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The Effectiveness of Using PhET Simulation on Parabolic Motion Material at Thammasat Wittaya School Thailand

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Abstract: This study aims to analyze the effectiveness of PhET Simulation interactive learning media in improving critical thinking skills and student learning outcomes on parabolic motion material at Thammasat Wittaya Dharmasathan School, Thailand. The method used was an experiment with a quantitative descriptive approach. The research sample was students of class Mattayom 5/1. Data collection techniques were carried out through pre-tests and post-tests. The results showed an increase in the percentage of student learning completion.as big as56.25% in the post-test. Effectiveness analysis using the N-Gain value showed an increase in learning outcomes with a score of 0.52 in the moderate category.The t-test showed a significant difference ($t = 3.65$, $p < 0.05$), indicating that the PhET simulation improved student learning outcomes.This means there is a significant difference between student learning outcomes before and after using PhET Simulation. Thus, PhET Simulation media is effective in improving students' understanding of physics concepts, particularly in parabolic motion.
Keywords: PhET Simulation, learning outcomes, critical thinking skills, parabolic motion, physics learning

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Introduction

Education is a conscious and planned effort aimed at creating a learning atmosphere that allows students to actively develop their potential (Law Number 20 of 2003). Education is a crucial aspect of life because it supports human survival. The primary goal of education is for students to acquire new knowledge while at school. Education encompasses not only the learning process but also all planning, processes, and evaluations within the learning process. The Indonesian education system consists of formal, informal, and non-formal education. Every citizen has the right to participate in compulsory education, namely formal education.

Indonesia has a system similar to the education system in several ASEAN countries, one of which is Thailand. Thailand's education system is based on the 1999 National Education Law. The curriculum used in Thailand is the 2008 Curriculum which emphasizes the freedom of every citizen to pursue an equal education (Murni, 2024). The level of education in Thailand

consists of four levels, namely Anuban (Kindergarten) for 3 years, Prathom (Primary School) for 6 years, Mattayom (Secondary Education) for 6 years, and Higher Education for 4-6 years (Azani et al., 2025). The vision of Thai education emphasizes student-centered or learning that focuses on student activity and teachers only act as facilitators in learning (Hakim, 2023). This vision is similar to what is implemented in Indonesia and several other countries which is a characteristic of education in the modern era.

Thammasat Wittaya Dharmasathan School (Thammasat Wittaya Foundation School) is one of the secondary schools in Thailand located in Khlong Sai Khao, Kong Ra District, Phatthalung Province, Postal Code 93180. This school is a foundation school based on an Islamic boarding school under the auspices of the Royal Thai government. Consisting of 9 Mattayom Classes including Mattayom 1/1, Mattayom 1/2, Mattayom 2/1, Mattayom 2/2, Mattayom 3/1, Mattayom 3/2, Mattayom 4/1, Mattayom 5/1, and Mattayom 6/1. The learning facilities provided by this school are very limited, teachers only teach in class using a blackboard. Some of the available science teaching aids are also limited with damaged conditions and cannot be used. In fact, according to research conducted by Saree (2020) stated that the lack of infrastructure such as learning media can be an obstacle in achieving learning objectives. The science subjects taught include mathematics, chemistry, and physics. With the many subjects taught at school, the learning schedule per subject is 45 minutes with a learning duration at school of 7 hours per day.

Physics is a unified science that studies the concepts, facts, and working principles of the universe. Therefore, physics has visual and abstract material because it encompasses the entire universe. The goal of learning physics is to develop scientific attitudes and systematic thinking based on students' concepts and logic (Tuhusula et al., 2020). According to Sari et al. (2022), the reality of current physics learning differs from the goals and concepts of physics itself, namely that teachers emphasize physics more as learning to memorize formulas and problems. This is in line with initial observations made by researchers at Thammasat Wittaya Dharmasathan School, namely that physics learning is teacher-centered, with students only memorizing and answering problems.

One of the materials in physics learning taught by teachers in schools is parabolic motion or projectile motion. Parabolic motion is a combined motion between horizontal and vertical motion or in physics it is called a combination of uniform linear motion (GLB) with uniformly accelerated linear motion (GLBB) (Tuhusula et al., 2020). Uniform linear motion (GLB) applies on the x-axis and uniformly accelerated linear motion (GLBB) applies on the y-axis with deceleration (Banawi, 2013: 23). In the parabolic motion material taught at the secondary school level, there are several assumptions and facts that students must know, namely:$a = -g$

1) At maximum height, the object's velocity is zero.
2) The acceleration due to gravity (g) has a constant or fixed value as long as the object is moving and pointing downwards.
3) Air resistance is neglected.
4) The Earth's rotation has no effect on movement.
5) The most effective angle to reach the furthest point is .45°
6) Quantities such as the initial position of the object, elevation angle, and initial velocity influence each other in parabolic motion (Hayeebaka et al., 2024).

Physics learning is highly dependent on the learning media used. The clearer the media, the greater the student's interest and understanding (Muzana et al., 2021). Learning media are any tools or devices, both visual and virtual, created or manufactured with the aim of increasing the effectiveness and efficiency of the learning process (Rumakur et al., 2023). One frequently used physics learning media is PhET Simulation. This learning media contains numerous science experiments, such as those involving mathematics, biology, chemistry, and physics. PhET Simulation is an interactive learning medium that provides students with access

to repeatable experiments without the physical hazards associated with direct experiments (Muzana et al., 2021). This simulation was created by the University of Colorado, United States of America, and can be downloaded from its official website.https://phet.colorado.edu/(Sudjito, 2019). The uniqueness of dThe advantage of PhET Simulation media is that learning uses an interactive approach for students with the aim of improving students' conceptual abilities, one of which is in the material on parabolic motion.

Based on research thatdoneby Wilujeng et al. (2024) that many students still consider parabolic motion as a difficult subject to learn because teachers only teach formulas without teaching concepts and the media used are less understandable. This problem was also found at Thammasat Wittaya Dharmasathan School, Thailand. Therefore, it is necessary to conduct research on the use of PhET Simulation learning media on parabolic motion material to determine the effectiveness of this media on students at Thammasat Wittaya Dharmasathan School, Thailand. If this PhET Simulation media is proven effective for use, it will be very beneficial for teachers and students in supporting the achievement of learning objectives.

Method

The research was conducted at the Thammasat Wittaya Dharmasatan School located in Khlong Sai Khao, Kong Ra District, ProvincePhatthalung, Thailand. This research is a quantitative descriptive study with data collection techniques using experimental methods. According to Hakim (2023), quantitative descriptive research is used to examine something in a specific population or sample. The sample used in this study was the Mattayom 5/1 class from the entire student population at Thammasat Wittaya Dharmasathan.

Procedurally, this research begins by selecting a sample randomly (random sampling) withThis means that each member of the population has an equal chance of being selected as a sample. The next step isconducted a pre-test on Mattayom 5/1 students to determine their initial understanding. Afterward, the teacher explained parabolic motion using PhET Simulation on the official website.https://phet.colorado.edu/sims/html/projectile-motion/latest/projectile-motion_all.htmlStudents are asked to complete a worksheet containing experiments and questions about the concept of parabolic motion. The next step is to complete the provided post-test. The results of the pre-test and post-test will be processed into initial and final learning outcome scores, then analyzed using a gain test to determine their effectiveness. Some of these analyses can be obtained from the following equation.

$$HB = \frac{The\ number\ of\ students\ who\ have\ completed}{The\ number\ of\ students} \times 100\%$$

The criteria for students who are considered to have completed the course are students who are able to obtain a score, while the average value of learning outcomes in one class is obtained from the following equation.$NT > 60$

$$\underline{x}^n = \frac{\Sigma x}{n}$$

Information:

$\underline{x}$: Average learning outcomes in one class

Σx : Total number of student scores

n : Total number of students

Based on the equations above, overall student learning outcomes can be classified into five categories: very good, good, adequate, poor, and very poor. These categories are shown in the following table of learning outcome ranges.

Table 1. Range of Learning Outcome Values

Mark	Qualification	Information
81-100	Very good	Completed
61-80	Good	Completed
41-60	Enough	Not Completed
21-40	Not enough	Not Completed
0-20	Very less	Not Completed

(Judge, 2023)

The effectiveness of learning media can be measured by the improvement in students' thinking skills. This can be done by analyzing the gain test.is a method for measuring the effectiveness of learning in improving student learning outcomes (Sukarelawan et al., 2024). The followingt N-Gain test equation used in this study.

$$(g) = \frac{\underline{X}_{post} - \underline{X}_{pre}}{\underline{X}_{max} - \underline{X}_{pre}}$$

Information:

$\underline{X}_{akhir}$: Mark*post-test*
$\underline{X}_{awal}$: Mark*pre-test*
$\underline{X}_{maksimum}$: Maximum value 100

Based on the equation above, the results of the standard gain analysis can be categorized into three levels, namely high, medium, and low, which are stated in the following table.

Table 2. Interpretation of N-gain Value

N-gain value	Information
$0{,}70 < g < 1{,}00$	Tall
$0{,}30 < g < 0{,}70$	Currently
$0{,}00 < g < 0{,}30$	Low

(Sari et al., (2022))

The gain analysis above requires a prerequisite test to determine the effectiveness of PhET Simulation in physics learning. This prerequisite test is a t-test, expressed by the following equation.

$$t = \frac{\underline{X}_1 - \underline{X}_2}{\sqrt{\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{(n_1 + n_2)^{-2}}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

Information:

$\underline{X}_1$ = average score of control class
$\underline{X}_2$ = average score of experimental class
S_1^2 =control class variance value
S_2^2 =experimental class variance value
n_1 = number of control class samples
n_1 = number of experimental class samples

The hypothesis of this research is:

H_0 = There was no difference in the physics learning outcomes of students in class Mattayom 5/1 in the pre-test and post-test.
H_a =There is a difference in the physics learning outcomes of students in class Mattayom 5/1 in the pre-test and post-test.

T-test testing rules jfish value then it is rejected meaning$|t_{hitung}| > t_{tabel} H_0$There is a difference in the physics learning outcomes of students in class Mattayom 5/1 in the pre-test and post-test.and if the value is then accepted$|t_{hitung}| < t_{tabel} H_0$This means that there is no difference in the physics learning outcomes of students in class Mattayom 5/1 in the pre-test and post-test.

Results and Discussion

This research was conducted in the Mattayom 5/1 class of the Thammasat Wittaya Foundation School with 16 students. The research was conducted over 3 meetings with a learning duration (3 x 45 minutes = 135 minutes) or equal to 2 hours 15 minutes. In the first meeting, students were directed to work on a pre-test of 10 questions. In this meeting, students did not receive any scientific stimulus and was purely to determine students' prior knowledge. In the second meeting, students were invited to carry out an online parabolic motion practicum through Phet Simulation and then complete the measurement data into the prepared LKPD. In this meeting, all students had the opportunity to carry out practicums using Phet Simulation even with makeshift devices. In the third meeting, students were asked to work on a post-test with the same number of questions as the pre-test but with a different question script.

Based on data collection conducted during 3 meetingsonThis study aims to determine the effectiveness of PhET Simulation media on students' critical thinking skills and learning outcomes. From the pre-test and post-test conducted on Thammasat Wittaya Dharmasathan students, scores were obtained which will later be processed into initial and final learning outcome scores as stated in the following graph.

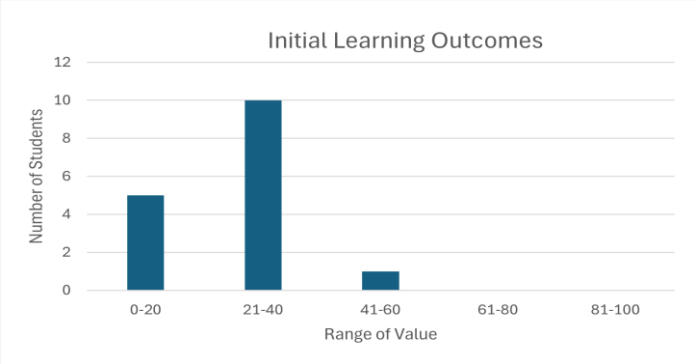

Figure 1. Initial Learning Outcomes of Students

Based on Figure 1 regarding the initial learning outcomes of students, it can be seen that students' knowledge of parabolic motion is still very low. This is evidenced by no students being able to achieve a complete category score with a score range of 61-100. Of the total number of students, there are 5 students who received a score with a range of 0-20, 10 students received a score with a range of 21-40, and 1 student received a score with a range of 41-60. This could be caused by many factors, one of which is the learning media used during physics learning, including media that is no longer relevant to technological developments.

After the pretest, students completed a practical exercise using PhET Simulation, followed by a posttest. This was done to evaluate student learning outcomes after studying parabolic motion using PhET Simulation. The evaluation of learning outcomes at this stage resulted in the final learning outcomes shown in the following graph.

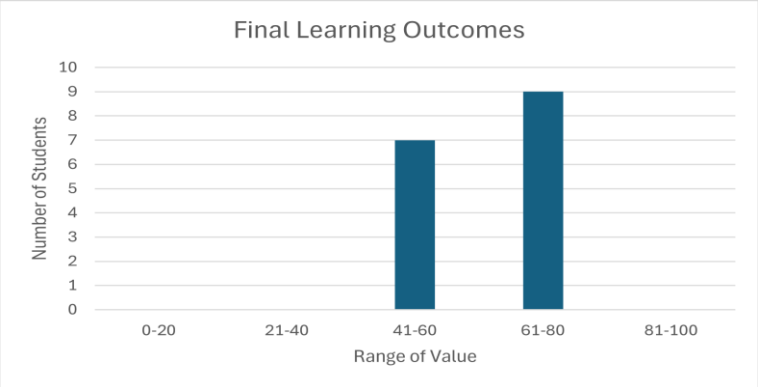

Figure 2.Final Learning Outcomes of Students

Based on Figure 2 regarding the final learning outcomes of students, it can be stated that students' knowledge of parabolic motion has increased. This is evidenced by the final learning outcomes of students, which state that there are 9 students who obtained a complete category score with a range of 61-80, while the remaining 7 students obtained a score with a range of 41-60. Thus, the initial learning outcomes of students have a completion percentage of 0%, while the final learning outcomes of students have a completion percentage of 56.25%, which is stated in the following table.

Table 3. Percentage of Student Learning Outcomes

Initial learning outcomes	Final learning outcomes
0%	56.25%

Analysis of students' critical thinking skills was carried out through a gain test which can be seen in the following table.

Table 4. Gain Test Analysis

$\underline{X}\ Pre$	$\underline{X}\ Post$	N-Gain Score	Category
30	66.88	0.52	Currently

The table above shows that the average pre-test and post-test scores were 30 and 66.88, respectively. The N-Gain value obtained through SPSS analysis was 0.52, categorized as moderate.

t-test table

cum. prob	$t_{.50}$	$t_{.75}$	$t_{.80}$	$t_{.85}$	$t_{.90}$	$t_{.95}$	$t_{.975}$	$t_{.99}$	$t_{.995}$	$t_{.999}$	$t_{.9995}$
one-tail	0.50	0.25	0.20	0.15	0.10	0.05	0.025	0.01	0.005	0.001	0.0005
two-tails	1.00	0.50	0.40	0.30	0.20	0.10	0.05	0.02	0.01	0.002	0.001
df											
1	0.000	1.000	1.376	1.963	3.078	6.314	12.71	31.82	63.66	318.31	636.62
2	0.000	0.816	1.061	1.386	1.886	2.920	4.303	6.965	9.925	22.327	31.599
3	0.000	0.765	0.978	1.250	1.638	2.353	3.182	4.541	5.841	10.215	12.924
4	0.000	0.741	0.941	1.190	1.533	2.132	2.776	3.747	4.604	7.173	8.610
5	0.000	0.727	0.920	1.156	1.476	2.015	2.571	3.365	4.032	5.893	6.869
6	0.000	0.718	0.906	1.134	1.440	1.943	2.447	3.143	3.707	5.208	5.959
7	0.000	0.711	0.896	1.119	1.415	1.895	2.365	2.998	3.499	4.785	5.408
8	0.000	0.706	0.889	1.108	1.397	1.860	2.306	2.896	3.355	4.501	5.041
9	0.000	0.703	0.883	1.100	1.383	1.833	2.262	2.821	3.250	4.297	4.781
10	0.000	0.700	0.879	1.093	1.372	1.812	2.228	2.764	3.169	4.144	4.587
11	0.000	0.697	0.876	1.088	1.363	1.796	2.201	2.718	3.106	4.025	4.437
12	0.000	0.695	0.873	1.083	1.356	1.782	2.179	2.681	3.055	3.930	4.318
13	0.000	0.694	0.870	1.079	1.350	1.771	2.160	2.650	3.012	3.852	4.221
14	0.000	0.692	0.868	1.076	1.345	1.761	2.145	2.624	2.977	3.787	4.140
15	0.000	0.691	0.866	1.074	1.341	1.753	2.131	2.602	2.947	3.733	4.073
16	0.000	0.690	0.865	1.071	1.337	1.746	2.120	2.583	2.921	3.686	4.015
17	0.000	0.689	0.863	1.069	1.333	1.740	2.110	2.567	2.898	3.646	3.965
18	0.000	0.688	0.862	1.067	1.330	1.734	2.101	2.552	2.878	3.610	3.922
19	0.000	0.688	0.861	1.066	1.328	1.729	2.093	2.539	2.861	3.579	3.883
20	0.000	0.687	0.860	1.064	1.325	1.725	2.086	2.528	2.845	3.552	3.850
21	0.000	0.686	0.859	1.063	1.323	1.721	2.080	2.518	2.831	3.527	3.819
22	0.000	0.686	0.858	1.061	1.321	1.717	2.074	2.508	2.819	3.505	3.792
23	0.000	0.685	0.858	1.060	1.319	1.714	2.069	2.500	2.807	3.485	3.768
24	0.000	0.685	0.857	1.059	1.318	1.711	2.064	2.492	2.797	3.467	3.745
25	0.000	0.684	0.856	1.058	1.316	1.708	2.060	2.485	2.787	3.450	3.725
26	0.000	0.684	0.856	1.058	1.315	1.706	2.056	2.479	2.779	3.435	3.707
27	0.000	0.684	0.855	1.057	1.314	1.703	2.052	2.473	2.771	3.421	3.690
28	0.000	0.683	0.855	1.056	1.313	1.701	2.048	2.467	2.763	3.408	3.674
29	0.000	0.683	0.854	1.055	1.311	1.699	2.045	2.462	2.756	3.396	3.659
30	0.000	0.683	0.854	1.055	1.310	1.697	2.042	2.457	2.750	3.385	3.646
40	0.000	0.681	0.851	1.050	1.303	1.684	2.021	2.423	2.704	3.307	3.551
60	0.000	0.679	0.848	1.045	1.296	1.671	2.000	2.390	2.660	3.232	3.460
80	0.000	0.678	0.846	1.043	1.292	1.664	1.990	2.374	2.639	3.195	3.416
100	0.000	0.677	0.845	1.042	1.290	1.660	1.984	2.364	2.626	3.174	3.390
1000	0.000	0.675	0.842	1.037	1.282	1.646	1.962	2.330	2.581	3.098	3.300
z	0.000	0.674	0.842	1.036	1.282	1.645	1.960	2.326	2.576	3.090	3.291
	0%	50%	60%	70%	80%	90%	95%	98%	99%	99.8%	99.9%
	Confidence Level										

Figure3.T-Test Help Table

From the analysis using SPSS, it was obtained that and from the following table with a significance level of 0.05, it was obtained at 2.131, because it was rejected, which means there is a difference in the physics learning outcomes of Mattayom 5/1 class students in the pre-test and post-test results. This shows that the use of Phet Simulation can improve students' thinking skills and student learning outcomes.$t_{hitung} - 13{,}680 t_{tabel} | t_{hitung} | > t_{tabel} H_0$This is in line with previous research conducted by Hakim (2023) that the use of PhET Simulation media can improve student learning outcomes.

Based on the results of the student questionnaire, all students enjoyed learning physics using the PhET Simulation. This was due to several factors, including its interactive nature, flexibility, and ability to be used outside of school, as well as its engaging UI (User Interface) and UX (User Experience). Furthermore, students felt that the teacher's active involvement made classroom learning more engaging and meaningful.

Conclusion

Based on the results of the research that has been conducted, it can be concluded that the use of PhET Simulation media in physics learning on parabolic motion material at Thammasat Wittaya Dharmasathan School is effective in improving critical thinking skills and student learning outcomes. This is evidenced by an increase in learning outcome scores from 0% of students completed to 56.25%, as well as an N-Gain value of 0.52 which is classified as a moderate category. Statistical tests also showed a significant difference between the pre-test and post-test results.

Suggestion

1. For teachers and educators, it is recommended to integrate PhET simulations into lessonsphysicsas an additional tool to teach abstract concepts such as parabolic motion.
2. For schools, it is hoped that they can provide digital-based learning facilities to support the use of interactive learning media.
3. For further researchers, they can develop PhET-based learning media on other materials or expand the research sample to obtain more generalized results.

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