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Motivation and Learning Outcomes after Using PhET Simulations on Hydrostatic Pressure: A Quantitative Analysis

Annisa Shafirah[1], Indri Sari Utami[1] *, Siti Khoirunisa[1], Fhazriani Riau[1], Helsa Putri Pratama[1], Novita Ayu Permata Sari[1], Ridwan[1], Muhammad Yusrizal[1]

[1] Department of Pyhsics Education, Universitas Sultan Ageng Tirtayasa. Indonesia

*Corresponding Author. isu_indrisariutami@untirta.ac.id

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Abstract

This article examines the relationship between learning motivation and physics learning outcomes on hydrostatic pressure material after the use of PhET simulation media in grade XI students at SMAN 1 Petir, Banten. The study used a quantitative approach with a descriptive-correlational design involving 22 purposively selected students. Research instruments included a Likert-scale learning motivation questionnaire, multiple-choice tests, and semi-structured interviews to strengthen interpretation. The results show that students' motivation is in the good category, while learning outcomes are very high and homogeneous, with 86.36% of students achieving a perfect score, creating a ceiling effect that reduces variability. Spearman correlation analysis yielded a coefficient of −0.23, indicating a very weak and insignificant negative relationship between motivation and learning outcomes, suggesting that motivation is not a key predictor of academic performance in this case. The findings point to the influence of other factors such as cognitive abilities, learning strategies, and test characteristics that better explain learning performance. Researchers recommend improving evaluation instruments to increase sensitivity, adding moderating variables such as self-regulated learning or self-concept, and using mixed methods for a more comprehensive understanding of the relationship between motivation and learning outcomes in science education.

Keywords: Learning motivation, PhET simulation, hydrostatic pressure

INTRODUCTION

The development of education in the digital age requires a learning process that is not only oriented towards the delivery of information, but also encourages active engagement and conceptual understanding among students. However, in practice, the learning process in the classroom is still often carried out traditionally, where students play a passive role as recipients of information. This situation has an impact on low learning motivation and limitations in students' ability to connect abstract concepts with reality. Studies show that teaching physics through lectures makes students more passive, less focused, and even sleepy, thereby reducing their motivation to learn and preventing them from achieving maximum learning outcomes (Melinda et al., 2021). One of the learning supports that needs to be developed at this time to complement existing facilities/infrastructure is the availability of adequate teaching materials. With adequate

teaching materials, students can learn and discuss the subject matter before the learning process begins (Satriawan & Rosmawati, 2016).

Physics holds the specter of a difficult subject in the minds of most students. In practice, students must engage in practical activities or demonstrations to understand the concepts in real life. There are various obstacles in achieving the desired learning outcomes. Inefficient physics laboratory management is one of these obstacles. This condition is reinforced by the results of a survey of physics teachers at the Physics MGMP Serang Regency, which found that only half of the teachers conducted practical work for each subject matter (52.4%), and 47.6% of teachers explained the lack of facilities and infrastructure that can be used for practical work. Furthermore, the lack of human resources in managing laboratories is a barrier to learning (Bhakti, Dwi, & Dasmo, 2019).

This relationship is clearly evident in physics learning, which is often considered complex due to its abstract nature, requiring multiple representational skills, and involving mathematical reasoning processes. Ramadhani & Sulisworo (2022) stated that students face difficulties in understanding physics when the learning process only takes place one way without the presence of tools that support concept visualization. Several studies have shown that problems in understanding physics concepts are often caused by students' minimal representation and visualization skills, so they tend to only memorize formulas without understanding the physical meaning behind them (Cari et.al, 2020; Nooritasari et al, 2020). One of the Physics topics that requires a good and correct conceptual understanding is static fluid material, especially hydrostatic pressure.

Hydrostatic pressure is the pressure caused by a force exerted on a fluid by a force applied to a specific area at a specific depth (Rahmawati & Wulandari, 2021). Conceptually, pressure in a fluid at rest is called hydrostatics. A crucial concept to understand in the concept of static fluids, particularly hydrostatic pressure, is that hydrostatic pressure is not affected by the density of the container, but rather by the density of the fluid, the surrounding air, the acceleration due to gravity, and the depth of the object within the fluid (Zulfa et al., 2020). When concepts cannot be clearly visualized, the thinking process becomes difficult, and understanding the physical meaning behind the formulas feels less meaningful. This situation not only hinders conceptual understanding but can also reduce self-confidence and motivation to learn. The inability to fully visualize concepts can cause students to quickly lose motivation and impact learning outcomes.

In the realm of learning theory, motivation is a crucial psychological element that influences students' level of participation and success in the learning process. Based on motivation theory in education, highly motivated students tend to demonstrate persistence, curiosity, and the ability to organize learning strategies more efficiently, which in turn influences the achievement of better learning outcomes (Schunk, Pintrich, & Meece, 2014). Students with high learning motivation tend to be more proactive in seeking understanding and show better results than students with low motivation. In physics learning, motivation to learn is often a barrier because physics is considered complex and requires representation skills. This situation encourages teachers to strive to make physics enjoyable and easy to understand. Research by Rahman & Sani (2021) also shows that learning motivation is closely related to learning outcomes, especially in disciplines that require in-depth conceptual understanding such as physics.

PhET is the choice of many teachers for conducting virtual physics practicums due to its free access and easy-to-use user interface. PhET's flexibility also makes it a portable simulation, as it can be accessed using a variety of devices. PhET provides interactive animation-based simulations of various learning materials in Physics, Chemistry, Biology, Mathematics, and Earth Sciences, allowing students to interact and explore their

understanding of the material learned through the simulation. PhET is able to connect concepts with real-world phenomena and provides visual depictions of phenomena that are difficult for students to observe directly (Perkins et al., 2006).

To address these issues, the use of interactive learning media has become an increasingly suitable alternative. PhET simulations are a proven effective tool for increasing motivation and conceptual understanding because they integrate virtual experiments, realistic visualizations, and direct interaction, allowing students to explore physics phenomena independently. Iskandar et al. (2021) stated that PhET was created using a research-based approach, combining previous findings and self-testing to create simulations that support student engagement and understanding of physics concepts. Therefore, they are specifically designed to enhance conceptual understanding and increase student engagement. Other research also The results indicate that the average learning motivation and problem-solving skills of students in the experimental class (using PhET) are in the high category, while the control class is low/moderate. There is a significant difference (sig 0.002 < 0.05) between the two classes. PhET also increases interest and conceptual understanding (Susilawati et al., 2022). Therefore, PhET can increase motivation, interest in learning, and have a positive effect on physics learning outcomes.

METHODE

1. Research Types and Designs.

   This study used a quantitative approach with a descriptive-correlational design, which aimed to determine the relationship between student learning motivation and learning outcomes after using PhET media on the concept of hydrostatic pressure (Sugiyono, 2019). A correlational design was chosen because this study did not manipulate variables but examined the relationship between variables as they were.

2. Subject and Location of Research.

   The research subjects were students in class XI 2B at SMAN 1 Petir in Banten who had participated in hydrostatic pressure learning using PhET media. A total of 22 students were selected using purposive sampling because they met the criteria of attending all learning sessions and were willing to be respondents. In addition, the physics teacher involved in the learning process was also interviewed to strengthen the research data (Moleong, 2017).

3. Research Instruments.

   The research instruments consisted of:

   a. Learning Motivation Questionnaire: using a Likert scale (1-5) with 14 items covering aspects of learning motivation, concept understanding, and learning methods using PhET media.
   b. Learning Outcome Test: consisting of 11 multiple-choice questions that measure understanding of the concept of hydrostatic pressure, validated by subject matter experts and evaluators.
   c. Semi-Structured Interviews: conducted with students and teachers to explore their experiences using PhET, their perceptions of learning motivation, and the obstacles they face in understanding the concept.

4. Research Procedure.

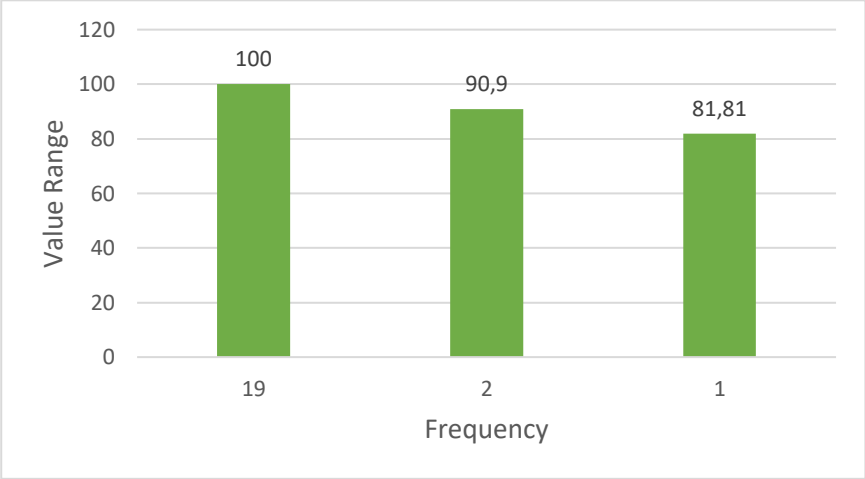
The research was conducted in three stages:

a. Preparation: instrument development, validation, and school permission (Sugiyono, 2019).
b. Implementation: teaching hydrostatic pressure using PhET simulations during three meetings, administering motivation questionnaires to students, learning outcome tests, and interviewing students and teachers (Saadah, 2023; Anriani et al., 2025).
c. Analysis: questionnaire and test data were analyzed using descriptive statistics and Pearson's correlation, while interview data were analyzed thematically to support quantitative results (Moleong, 2017).

5. Research ethics.

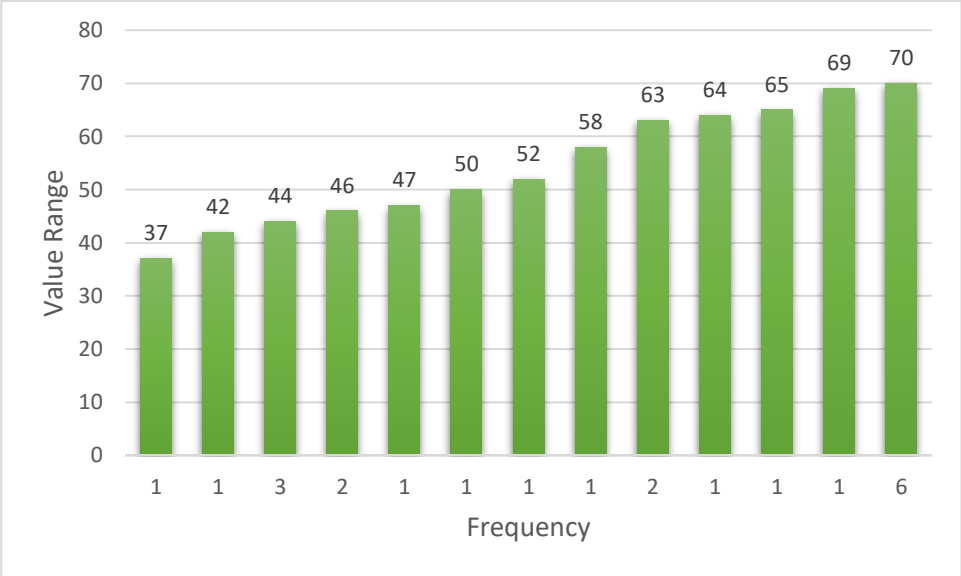
The research was conducted with the approval of the school and students, and ensured the confidentiality of respondent data. Interviews were conducted with the permission and consent of participants, and the results were used solely for academic purposes (Moleong, 2017).

RESULT AND DISCUSSION



Graphic 1. Frequency Distribution of Values

The frequency distribution of scores (Graphic 1) shows that there were 19 students (86.36%) who obtained a perfect score (100), 2 students (9.09%) who were in the range of 90-99, and only 1 student (4.55%) who were in the range of 80-89. All students obtained scores not less than 80. This statement confirms the results that this test shows a significant ceiling effect, where most students can achieve the highest score, so that the variation in scores is very limited.



Graphic 2. Frequency Distribution of Motivation Categories

Based on the motivation classification (Graphic 2), 12 students (54.55%) were classified as high-motivation (scores 56-70), 9 students (40.91%) were classified as medium-motivation (scores 42-55), and only 1 student (4.55%) was classified as low-motivation (scores 28-41). This indicates that although most students are highly motivated, there is a greater variation in motivation levels compared to learning outcomes.

In-Depth Analysis of 3 Special Students					
Students	Value	Motivation	Grade Ranking	Value Category	Value Motivation
A	81,81	65	22 (terakhir)	Improvement	Very High
B	90,90	50	20,5	Very Good	High
C	90,90	70	20,5	Very Good	Very High

Table 1. In-depth Analysis of 3 Special Students

A thorough analysis of the three students (Table 1) reveals complex dynamics. Student A, who has very high motivation (65), is actually ranked last (81.81). Meanwhile, Student B (high motivation, 90.90) and Student C (very high motivation, 90.90) also did not achieve perfect scores despite their relatively high motivation. This case indicates that high motivation does not automatically guarantee optimal academic achievement, and other factors such as.

Item Validity			
Item	Correlation	Validity Criteria	Alpha if the item is deleted
P1	0,846	Valid (r>0,3)	0,953
P2	0,832	Valid (r>0,3)	0,952
P3	0,785	Valid (r>0,3)	0,951
P4	0,821	Valid (r>0,3)	0,952
P5	0,803	Valid (r>0,3)	0,951
P6	0,867	Valid (r>0,3)	0,953
P7	0,879	Valid (r>0,3)	0,953
P8	0,745	Valid (r>0,3)	0,95
P9	0,714	Valid (r>0,3)	0,949
P10	0,853	Valid (r>0,3)	0,953
P11	0,839	Valid (r>0,3)	0,953
P12	0,865	Valid (r>0,3)	0,953
P13	0,701	Valid (r>0,3)	0,949
P14	0,682	Valid (r>0,3)	0,949

Table 2. Validity Test Per-Item on Likert Scale

Based on the data analysis that has been conducted on the relationship between learning motivation and student learning outcomes on the topic of hydrostatic pressure, several important findings can be identified that provide a comprehensive picture of the learning dynamics in this study. Data regarding learning motivation measured using a 14-item Likert Scale shows quite clear differences among the 22 respondents, with scores ranging from 37 to 70 out of a maximum score of 70. The average motivation score reached 56.59 which is higher than the theoretical mean value (42), indicating that students generally have a good level of learning motivation, although the standard deviation of 11.46 indicates that there are quite significant individual differences. A total of six students (27.3%) obtained the maximum score indicated very high learning motivation, while only one student (4.5%) had a relatively low score, reflecting a fairly positive distribution in terms of learning motivation.The hydrostatic pressure test results showed an extraordinary success rate, with 19 students (86.36%) achieving a perfect score (100%) and only three students (13.6%) scoring below the standard. The class average score was 98.34 with a standard deviation of 4.55, indicating very uniform student achievement. The very low difficulty level of the questions, with 19 students (86,36%) successfully answering all questions correctly, raises questions about the reliability of the measuring instrument as a comprehensive assessment of student ability. This occurrence may reflect a ceiling effect, where most students achieve the highest scores, thereby reducing the data variation that is important for optimal correlation analysis between motivation and learning outcomes.Analysis of the relationship between learning motivation and academic outcomes reveals a complex and inconsistent pattern (Sari & Utami, 2022), also found a low correlation between motivation and achievement, with this relationship being insignificant in the context of physics learning in Indonesia.

However, there are also groups of students with high motivation and achievement, which aligns with traditional motivation-achievement theory. There are also highly motivated students who do not achieve optimal results, and an interesting case where a student with the lowest level of motivation was able to achieve a perfect score. The Spearman correlation coefficient calculation yielded a value of -0.23, indicating a very

weak and statistically insignificant negative relationship. These results imply that in the context of learning hydrostatic pressure in the analyzed sample, there is no significant relationship between learning motivation and learning outcomes, which may be influenced by other, more dominant factors such as cognitive ability, learning strategies, or the nature of the assessment tool.

The frequency distribution related to academic achievement shows a clear positive trend, with the majority of students in the excellent category (86.4%). In contrast, the distribution of motivation shows a more balanced pattern, with 54.5% of students having high motivation and 40.9% having moderate motivation. A study of three students with suboptimal achievement reveals an interesting profile, with two highly motivated students (scoring 70 and 63) achieving only 90.9%. This suggests that high motivation does not always align with maximum academic achievement, possibly due to factors such as accuracy, conceptual understanding, or technical aspects when working on problems. This research is based on a multidimensional approach to understanding the motivation-achievement relationship (Liem & Chua, 2023). This approach supports understanding the determinants of academic success, where motivation needs to be viewed as one of many interacting variables.

Limitations in the methods used in this study, particularly the high level of homogeneity in the achievement variable and the possible lack of appropriate measuring instruments, open up opportunities for further research with a more comprehensive design. Recent findings using a person-centered approach reveal that students' motivation and self-regulation profiles in science are highly diverse and show complex patterns of relationships with learning outcomes (Senavirathna et al., 2024). Therefore, the application of mixed methods, the addition of moderator variables such as self-regulated learning and academic self-concept, and the development of more accurate and reliable measurement tools can help in understanding the complex relationship between motivation and learning outcomes in the context of science education in Indonesia. However, this research has made a significant contribution to understanding the dynamics of classroom learning and reminds educators that academic success is the result of various factors that need to be analyzed comprehensively and in the appropriate context.

CONCLUSION

The findings of this study indicate that, overall, students demonstrate strong motivation and excellent academic performance in the topic of hydrostatic pressure. Although individual motivation scores vary, the overall average reflects a positive attitude toward learning. However, the learning outcomes reveal a clustering of high scores (a ceiling effect), which limits meaningful variation in performance data. Furthermore, motivation alone does not appear to be a strong predictor of academic success. Several highly motivated students did not achieve perfect scores, while at least one student with low motivation performed exceptionally well. The weak and insignificant negative correlation (Spearman's $\rho = -0.23$) supports the conclusion that motivation is not the primary factor influencing test results in this context.

These findings align with previous research indicating that the relationship between motivation and achievement in physics education is often complex and inconsistent. The presence of ceiling effects and the limited sensitivity of the assessment instrument also suggest that the test used may not accurately measure students' true conceptual understanding. Overall, this study emphasizes that academic achievement is

influenced by multiple interacting variables, such as cognitive abilities, conceptual comprehension, and learning strategies. Future research is encouraged to use more comprehensive assessment tools, incorporate additional moderating factors, and apply more diverse research approaches to better capture the complex relationship between motivation and learning outcomes in science education.

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