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The Effectiveness of PBL-Based Multimedia Articulate Storyline and Phet Simulation on Student Learning Outcomes

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ABSTRACT

This study examines the effectiveness of PBL-based multimedia using Articulate Storyline compared to PhET simulation in improving student learning outcomes on the topic of Regular Changing Straight Motion (GLBB). A quasi-experimental design with a pretest-posttest non-equivalent control group was applied to two intact classes: the experimental group used PBL-based Articulate Storyline, while the control group used PhET simulation. The research instrument was a validated multiple-choice test consisting of 10 items, with content validity reaching 86%. Data analysis included normality and homogeneity tests, paired sample t-tests, independent sample t-tests, and N-Gain analysis. Results showed that the experimental class achieved a higher posttest mean score (77.09) compared to the control class (59.57), with N-Gain values of 0.60 (medium) and 0.33 (low), respectively. Effect size analysis also indicated a very large impact of PBL-based Articulate Storyline. These findings suggest that combining multimedia with structured pedagogical approaches, such as PBL, provides more effective learning experiences than exploratory simulations. The novelty of this research lies in directly comparing two popular interactive media within the same experimental framework, offering empirical evidence that PBL-integrated multimedia leads to greater improvements in conceptual understanding of physics.

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1. INTRODUCTION

Learning physics is considered difficult because of its abstract concept and lack of innovation in learning so that it affects students' abilities (Ahmad et al., 2021; Astuti et al., 2019; Fatmi et al., 2021). Teaching physics in the classroom often has to struggle to convey abstract ideas to students. Some topics in physics, such as Regular Changing Straight Motion (GLBB), cannot be understood through mere mastery of theory. The basic concepts are indeed explained with mathematical equations regarding the relationship between speed, acceleration, and time. However, due to its abstract nature,

an understanding that only relies on theory often makes it difficult for students to relate the concept to the real phenomena around it. Thus, it takes more than just memorizing formulas or textual explanations.

In addition to mastery of theory, understanding GLBB also requires the ability to conceptually visualize the process of motion (Arni et al., 2024; Mlotshwa et al., 2020). Students need to imagine how an object moves when its acceleration is constant, how speed changes over time, and how those relationships are depicted in a graph. Through visualization skills, abstract theories can be linked to concrete events, such as cars accelerating faster or falling balls being influenced by gravity. The integration between theory and imagination is what makes GLBB learning more meaningful and easy for students to understand. Therefore, it takes effort in making physics relevant to students' experiences and actively engaging them. One of the most effective and reliable ways is multimedia.

The use of multimedia in teaching and learning in schools can bring significant benefits. Multimedia-based learning presents engaging material through the display of image visualization, animation, audio, video, and accommodates student responses (Ali, 2019; Efendi & Distira, 2024). Unlike conventional media, students can learn through exploration, provide stimulation and receive feedback processes in real-time. The goals of both aspects related to motivating learners and students' cognitive engagement also occur.

One of the software that supports multimedia development is Articulate Storyline 3. This tool is aimed at enabling educators or education developers to create content that engages teaching materials in digital form that is non-linear, flexible, and responsive. Articulate Storyline 3 has interesting features and can be combined with audio, video, animation, and so on. Media developed with these features can be adapted to students' thinking processes and to complex scenarios in learning (Efendi & Distira, 2024; Small, 2017).

PhET Interactive Simulations is one of the interactive media that is commonly used in physics learning besides Articulate Storyline. The simulation is web-based and developed by the University of Colorado Boulder to present science concepts through interactive animation as well as virtual experiments. Students can explore concepts independently and observe the relationships between variables through a visual display that is immediately visible (Jamil, 2017; Lu et al., 2019). The learning context of Regular Changing Straight Motion (GLBB) becomes easier to understand because PhET presents the relationship between acceleration, speed, and time using graphs and representative animations. The popularity of the PhET is supported by its easy access as well as its ability to visually and interactively represent physics experiments.

Problem-Based Learning (PBL) provides a strong reason for its use in the development of learning media. The PBL approach is concerned with using intelligence from within individuals in a group of people or environments to solve meaningful problems(Saad & and Zainudin, 2024; Yamamoto et al., 2018). This approach is effective in developing higher-level thinking skills such as critical thinking, problem-solving, and self-reflection.

The novelty of this research lies in the integration of Articulate Storyline with the Problem-Based Learning (PBL) approach in physics learning, especially in the material of Regular Changing Straight Motion (GLBB). Previous studies have focused more on the development of *Articulate Storyline* as an interactive medium or assessing the effectiveness of *PhET Simulation* alone in improving the understanding of physics concepts. However, this study not only assesses the effectiveness of the media, but also directly tests the comparison of learning outcomes between classes using *PBL-based* Articulate Storyline and classes using *PhET Simulation*. This approach puts research in a unique position because it combines interactive digital media with problem-based learning strategies that demand deeper cognitive engagement.

In contrast to previous studies, this study emphasizes a combination of technological and pedagogical aspects that are rarely explored simultaneously. *Articulate Storyline* in previous research tends to be used as a medium for presenting content or evaluation, while *PhET* is used to encourage students' self-exploration (Tarigan, 2024). This study distinguishes itself by assessing the effectiveness *of Articulate Storyline* which is designed following the steps of PBL so that students are not only

exploring, but also trained to solve real problems systematically. With a direct comparison of *PhET Simulation*, this study makes a new contribution in explaining the extent to which the effectiveness of multimedia-based PBL approaches is able to surpass exploratory simulations that are more commonly used in physics learning.

The novelty of this research lies in the effort to compare two popular interactive media, namely Articulate Storyline based on Problem-Based Learning (PBL) and PhET Simulation, in the context of Regular Changing Straight Motion (GLBB) material. Previous studies have generally only focused on the development and feasibility of one media separately, for example the effectiveness *of Articulate Storyline* in improving learning outcomes or the practicality of using *PhET* in visualizing physics concepts. However, this study placed the two in an equivalent experimental design to see the difference in their impact on improving student learning outcomes. This comparison is important because GLBB includes abstract material that requires theoretical understanding as well as visualization skills, so the two media have different potentials to support learning.

The fundamental difference with previous studies is in the integrative approach used. *Articulate Storyline* in this study is not just used as a presentation medium, but is designed with a PBL flow so that students are directed to solve real problems systematically. Meanwhile, *PhET Simulation* is used as a control medium that emphasizes more on self-exploration and visual representation. Thus, the novelty of this research is to test the effectiveness of two technology-based approaches that are both popular but have different pedagogical strategies, in the context of GLBB topics that have not been widely studied in the literature (Rahman, 2019). This makes a new contribution to answering the question of whether the integration of PBL with interactive multimedia is superior to exploratory simulations in improving students' physics learning outcomes.

Based on the explanation above, this study focuses on comparing the effectiveness of two interactive learning media, namely Articulate Storyline based on Problem-Based Learning and PhET simulation, on student learning outcomes on the topic of Regular Changing Straight Motion (GLBB). Media Articulate Storyline was developed using the PBL approach by following the steps of the ADDIE model, although this article only discusses the development stage. This research is expected to contribute to the development of physics learning innovations that are more interesting, meaningful, and in accordance with the needs of students in the classroom.

2. METHOD

This study employed a quantitative approach with a quasi-experimental design, specifically the pretest-posttest non-equivalent control group design. The research involved two intact classes: one experimental class that was taught using interactive learning media based on Problem-Based Learning (PBL) with Articulate Storyline, and one control class that was taught using PhET simulation. Both classes were selected to have relatively similar initial abilities, as indicated by their previous physics exam scores. The average prior score of the experimental class was 68.50 (SD = 7.20), while the control class was 67.80 (SD = 6.95). An independent samples t-test confirmed that there was no significant difference between the two groups ($p > 0.05$), indicating equivalence before the treatment.

The research instrument was a multiple-choice test originally consisting of 20 items, which had undergone a validation process. After expert review and item analysis, 10 items were selected for the final test because they met the validity and reliability criteria. The validation process involved two physics content experts and one educational evaluation expert who assessed the items based on content relevance, clarity of language, and alignment with the learning objectives. The average validation score was 86%, which falls into the "very valid" category. Items that did not meet the criteria were revised or removed to ensure that the instrument accurately measured students' understanding of the Regular Changing Straight Motion (GLBB) topic.

Data analysis was carried out through several statistical procedures using SPSS version 20. First, normality was tested using the Kolmogorov-Smirnov test, and homogeneity of variance was tested with Levene's Test. To measure the improvement in each group, a paired sample t-test was conducted, while an independent samples t-test was used to compare posttest results between the experimental

and control groups. Additionally, N-Gain analysis was performed to determine the effectiveness of the treatments in improving learning outcomes, with categorization into low, medium, or high effectiveness levels based on Hake's criteria.

3. FINDINGS AND DISCUSSION

The learning media used in this study consisted of Articulate Storyline 3 based on Problem-Based Learning (PBL) in the experimental class and PhET simulation in the control class. Articulate Storyline 3 is designed with an interactive and responsive interface, combining multimedia elements such as animation, audio, video, and interactive quizzes that support both self-paced and directed learning. The simple navigation design makes it easy for students to move between materials, while the learning flow follows PBL steps so that students are systematically directed in solving problems. Research shows that Articulate Storyline 3 is highly feasible to use as an interactive learning medium with a high feasibility score and significant effectiveness in improving learning outcomes (PDF). Similar results were also reported by researchers from Gorontalo State University in 2025, which obtained a validation percentage of media and material experts of 97% (the "very feasible" category).

The initial stage of the study begins with the determination of experimental classes and control classes that have relatively equivalent initial abilities based on previous exam scores. The research instrument in the form of ten multiple-choice questions was compiled and validated by material experts and evaluation experts to ensure the suitability of the content with the learning objectives. Both classes were given a pretest to measure initial competency in the Regular Changing Straight Motion (GLBB) material. After that, the experimental class followed learning using Articulate Storyline media based on Problem-Based Learning (PBL), while the control class received learning through PhET simulations. Posttest is given after learning is completed to measure the improvement of student learning outcomes, as well as the procedure also applied by the research (Mahayukti, 2018; Pertiwi et al., 2025) which uses a pretest-posttest non-equivalent control group design in evaluating the effectiveness of technology-based learning media.

The pretest and posttest results were analyzed using the Kolmogorov-Smirnov and Shapiro-Wilk normality tests to ensure normal data distribution, as well as the Levene's Test homogeneity test to check the similarity of variance between groups. The paired sample t-test was used to compare learning outcomes before and after treatment in each group, while the independent sample t-test was used to assess the difference in learning outcomes between the experimental and control classes. The effectiveness of improving learning outcomes was measured using N-Gain, which was then categorized based on the Hake criteria. This analysis procedure is in line with the findings (O'Hare & McGuinness, 2015) which emphasizes the importance of statistical prerequisite tests before conducting parametric tests to maintain the validity of research results.

The learning media used in this study consisted of Articulate Storyline 3 based on Problem-Based Learning (PBL) in the experimental class and PhET simulation in the control class. Articulate Storyline 3 is designed with an interactive and responsive interface, combining multimedia elements such as animation, audio, video, and interactive quizzes that support both self-paced and directed learning. The simple navigation design makes it easy for students to move between materials, while the learning flow follows PBL steps so that students are systematically directed in solving problems. Research (Agbo et al., 2023; Mahayukti, 2018) shows that Articulate Storyline 3 is very feasible to use as an interactive learning medium with a high feasibility score and significant effectiveness in improving learning outcomes. Similar results were also reported by(Farimani & Shahri, 2020), which obtained a percentage of validation of media and material experts of 97% (category "very feasible").

PhET simulations were used in the control class with the aim of providing a visual and interactive experience of exploring GLBB concepts. The PhET provides a representation of physical phenomena that can be manipulated directly by students, such as changing the value of acceleration or velocity, so that the relationships between variables can be observed in real time. This media is effective in facilitating discovery-based learning, especially on abstract concepts. Study (Apendi et al., 2024; Yusuf & Sodik, 2023) demonstrated that the use of PhET in the learning of continuity principles significantly

increased the average score of the posttest and achieved a high category N-Gain. Another study also revealed that PhET simulations on temperature and heat materials produced an N-Gain of 0.669 (medium category), demonstrating its contribution to improving student learning outcomes (Pertiwi et al., 2025).

The experiment compared the effectiveness of Articulate Storyline integrated with Problem-Based Learning (PBL) and PhET Simulation on student learning outcomes in the topic of Regular Changing Straight Motion (GLBB). Both classes had equivalent initial abilities, as confirmed by the results of normality and homogeneity tests (Table 1).

Table 1. Results of Normality and Homogenity Tests

Test	Sig. Value	Criteria	Result
Kolmogorov-Smirnov (Pretest & Posttest, both groups)	0.498 – 0.597	> 0.05	Normal distribution
Kolmogorov-Smirnov (Pretest & Posttest, both groups)	0.498 – 0.597	> 0.05	Normal distribution

The pretest–posttest analysis showed that both groups experienced significant improvement, but the experimental class achieved higher results. The average score of the experimental class increased from 42.22 to 77.09 (N-Gain = 0.60, medium category), while the control class improved from 39.57 to 59.57 (N-Gain = 0.33, low category). Effect size analysis confirmed that the intervention had a strong impact, with Cohen's d = 4.975 (very large) in the experimental class and d = 3.521 (large) in the control class. The independent samples t-test also showed a significant difference between posttest means ($t = 10.032$, $p < 0.001$).

Table 2. Comparison of Learning Outcomes

Class	Pretest Mean	Posttest Mean	N-Gain	Category	Effect Size
Experimental (PBL–Articulate)	42.22	77.09	0.60	Medium	d = 4.975 (very large)
Control (PhET Simulation)	39.57	59.57	0.33	Low	d = 3.521 (large)

The findings indicate that PBL-based Articulate Storyline is more effective than PhET simulation in enhancing students' understanding of GLBB. The integration of problem-solving steps within multimedia learning encouraged deeper cognitive engagement and better conceptual visualization, which are crucial for abstract topics such as acceleration and velocity. While PhET simulations provided exploratory learning experiences, they did not systematically guide students in solving contextual problems.

These results are consistent with previous studies showing the effectiveness of multimedia in physics learning (Suarsana et al., 2019), but the novelty of this study lies in comparing two widely used interactive media within the same experimental framework. The higher N-Gain and stronger effect size in the experimental class demonstrate that combining multimedia with structured pedagogical strategies such as PBL is more effective than relying on exploratory simulations alone. This implies that technology integration in physics learning should not only focus on the media itself but also on how it is pedagogically designed to promote meaningful problem-solving and knowledge construction.

Figure 1. Multimedia Articulate Storyline

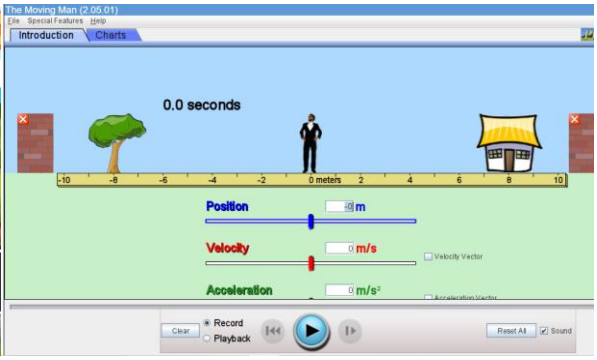

Figure 2. Media Phet Simulation

The normality test was carried out using SPSS 20 to determine whether the pretest and posttest data from the experimental class and the control class were normally distributed. The data is said to be normally distributed if the significance value on the *test of normality* exceeds 0.05. The methods used in this test are Kolmogorov-Smirnov and Shapiro-Wilk. The results of the normality test are presented as follows.

Pretest and posttest data in both groups were analyzed to determine the feasibility of parametric tests. The normality test using Kolmogorov-Smirnov and Shapiro-Wilk produced a significance value of more than 0.05 in the entire group, namely experimental pretest (0.590), control pretest (0.597), experimental posttest (0.577), and control posttest (0.498). The distribution of data meets the requirements of normality. Research By (Suharna et al., 2020) It also states that normality tests on pretest and posttest data are acceptable when the significance value exceeds 0.05, which supports the use of parametric tests in advanced analysis.

Table 3. Normality Test Results Pretest Posttest Experiment and Control Class

		Kolmogorov–Smirnov			**Shapiro–Wilk**		
Pretest Value	1 = experiment, 2 = control	Statistic	df	Itself.	Statistic	df	Itself.
	Eksperimen	0.116	23	0.200*	0.966	23	0.590
	Control	0.131	23	0.200*	0.966	23	0.597
Postest Grades	Eksperimen	0.096	23	0.200*	0.965	23	0.577
	Control	0.111	23	0.200*	0.962	23	0.498

*. This a lower bound of the true significance

a. Lilliefors Significance Correction

The variance homogeneity test was carried out using Levene's Test, resulting in a value of F = 0.393 and a significance of 0.534 (> 0.05), which showed that the variance between groups was homogeneous. Research by (Megawati & Trisnawati, 2022) The effects of using structured learning modules in chemistry learning also reported that pretest and posttest data were tested with Levene's Test, and met the homogeneity of variance before proceeding to further testing.

Table 4. Result of Homogenity Test

Levene's Test for Equality of Variances		t-test for Equality of Means									
						Significance		Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
		F	**Sig.**	**t**	df	One-Sided p	Two-Sided p			Lower	Upper
Pretest Score	Equal variances assumed	0.001	0.971	0.751	44	0,228	0.457	2.652	3.531	-4.465	9.769
	Equal variances not assumed			0.751	43.933	0,228	0.457	2.652	3.531	-4.465	9.769
Posttest Score	Equal variances assumed	0.389	0.534	10.032	44	< 0.001	< 0.001	17.552	1.747	14.021	21.084
	Equal variances not assumed			10.032	42.894	< 0.001	< 0.001	17.552	1.747	13.989	21.044

Paired sample t-test pada kelas eksperimen menghasilkan rata-rata pretest 42,22 meningkat to 77.09 posttest, t = –23.861, sig. < 0.001, the effect was very large (Cohen's d = 4.975). This procedure is in line with the research on the development of PBL-based Articulate Storyline media using a paired t-test and concluding the effectiveness of the media in improving learning outcomes (tcal > ttable and N-Gain 0.61). The paired sample t-test in the control class yielded an average from 39.57 to 59.57, t = –16.884, sig. < 0.001, large effect (Cohen's d = 3.521). These results are consistent with research by (Mellon et al., 2017) who applied media-based PBL before and after treatment, with a significant improvement based on paired t-tests after meeting normality and homogeneity.

Table 5. Comparison of Experimental and Control Classroom Learning Scores Before and After

		Mean	**N**	**Std. Deviation**	**Std. Error Mean**
Pair 1	Pre_Eks	42.22	23	12.049	2.512
	Post_Eks	77.09	23	5.426	1.131
Pair 2	Pre_Kontrol	39.57	23	11.900	2.481
	Post_Kontrol	59.57	23	6.381	1.330

Independent samples t-test showed a difference in posttest values between the experimental class (mean = 77.09) and the control class (mean = 59.57). The value of t = 10.032 with a significance of p < 0.001. The average difference is 17,522 points. The size effect (Cohen's d = 2.958) showed a large effect. Quasi-experimental study by (Maharani et al., 2021) which tested the effectiveness of Problem Based Learning (PBL) assisted by Articulate Storyline media on students' critical thinking skills also stated the results of the posttest comparison between the experimental and control groups were significant at the level of p < 0.001 (the N-Gain value of the experimental class was higher).

The effectiveness of the media can also be seen from the acquisition of the N-Gain value. The experimental class obtained an N-Gain value of 0.60 in the medium category, while the control class obtained 0.33 in the low category. These results are consistent with research (Distira et al., 2025), who reported the effectiveness of multimedia-based learning with an increase in posttest from 40.83 to 84.50, and high N-Gain.

Table 6. Comparison of Experimental Classes and Control Classes

				Significance	
N			Correlation	One-Sided p	Two-Sided p
Pair 1	Pre_Exp & Post_Exp	23	0.960	< 0.001	< 0.001
Pair 2	Pre_Control & Post_Control	23	0.988	< 0.001	< 0.001

A significant increase in the experimental class showed that the use of Articulate Storyline media based on Problem Based Learning (PBL) had a positive impact on student understanding. The characteristics of PBL that emphasize real problem solving combined with multimedia displays are proven to strengthen students' information absorption. Media interactivity allows students to experience conceptual simulations visually and responsively, thus encouraging deeper cognitive engagement.

The effectiveness of the media is also reflected in the very large effect size value of the paired t-test results (Cohen's d > 2.0). This effect showed a strong influence of treatment on changes in learning outcomes. This value illustrates that the improvement in learning outcomes is not just a coincidence or a natural outcome, but a real result of a systematically designed learning intervention.

Comparison with the control class showed that although the PhET simulation was able to improve learning outcomes, its effectiveness was not as strong as the PBL-based Articulate Storyline. This shows that not only the media used is important, but also how it is integrated with the right learning strategy. PhET simulations are exploratory, but they do not fully lead students to find solutions to a problem systematically. The results of higher N-Gain values in the experimental class reinforce the evidence that learning with a multimedia-based PBL approach is able to facilitate meaningful knowledge improvement. This increase is in line with the characteristics of constructivistic learning, in which students build their own knowledge through active, contextual, and reflective activities.

The effectiveness of the use of Problem Based Learning (PBL)-based Articulate Storyline multimedia has important implications for classroom learning practices. The integration of media with problem-solving approaches provides a strategic alternative in improving student learning outcomes, especially in conceptual and applicative materials. The role of teachers is not only as a facilitator but also as a learning designer is becoming increasingly crucial, because the preparation of content and problem triggers must be adjusted to the needs and characteristics of students. This media also encourages digital transformation in learning, which is in line with the demands of the Independent Curriculum and the direction of technology-based education policies. Articulate Storyline-based learning not only strengthens the cognitive aspect, but also trains students' critical thinking, problem-solving, and independent learning skills. Thus, the results of this study contribute to strengthening technology-based and competency-oriented learning practices in the 21st century.

Discussion

The results of this study show that the use of PBL-based Articulate Storyline significantly improved student learning outcomes compared to PhET simulations. The experimental class reached a higher posttest average and a medium category N-Gain, while the control class achieved only a low category. This indicates that multimedia, when integrated with structured pedagogical strategies, provides stronger support for conceptual understanding than exploratory simulations alone (Basilaia & Kvavadze, 2020; Efendi & Distira, 2024; Fung, 2017; Pujawan, 2018).

The effectiveness of Articulate Storyline is largely due to its ability to combine interactive features such as animation, audio, and quizzes with the systematic stages of PBL. Students were not only exposed to visualizations but also guided to analyze problems, generate solutions, and reflect on their learning. This process encouraged deeper engagement with the content and supported the development of higher-order thinking skills, in line with the principles of constructivist learning (Ahmad et al., 2021; Bilbao et al., 2016; Durak & Saritepeci, 2017).

On the other hand, PhET simulations offered valuable opportunities for exploration and discovery. Students could manipulate variables such as acceleration and velocity to observe real-time changes. However, because the learning process relied heavily on independent exploration, some students may not have been able to construct knowledge systematically. This explains why the control group, although showing improvement, did not reach the same level of effectiveness as the experimental group (Rose et al., 2017; Suryanti & Masduki, 2024; Wang et al., 2023; Zhang, 2023).

The findings align with previous studies reporting the positive impact of multimedia in physics education. For instance, (Yusuf & Sodik, 2023) found that PhET improved conceptual understanding in continuity principles, highlighted the feasibility of Articulate Storyline in interactive learning design (Jou et al., 2021; Lu et al., 2019; Mehrvarz et al., 2023; Qohar et al., 2021). However, the novelty of this research lies in directly comparing two widely used interactive media within the same experimental framework, providing evidence of how PBL-based multimedia outperforms exploratory simulations in the context of GLBB.

The effect size analysis strengthens this conclusion. The very large Cohen's d value in the experimental class demonstrates that the observed improvement was not coincidental but the result of a systematic instructional intervention. This suggests that the integration of multimedia and PBL can be considered a powerful alternative for teaching abstract concepts, particularly in physics, where visualization and problem-solving are both crucial.

These findings have important pedagogical implications. Teachers should not only adopt digital tools but also carefully integrate them with suitable instructional models. Multimedia such as Articulate Storyline becomes more effective when embedded in structured strategies like PBL, which direct students to actively construct knowledge. This also supports the current educational paradigm that emphasizes digital transformation, problem-solving, and critical thinking as part of 21st-century competencies (Imaniyati et al., 2024).

Despite these promising results, the study has several limitations. The sample involved only two classes, limiting the generalizability of the findings. The focus was restricted to a single topic (GLBB), which may not represent the full range of physics concepts. In addition, the assessment instrument consisted of only 10 multiple-choice questions, which may not fully capture students' higher-order thinking skills such as reasoning, analysis, and problem-solving.

Future research should expand the scope by involving larger and more diverse samples across multiple schools, applying the intervention to various physics topics, and employing more comprehensive instruments that include open-ended or performance-based tasks. Longitudinal studies are also recommended to evaluate the sustained impact of PBL-based multimedia on motivation, retention, and problem-solving abilities. Such efforts will not only strengthen the empirical evidence but also guide best practices in integrating technology with pedagogy for effective physics education.

4. CONCLUSION

The results showed that the use of Articulate Storyline 3 learning media based on Problem-Based Learning (PBL) was significantly more effective in improving student learning outcomes in Regular Changing Straight Motion (GLBB) material compared to the use of PhET simulations. Statistical analysis showed that the average posttest score of the experimental class was higher than that of the control class, with a significant difference in the 95% confidence level. The N-Gain value in the experimental class was in the medium category, while the control class was in the low category. This effectiveness is reinforced by the characteristics of Articulate Storyline 3 which combines interactive displays, rich multimedia, and systematic learning flows according to PBL steps, thus facilitating students to think critically and solve problems in a structured manner. These results confirm that the success of learning is not only influenced by the availability of media, but also by the suitability of media integration with the learning strategies used. Articulate Storyline 3 provides a directional and structured learning experience, while the PhET excels in exploratory learning that gives students the freedom to explore concepts. Thus, teachers are advised to choose and integrate learning media according to the objectives, characteristics of the material, and the needs of students. The implications of this study also support the implementation of technology-based learning that is in line with the Independent Curriculum, in order to improve 21st century competencies such as critical thinking, creativity, collaboration, and communication.

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