were interested in this KBM, 100% of students stated that they wanted to apply the use of SW Lab-VirPhET to other learning, specifically SCIENCE learning, 100% students states that learning using Lab. Virtual PhET simulation makes them love physics lessons, 100% of students declare learning using the Lab. Virtual PhET simulations can assist them in understanding material and answering questions and 100% of students state that they can understand Sound Wave material after learning by using the Lab. Virtual PhET simulation, even 100% of students stated that the language used in SW was easy to understand.

Table 3. Student responses to the use of SW Lab. Virtual PhET simulation

| No | The aspect that was responded to | Respon of Students |
|----|---------------------------------|--------------------|
|    |                                 | Yes | Not |
| 1  | Are you happy with learning to use SW Lab. Virtual PhET simulation? | 100% | 0% |
| 2  | Do you think using SW Lab. Virtual PhET simulation is interesting? | 100% | 0% |
| 3  | Do you want to use SW Lab. Virtual PhETini simulation is applied to other learning, specifically SCIENCE learning? | 100% | 0% |
| 4  | Do learning using SW Lab. Virtual PhET simulation makes you like learning physics? | 100% | 0% |
| 5  | Do learning using SW Lab. Can virtual simulation PhET help you in understanding material and answering questions? | 100% | 0% |
| 6  | Can you understand the Sound Wave material after learning by using SW Lab. Virtual PhETini simulation? | 100% | 0% |
| 7  | Is it easy for you to understand the language in SWLab. Virtual PhET ini simulation? | 100% | 0% |

Some previous research results show that positive student responses are also obtained when the SW COCOAER model is applied [10], SW is based on a scientific approach [12,25,28], SW is assisted by PhET [14], SW is based on discovery learning [22], SW is based on guided inquiry [29], and SW based on Problem Solving [30]. Based on the results of previous studies and also the results of this study can be said that students are happy to give a positive response to the use of SW which has innovative value in it.

4. Conclusion
Based on the results of previous research and also the results of this study can be said that students are happy to give a positive response to the use of SW which has innovative value in it. Use of SW Lab. Virtual simulation of PhET in sample schools can improve student learning outcomes. The management of learning by teachers using SW Lab. Virtual simulation PhET also experienced improvements and improvements that have an impact on student activity and grades. Student responses to learning using
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