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Promoting Science Process Skills through The Implementation of PhET Simulations on Vibration and Wave

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ABSTRACT

The purpose of this study was to determine the science process skills of students in the application of PhET Simulations on vibration and wave material. The aspects of science process skills studied are observing; processing, analyzing data and information; communicating results. The method used in this research is a pseudo-experimental method using a one group pretest and posttest design. The sampling design used purposive sampling. The subjects of this study were 30 students of class VIII-B MTsN 1 Kota Surabaya. The improvement of science process skills was measured using Normalized Gain with an average score of 0.73 in the high category. Based on the results of this study, it can be concluded that PhET Simulations on vibration and wave material can improve students' science process skills.

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1. Introduction

Education is a human endeavor to achieve skills in the form of knowledge to shape character (Ainia, 2020) and build personality (Alfath et al., 2022) (Alfath et al., 2022). Education is also very influential in educating the nation's life and improving the quality of human resources (Siregar & Marpaung, 2020). Education will continue to change with the development of various aspects of life over time (Maharani & Meynawati, 2024). Changes that occur include competence, quality of teaching staff, facilities and infrastructure, quality of education, and educational curriculum tools (Putri et al., 2023). Teachers direct students in the learning process and are more student-centered (Arifin et al., 2021). Students can be more active in learning so that they are trained to think critically, creatively, innovatively, participatively, and collaboratively (Zuhraina & Husna, 2022).

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The Independent Curriculum is applied to all subjects, one of which is Natural Science (Marzuki, 2023). Natural Science is a systematic discovery process in studying natural phenomena and symptoms (Asmoro & Mukti, 2019). Natural Science is contextual learning that functions to provide learning experiences and guide students to acquire basic science concepts (Sutarto et al., 2021). Learning science subjects at stage D at the junior high school level includes elements of science understanding and process skills (Riswakhyuningsih, 2022). The element of understanding science is related to high-level thinking skills (HOTS), while process skills to hone thinking skills in applying science in everyday life (Hardanie et al., 2021). The process skills in question are science process skills (Tunisa & Astriani, 2023). Natural science is related to science process skills because science learning cannot be separated from investigative or experimental activities to understand and prove theories or concepts (Wahyuningsih & Fatonah, 2021)

Science process skills are needed in the 21st century to train logical and rational thinking (Mardhiyah et al., 2021)(Mardhiyah et al., 2021). Science process skills are a bridge to foster the critical thinking, creative, communication, and collaboration skills needed in the 21st century (Hardanie et al., 2021). Science learning can apply science process skills to train students' scientific thinking skills (Hardianti et al., 2020). Science process skills teach how to acquire knowledge and are an important goal in science learning (Fitriah et al., 2023). Science process skills taught to students provide opportunities for students to do something that is not only applied in the learning process but also becomes the basis for solving problems in life (Usman & Faradina, 2023).

Learning in the 21st century helps students develop science process skills during science learning both in the classroom with the teacher and through practicum activities in the laboratory (Lusidawaty et al., 2020). To carry out experimental activities, supporting learning media are needed (Gabriela, 2021). The limitation of practicum tools and materials is an obstacle in carrying out experimental activities at school (Defianti et al., 2021). Abstract material has the potential to cause various difficulties in learning it, especially for students in lower grades who are generally not yet able to think abstractly (Zahwa & Syafi'i, 2022). One possible way to help students understand difficult information in learning is to facilitate the learning process using learning media (Rahayu, 2020). Teachers can use interactive media as a tool to support learning activities (Listiani et al., 2022). Multimedia or interactive media is a combination of graphics, text, photos, audio and animation and creates interaction between users and computers (Sakiah & Effendi, 2021). As technology advances, practicum activities can be carried out using simulations operated by software. One of the simulations that can be used is PhET Simulations.

PhET Simulations was developed by the University of Colorado (Muzana et al., 2021). PhET Simulations are interactive that can help students understand new experimental topics that are not found in real laboratories and strengthen thinking and concepts between students and teachers (Triani et al., 2023). PhET Simulations are easy to use and use fun and interesting features (Hidayat & Subekti, 2022). PhET Simulations can visualize abstract concepts to be more concrete so that learning objectives and learning processes become more meaningful and as a solution to the limitations or absence of laboratories for practicum (Fatimah et al., 2020). PhET

Simulations can reduce misconceptions that occur in students (Triyatno et al., 2022). PhET Simulations have the advantages of being safer, cost-effective, clean, flexible, and time efficient when compared to a real laboratory (Sujanem et al., 2019). PhET Simulations provides an attractive appearance and learning materials that are experimental and theoretical and are able to attract students to use it and can build students' thinking concepts and science process skills (Azizaturredha et al., 2019). Science learning is related to the laboratory to develop students' knowledge (cognitive), affective (attitude) and psychomotor (skills), so that the delivery of theory and practicum activities must be balanced (Ufie, 2020). Thus, PhET Simulations is able to support abstract science learning and become an alternative to conduct experiments because science is closely related to experimental activities. PhET Simulations contain virtual stimuli that can initiate student curiosity in constructing concepts and applying them through variable manipulation so that they can influence experiments. In science learning itself, student involvement in creative thinking is needed in the learning process (Busrial, 2022). The nature of PhET Simulations can improve creative thinking, motivation, and have a positive effect on students' skills and cognition (Oktaviana et al., 2020). PhET Simulations can help students optimize the learning process and explore and understand the concepts learned. Djola et al. (2021); Laurence (2022); Novebrini et al. (2021) show that PhET Simulations have an impact on improving science process skills, thus showing that PhET Simulations have a positive impact on improving science process skills, PhET Simulations are recommended in science learning because learning becomes more interesting, effective in the era of massive technological advances, and effective in the era of massive technological advances. This can be interpreted that the use of PhET Simulations in science learning can improve students' abilities including students' science process skills (Puspita, 2020).

In this study, vibration and wave materials can be used. Vibration and wave materials are suitable for guiding students to conduct experiments to find and understand well the concepts of vibration and waves (Maslahah & Budiyanto, 2023). The abstract nature of vibrations and waves causes students to experience difficulties, for example in determining amplitude and frequency, thus requiring PhET Simulations (Ekahana et al., 2022). When learning on this material is done conventionally, such as using ropes, students cannot manipulate variables such as amplitude and frequency (Oktaviana et al., 2020). According to (Santiawati et al., 2022) vibrations and waves are suitable for improving science process skills. If this learning uses PhET Simulations, students can freely and easily experiment in manipulating variables, such as amplitude and frequency so that this material can be used in this study.

Based on the background previously described, in science learning it is necessary to apply PhET Simulations to improve science process skills. This is because science learning is closely related to practicum activities. Thus, researchers are interested in examining the implementation of PhET Simulations on vibration and wave material to improve science process skills.

2. Method

This study used a poor-experimental method using a one group pretest and posttest design. Research using one group pretest and posttest design is limited to research with a small scope, namely one experimental class with predetermined

subjects that are not randomly selected because the subjects are selected based on the initial objectives regarding the selected research subjects (Creswell, 2019). The sampling design used purposive sampling. The subjects of this study were 30 students of class VIII-B MTsN 1 Kota Surabaya. The instruments used in this study were pretest and posttest. Furthermore, the test questions were used to determine the improvement of science process skills. The data collection method of this study used tests. To measure students' science process skills, there are three indicators. Each indicator consists of three questions. Thus, the pretest and posttest questions used totaled nine questions. The pretest and posttest questions are about vibration and wave material. This test method was carried out before the learning process with a pretest and after the learning process with a posttest. Data were analyzed using Normalized Gain. Normalized Gain is used by measuring pretest and posttest to determine learning improvement. The Normalized Gain formula is as follows:

$$<g> = \frac{<Sf> - <Si>}{<Smaks> - <Si>}$$

To analyze the Normalized Gain results based on the Normalized Gain criteria in Table 1.

Table 1. Score Criteria for Normalized Gain

Score	Criteria
(<g>) ≥ 0,7	High
0,7 > (<g>) ≥ 0,3	Medium
(<g>) < 0,3	Low

3. Results and Discussion

Results

The results of the science process skills test can see an increase in science process skills through the pretest and posttest. Before the learning activities begin, students are given a pretest and a posttest is given to students after implementing the PhET Simulations. The indicators of science process skills measured are observation; process, analyze data and information; and communicate results. The pretest and posttest questions consist of 9 questions and each indicator of science process skills consists of 3 questions. The results of each science process skill indicator for pretest and posttest have shown in Figure 1.

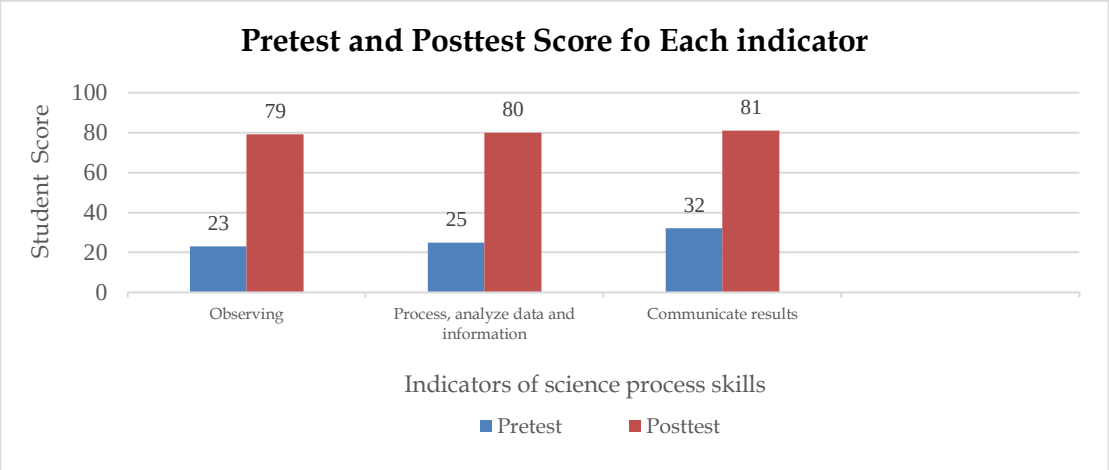

Figure 1. Pretest and Posttest Score for Each Indicator

Based on Figure 1, the pretest score of science process skills before learning has the lowest average score on the observation indicator with an average score of 23 and the highest average score on the indicator communicating the results with an average score of 32. While the posttest score of students' science process skills after learning by applying PhET Simulations based on Figure 1 shows the lowest average score on the observation indicator with an average score of 79 while the highest average score on the indicator communicating the results with a score with an average score of 81. This shows an increase in students' science process skills after the application of PhET Simulations.

The results of students' science process skills tests in the form of pretests and posttests were then analyzed using N-Gain to determine whether there were differences before and after implementing learning using PhET Simulations. N-Gain results can be seen in Table 2.

Table 2. Science Process Sills N-Gain Results

Indicator	Pretest	Posttest	N-Gain	Criteria
Observing	23	79	0,73	High
processing, analyzing data and information	25	80	0,73	High
Communicating results	32	81	0,72	High
Mean			0,73	HIgh

Based on Table 2, it shows that the observation indicator has an N-Gain of 0.73, meaning that the increase in the observing indicator is in the high category. The indicator of processing, analyzing data and information has an N-Gain of 0.73, meaning that the increase in the indicator of processing, analyzing data and information is in the high category. While the indicator communicating the results has an N-Gain of 0.72, meaning that the increase in the indicator communicating the results is in the high category.

Discussion

Based on the results of research on science process skills tests that have been obtained, it shows that most students experience an increase in science process skills in the high category. This is in accordance with the research of Azizaturredha et al., (2019) that the use of PhET Simulations is effective in learning because it can improve students' science process skills and help students in building thinking concepts. This finding is supported by previous research by (Winda et al., 2023) that there was an increase in the results of students' science process skills after implementing learning by using PhET Simulations.

Table 2 above shows that each indicator of science process skills has increased as seen in the Normalized Gain on students' pretest and posttest results which are in the high category. The average Normalized Gain score obtained on the measurement of science process skills is 0.73 with a high category. The highest Normalized Gain was in the observing indicator with a score of 0.73 and the indicator of processing, analyzing data and information with a score of 0.73. Observation skills are the skills most often used in research so that students are trained in using observation skills (Önder et al., 2022). Furthermore, the lowest Normalized Gain is in the indicator of communicating results with a score of 0.72 with a high category. The skill of communicating results is explaining the results of observations from the table or graph observed (Azizi & Herman, 2020). Before

students were given treatment, students obtained low results on the pretest because they did not understand how to communicate the results of the experiment and after being given treatment students were able to communicate the results of the experiment well (Elfeky & Elbyaly, 2023). So that the use of PhET Simulations with good guidance can improve students' science process skills (Arifullah et al., 2020).

In previous research, Badriyah et al. (2023) showed that the use of PhET Simulations can visualize abstract concepts to be more concrete, thus strengthening student understanding. The improvement of students' science process skills shows that PhET Simulations is effectively used in learning vibration and wave materials (Santiawati et al., 2022).

4. Conclusions

Based on the results of the data analysis above, researchers obtained an average score of science process skills of 0.73 with a high category. Based on the results of the data analysis above regarding the average score of science process skills, it can be concluded that PhET Simulations can improve science process skills on vibration and wave material.

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