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Student Responses to Hydrostatic Pressure Physics Learning Using the Phet Simulation-Based Inquiry Method

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Abstract
The purpose of this study was to determine students' responses to learning about hydrostatic pressure using the PhET Simulation-based inquiry method. Simulation-based learning was chosen because the material on hydrostatic pressure is abstract and requires visualization to improve conceptual understanding. Understanding the concept is a process for someone to think in order to be able to understand and understand a concept in learning and also to process a learning material that will be received so that it becomes more (Fitriyani et al., 2023). The research was conducted at MAN 2 Kota Jambi with 15 students from class XI F8 selected using purposive sampling. The research approach used a quantitative approach with a descriptive method. The research instrument was a 1–5 Likert scale questionnaire consisting of 10 statements, covering two main aspects: (1) attitude towards the PhET Simulation media, and (2) general attitude towards learning. Data were collected after students participated in inquiry-based learning that allowed them to explore the variables of depth, density, and gravity through independent simulation.The descriptive analysis results show that the overall average score was 4.12, which falls into the "Good" category. In terms of attitudes toward PhET media, the average score of 4.12 indicates that students felt helped in understanding the concepts and enjoyed the learning process. In terms of general attitudes toward learning, the average score of 4.12 indicates an increase in motivation, speed of understanding, and concept retention. The highest score was on the statement regarding the ease of remembering concepts (Fitriyani et al., 2023)(4.4), while the lowest score came from several individual responses that did not affect the general trend. Overall, PhET Simulation-based inquiry learning received a positive response ( ) from students and was considered effective in improving their understanding of physucs concepts, especially hydrostatic pressure. This learning model is recommended for application tp other physics materials that require interactive visualization.

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1. INTRODUCTION

In physics learning, hydrostatic pressure material is often challenging for students because, in addition to the abstract nature of the concept, visualization skills are needed to understand the relationship between variables such as depth, fluid density, and gravity. expert solves problems in an organized manner and always prioritizes concepts in the process of determining answers (Cicyn Riantoni et al., 2023). This condition results in low conceptual understanding, lack of motivation to learn, and minimal student involvement in the learning process. Using this Phet Simulation can make the learning process more interesting, fun, and challenging (Ismalia et al., 2022)(Wati &

Rakhmawati, 2020). Therefore, learning media that can provide clear and interactive visual representations is needed in this case, and it is hoped that students can understand the concepts more concretely.

The development of educational technology provides opportunities to present digital simulation-based learning experiences. One of the most widely used media is **PhET Simulation,** an interactive simulation designed to help students explore physics concepts through virtual experiments(Ismalia et al., 2022). This medium allows students to manipulate variables directly and observe changes in phenomena in real-time, making learning more meaningful (Moore et al., 2021). In hydrostatic pressure material, PhET provides clear visualization of the $P=\rho gh$ relationship, including changes in pressure due to depth and fluid type.

In addition to the use of media, the application of the inquiry method also plays an important role in increasing student engagement. Cognitive engagement, in this context, encompasses students'active involvement in interpreting, analyzing, and synthesizing information rather than passively receiving content (Wahyuni Fitria & Nafiah, 2025). Through this approach, students are encouraged to discover concepts independently through a process of questioning, trying, observing, and concluding. Simulation-based inquiry methods have been proven to improve conceptual understanding, scientific thinking skills, and positive attitudes towards learning Physics. academic skills, it is necessary to add experimental methods to learning. The experimental method will provide direct experience to students in constructing knowledge (Rahim & Nadira, 2022)(Article & Wulansari, 2026) (Rahmawati & Rustaman, 2022). The collaboration between the inquiry method and PhET Simulation is considered effective in helping students understand physical phenomena that are difficult to observe directly.

Several previous studies have stated that the use of digital simulations can improve learning outcomes, interest, and motivation of students in learning science (Sari & Prastowo, 2021; Nugroho et al., 2023). However, the success of implementing the inquiry method and using PhET media greatly depends on how students respond to their learning experiences. Student responses can be an important indicator to determine whether the learning strategy is appropriate for the needs and characteristics of the students.

Given this background, the purpose of this study is to analyze student responses to learning about hydrostatic pressure using the PhET Simulation-based inquiry method . This study aims to provide an overview of the level of student acceptance, the effectiveness of the media, and the potential for developing simulation-based learning methods for other physics materials.

2. METHOD

The design used in this study was quantitative descriptive and survey approach, because the main objective was to describe students' responses to the application of the PhET Simulation-based inquiry method in hydrostatic pressure material. This approach was chosen to obtain an objective picture of students' opinions and learning experiences after participating in learning with interactive simulation media(Pratama, 2026).

The research was conducted on students who had studied hydrostatic pressure material through an inquiry-based learning model using PhET Simulation as a supporting medium. Findings indicate that action research is an established element of professional learning in Ghana's Colleges of Education, though pedagogical support varies considerably across institutions (Quarshie et al., 2026). The research population consisted of all students in class XI F8 MAN 2 Kota Jambi who participated in learning hydrostatic pressure material, while the research sample consisted of 15 students selected through total sampling because all of these students were directly involved in the learning process.

A Likert scale questionnaire consisting of 10 questions was used as a reference for data collection. This instrument was developed to measure two main aspects, namely students' attitudes towards the PhET Simulation media and students' general attitudes towards the hydrostatic pressure learning provided. Each statement was assessed using a five-point scale, ranging from 1 (strongly disagree) to 5 (strongly agree).The formulation of the statements was adjusted to the indicators of concept understanding, learning involvement, motivation, and students' perceptions of the effectiveness of simulation media(Ningsih, 2022). This refers to previous research that emphasizes the importance of measuring these aspects in PhET- based learning (Nugroho & Widodo, 2021).

PhET Simulation: Fluid Pressure and Flow, an interactive computer-based simulation used as a learning medium in this study, displays visualizations of physical variables such as fluid depth, density, and gravity. Through this medium, students can independently explore the concept of hydrostatic pressure through various virtual experiments.The equipment used included laptops with the Windows 10 operating system and a stable internet connection to run the PhET application. The learning materials used were inquiry worksheets containing the steps of observation, analysis, and verification of concepts that students had to carry out while using the simulation.

From each piece of data collected, the average value and percentage of student responses to each questionnaire item were analyzed using descriptive statistical techniques. The collected data were analyzed using descriptive statistical techniques by calculating the average value and percentage of student responses to each questionnaire item. The results of the analysis were used to describe the level of student acceptance of the media and learning methods used. The results of the findings then became the basis for drawing conclusions about the effectiveness of PhET Simulation in helping students understand the concept of hydrostatic pressure and in improving their experience and motivation.

3. RESULTS AND DISCUSSION

In this activity, the researcher found several findings that showed information about students' abilities and learning interests, which could be used as part of knowledge or a reference for future learning. The aspects of attitude towards the PhET Simulation media can be seen in

Table 1. Aspects of Attitude Towards PhET Simulation Media

No	Indicator	Actual Score	Maximum Score	Percentage
1	PhET media facilitates understanding of the concept of hydrostatic pressure	60	75	80
2	The simulation display is attractive and facilitates visualization of the formula $P=\rho gh$	61	75	81.3
3	Allows exploration of depth, density, and gravity variables	64	75	85.3
4	Learning becomes fun	63	75	84.0
5	This media is suitable for physics learning	63	75	84.0
Number		311	375	414.6%

Average Percentage				82.9% (Excellent Category)

Interpretation:
Based on the data, all indicators show values above 80%. The indicator with the highest percentage is variable exploration ability (85.3%), which indicates that PhET strongly supports the implementation of inquiry activities. The overall average value of 82.9% places this aspect in the Very Good category.
Research by Putra et al. (2021) found contrasting results and stated that PhET's interactive visualizations can improve students' understanding of abstract concepts in fluid material . Research by Siregar & Lestari (2022) also shows that attractive simulation displays can increase student motivation and concentration in learning physics concepts.
In addition, this study also found several findings that indicate students' understanding of physics theories, concepts, and phenomena, so that can be part of knowledge or a reference for future learning. The general attitude towards learning can be seen in Table 2.

Table 2. General Attitudes Toward Learning

No	Indicator	Actual Score	Maximum Score	Percentage
6	Understand the material faster	63	75	84
7	Increasing learning motivation	60	75	80.0
8	Facilitating the recall of concepts of pressure and force	66	75	88.0
9	Connecting the material to real-world phenomena	63	75	84.0%
10	Want this method to be used in other physics materials	60	75	80.0
Total		312	375	416
Average Percentage				83.2% (Excellent Category)

Interpretation:
The average percentage of 83.2% indicates a very positive response from students to the overall learning process. The indicator with the highest value is ease of remembering concepts, which reached 88%. This data is consistent with the research by Sari & Nugroho (2021), which states that dynamic visualization in digital simulations can strengthen students' mental representations, making it easier for them to understand and remember concepts. Thus, the use of PhET Simulation has been proven to provide significant cognitive support in helping students build conceptual understanding of hydrostatic pressure material. The Physics lecture process is a learning process that has a lot to do with understanding concepts in analyzing and recognizing the universe(Yusuf et al., 2022).
There was also a considerable increase in student learning motivation, which rose by 80%. This result supports the findings of Dewi & Kurniawan (2023), which reveal that simulation-based

inquiry methods can increase student participation, both emotionally and intellectually, in the science learning process. This increase in motivation level shows that the use of PhET not only helps strengthen conceptual understanding but also creates a more interesting and interactive learning experience, which encourages students to be more actively involved in learning. There are several ways to increase students' interest in learning. First, using interesting learning media with the aim of increasing students' understanding of physics learning itself(Sofna et al., 2023).

Table 3. Overall Response Summary

Aspect	Percentage
Attitude toward PhET Simulation Media	82.9
General Attitude toward Learning	79.2
Overall Average	81.0% (Very Good)

The overall average of 81.0% shows a very good response from students to the use of PhEt Simulation learning media in hydrostatic pressure learning. This media acts as an effective stimulus to increase their involvement and understanding in learning.

From the existing data, the results show that this question is random. For more details, see Table 4, which contains the results of the runs test.

Table 4. Results of the Runs Test

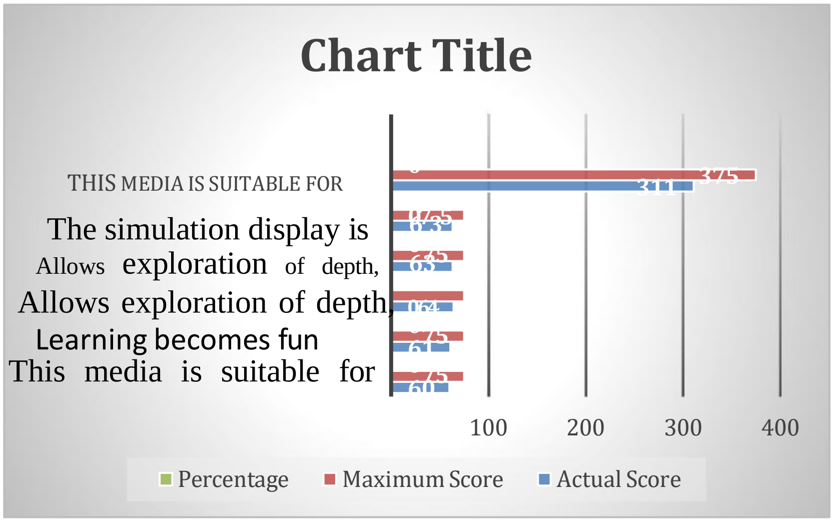
Variable	Asymp. Sig (2-tailed)	Description
Student Response	0.873	The data is randomly arranged (Ho accepted)

The figure shown is 0.873, which is higher than 0.05. From this, it can be concluded that Ho is accepted. This shows that the student response data to the use of PhET Simulation is random, so that the instrument used does not provide specific directions or create a systematic pattern of answers

4. CONCLUSION

Based on the results of the questionnaire data analysis in Tables 1–4, it can be seen that the use of PhET Simulation in teaching hydrostatic pressure has a positive effect on student responses, both in the cognitive, affective, and motivational domains. From this, we can indicate that the use of digital simulation media can provide a more meaningful learning experience compared to traditional learning methods. The development of this interactive learning media aims to improve student learning outcomes and motivation and is expected to improve the quality of learning (Suri et al., 2022). This condition is also in line with the demands of 21st-century learning, which prioritizes digital literacy, exploration skills, and inquiry-based learning approaches. **Attitudes toward PhET Simulation media**

1. Attitude Aspects Towards PhET Learning becomes fun Learning becomes fun

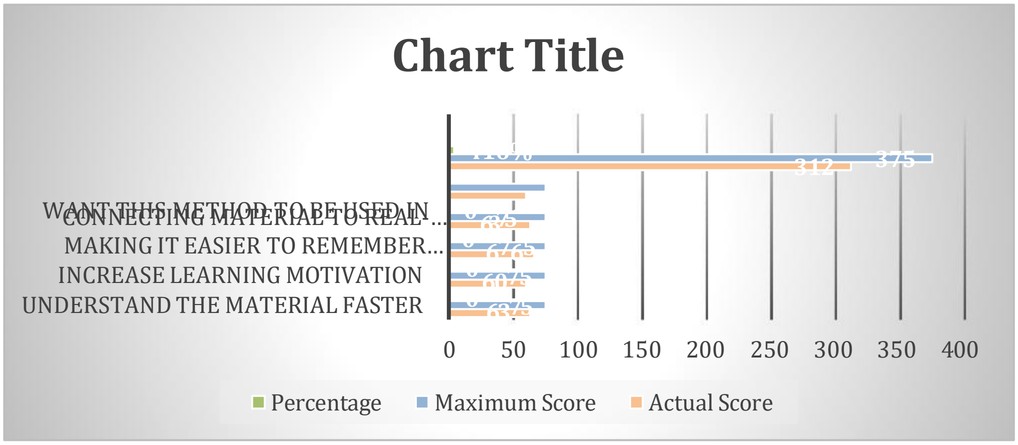


In terms of **attitudes towards PhET Simulation media**, as shown in Table 1, all indicators received a very good average score of 82.9% with a percentage above 80%. This score shows that students consider PhET to be an effective learning medium that is easy to use and helps them understand concepts. The consistently high percentages across all indicators indicate that PhET is not only visually appealing, but also able to meet students' cognitive needs in understanding hydrostatic pressure material. This media provides students with the opportunity to learn concepts independently through exploration and direct interaction with simulation objects, making the learning experience more active and meaningful.

The indicator with the highest percentage, namely the ability to explore physical variables by 85.3%, shows that students are greatly assisted when they can manipulate variables such as depth, fluid density, and gravitational acceleration. The opportunity to instantly change parameters allows students to understand the causal relationships between physical variables more clearly(Hartati, 2026) . This is important because hydrostatic pressure is an abstract concept that requires visualization to clarify the relationship between these concepts. Thus, PhET provides a virtual experimental environment that resembles a mini-laboratory, where students can conduct investigations without the limitations of tools and physical conditions. Putra et al. (2021) and Kholifah & Pratiwi (2023) obtained similar findings, stating that interactive visualization greatly supports exploratory skills and conceptual understanding in physics learning.

In addition, attractive and easy-to-understand simulation displays also contribute greatly to the high positive response from students. Color visualization, dynamic objects, and an intuitive interface make students more focused on the presentation of concepts, thereby minimizing confusion in understanding the material. Siregar & Lestari (2022) found that visually appealing media displays can increase student attention, focus, and motivation during the learning process. Thus, the success of PhET lies not only in its flexible simulation functions but also in its visual aesthetics that support user comfort. The combination of interactivity and an attractive interface makes PhET a powerful tool in creating a more enjoyable and accessible learning experience for students.

2. General Attitude Toward Learning



In terms of general attitudes towards learning (Table 2), the average score of 83.2% shows students' positive response to the learning process using the PhET Simulation-based inquiry method. The indicator with the highest percentage is ease of remembering concepts, which is 88%. This shows that the dynamic, manipulative, and real-time visual representations in PhET are able to help students form stronger cognitive structures. Visualizations of changes in pressure due to depth, fluid density, or gravity help students understand cause-and-effect patterns directly, making the process of recalling concepts faster and more accurate(Article & Wulansari, 2026). These findings are consistent with the research by Sari & Nugroho (2021) and Rahmawati & Yuliani (2023), which states that simulation-based digital media is very effective in strengthening information storage and increasing long-term retention in science learning.

In addition, the learning motivation indicator, which reached 80%, shows that the use of PhET Simulation not only improves cognitive aspects but also has a positive impact on students' affective aspects. The learning experience is more interesting, interactive, and challenging with the help of simulations. This encourages students to participate more in the process of exploring and discovering concepts. The increase in student motivation and engagement is in line with the findings of Dewi & Kurniawan (2023) and Fauziah et al. (2022), This use of technology trains students in digital literacy and technical skills relevant to modern learning needs (Rahmawati, 2026). who argue that the use of simulation media can increase the desire to know , as well as the role of students in science learning. Because the learning experience is considered enjoyable and relevant, most students also expressed interest in using this method for other physics topics, indicating that PhET Simulation has the potential to be more widely integrated into physics learning in schools.

3. Overall Average Student Responses

Table 3 shows that the average student response reached 81.0%, which falls into the Very Good category. This high percentage indicates that the use of PhET Simulation is not only well received by students but also contributes significantly to conceptual understanding and the quality of the learning process. The visualization of abstract concepts, such as the relationship between depth, fluid density, and hydrostatic pressure, becomes clearer through graphical representations and interactive simulations. This allows students to observe, predict, and test concepts directly through a safe and flexible digital environment. Thus, PhET serves as a medium that bridges the gap between theory and practice, thereby reducing students' difficulties in learning physical phenomena that cannot be observed directly using conventional teaching aids. Furthermore, these findings also support the principle of constructivist learning, which places students as active participants in constructing their knowledge. Through independent exploration, observation of simulated phenomena, and real-time manipulation of variables, students have the opportunity to construct their understanding based on personal learning experiences. The effectiveness of this approach is in line with international studies such as Haque et al. (2020) and Nguyen et al. (2022), which found that the use of interactive simulations in science learning plays a major role in improving conceptual understanding, reducing misconceptions, and encouraging increased learning motivation. With strong data support in Table 3, the results of this study further confirm that PhET Simulation is a viable primary alternative in physics learning, especially for material that requires dynamic visualization and variable-based experiments.

Results of the Runs Test

The data in Table 4 shows that 0.873, the significance value obtained, is well above the significance threshold of 0.05. This indicates that the student response data is random, so Ho is accepted. In other words, the pattern of student answers does not show any systematic trends or repetitions. This condition shows that the data distribution is reasonable and is not influenced by technical factors such as repeated answers or instrument statement bias. These results also prove that the questionnaire was filled out naturally by students without pressure or inter-item dependence.

The existence of random data patterns indicates that the questionnaire instrument is of good quality because it does not direct students to give certain answers. The validity of this instrument strengthens the reliability of the research results, considering that each response truly reflects students' perceptions and experiences of using PhET Simulation media in learning hydrostatic pressure. This finding is in line with Ridwan & Sari (2021), who emphasize that the runs test is an important procedure for testing data independence, thereby ensuring that the data obtained is not distorted by internal bias in the instrument. Thus, this analysis provides assurance that the research conclusions can be interpreted objectively.

The development of technology-based physics learning has benefited significantly from this data. With accurate and unbiased data, the findings of researchers can be used as a reliable reference for teachers to create more effective learning strategies, particularly in utilizing digital simulations such as PhET. Furthermore, these results can serve as an empirical basis for designing the development of simulation-based learning media that is more interactive, adaptive, and tailored to the learning needs of students in the digital age. The reliability of the instruments and the quality of the data verified through runs tests help ensure that the research recommendations are not only relevant but also can be implemented more widely in schools in the context of physics learning.

Overall, the use of PhET Simulation has a significant positive impact on students' conceptual understanding, learning motivation, and attitudes in physics learning. Thanks to its dynamic visualization and variable exploration features, PhET is a highly suitable medium for abstract material such as hydrostatic pressure. Supported by statistical analysis results and findings from the latest literature, this study recommends that interactive digital simulations be more widely integrated into physics learning at the secondary school level, especially for material that requires safe and flexible virtual experiments.

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