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Comparing Simulation-Based and Traditional Teaching Approaches in Improving Students' Learning Outcomes and Attitudes toward Newton's Laws

Seuth BORLIBOUNE, Souliya KEOVILAYLACK, Sone XAIYALATH, Thonglith VILAISANE, Sompong SIBOUALIPHA*

Bankeun Teachers Training College, Laos.

Abstract

This study investigates the impact of simulation-based learning on students' comprehension and engagement with Newton's Laws of Motion, a foundational concept in physics education. Employing a quasi-experimental design, the research compared two distinct instructional methods: traditional lecture-based teaching and interactive physics simulations. The findings revealed a significant difference in post-test performance between the two groups, with students in the simulation-based group achieving an average score of 80.82, compared to 74.21 in the control group ($p < 0.05$). This disparity underscores the effectiveness of simulation-based learning in fostering a deeper understanding of Newtonian mechanics. Beyond academic performance, the study also examined student engagement, revealing that the experimental group demonstrated markedly higher levels of interest and motivation, as reflected in their average attitude score of 4.15, compared to 3.25 in the control group ($p < 0.05$). Qualitative feedback from students in the simulation-based group further highlighted their enthusiasm for the interactive approach, with many noting that real-time visualizations and the ability to manipulate variables in a virtual environment significantly enhanced their grasp of complex concepts. Despite these promising results, the study identified several challenges that could hinder the broader adoption of simulation-based learning. Technological limitations, such as inadequate access to simulation tools or unreliable software, emerged as a significant barrier. Additionally, the need for comprehensive teacher training to effectively integrate simulations into the curriculum was emphasized, as educators must be equipped to guide students in leveraging these tools optimally. Another concern was the potential overreliance on virtual experiments, which might limit students' opportunities to develop hands-on experimental skills that are crucial for practical scientific inquiry. To address these challenges, the study proposes a hybrid instructional model that combines the strengths of traditional teaching methods with the dynamic, interactive elements of simulation-based learning. This approach aims to create a balanced educational experience that maximizes student understanding and engagement while mitigating the limitations of each method. Looking ahead, the study calls for further research to explore scalable implementation strategies for simulation-based learning, ensuring that it can be equitably and efficiently integrated into diverse educational settings. Future studies should also investigate the long-term impact of this approach on students' retention of knowledge and their ability to apply physics concepts in real-world scenarios. By addressing these challenges and refining instructional models, educators can harness the potential of simulation-based learning to transform physics education, making it more accessible, engaging, and effective for students worldwide.

Keywords: *Simulation-based learning, Newton's Laws, student engagement, conceptual understanding, physics education*

***Correspondence:** *Seuth BORLIBOUNE; Tel: 020 29596930; Email: borlibounes@yahoo.com*

1. Introduction

1.1 Background of the study

The fundamental concepts of Newton's Laws of Motion, which form the foundation of classical mechanics and explain the relationship between a body and the forces acting on it, have always been a core part of high school science curricula. Traditionally, these laws have been taught using lecture-based methods, in which the teacher explains the concepts through examples and students take notes, solve problems from textbooks, and occasionally. However, students frequently struggle to establish a solid comprehension of these ideas due to their abstract character. Teaching Newton's Laws of Motion remains difficult in physics education, since students frequently struggle with abstract concepts and misconceptions that limit their understanding (Serhane et al., 2023). Despite numerous educational methods, recent research has discovered several persisting issues. Traditional teaching approaches, such as lectures and textbook-based training, are commonly employed, yet they frequently fail to address students' misconceptions effectively. One of the most prevalent learning challenges is a misunderstanding of Newton's First Law. Numerous learners assume that an object in motion must have a constant force acting on it, failing to comprehend the notion of inertia (Lark, 2007). Similarly, Newton's Second Law is frequently misunderstood, with pupils unable to distinguish between mass and weight or understand the direct relationship between force, mass, and acceleration (Putri et al., 2021). The third law of Newton, which asserts that every action has an equal and opposite reaction, poses still another fundamental problem. According to research, students commonly struggle to detect action-reaction force pairs, particularly in real-world scenarios such as walking, jumping, and object collisions (Serhane et al., 2023). This issue stems from pre-existing beliefs that forces only act when there is apparent movement. Traditional training frequently emphasizes solving mathematical issues rather than conceptual understanding. As a result, students often memorize Newton's Law formulations without fully understanding its fundamental concepts (Bui et al., 2023). This issue stems from pre-existing beliefs that forces only act when there is apparent movement. Traditional training frequently emphasizes solving mathematical issues rather than conceptual understanding. As a result, students often memorize Newton's Law formulations without fully understanding its fundamental concepts (Bui et al., 2023).

Interactive simulations and real-world tests have been proposed as strategies for increasing motivation and learning results. Long-term recall of Newton's Laws is another concern, since students may struggle to apply these ideas in real-world scenarios or sophisticated physics problems (Putri et al., 2021). Lacking ongoing reinforcement through active learning procedures, conceptual knowledge may disappear over time. However, as technology advances in education, creative methods such as simulation-based learning are growing popularity, particularly in physics instruction. Simulation-based teaching combines digital technologies with interactive learning environments to create a more engaging and dynamic experience (Putri et al., 2021). In order to ascertain how well these two strategies improve students' learning results and attitudes towards Newton's Laws, this study will compare them. Students can alter variables, observe dynamic systems, and visualise abstract and challenging topics using interactive, computer-generated settings known as physics simulations. Without the limitations of tangible materials or lab apparatus, simulations allow students to witness real-time examples of the interactions between forces, mass, and acceleration in relation to Newton's Laws. This adaptability may provide a deeper comprehension than conventional approaches, particularly in situations that are challenging to imagine, like the frictionless setting needed to investigate Newton's First Law. The application of simulation-based teaching techniques in physics classes has attracted a lot of attention lately, especially in light of their superiority over conventional teaching strategies. Erceg et al. (2023) investigated how university students' comprehension of Newton's laws was affected by various homework formats, including simulation-based, video-based, and standard paper-and-pencil assignments. The results showed that homework based on simulations was more successful in improving conceptual knowledge and cultivating favourable attitudes towards physics assignments. Similarly, Alshaya & Ghazal (2023) carried out a quasi-experimental study in the United Arab Emirates to investigate the effects of computer simulations on the knowledge of Newton's Second Law of Motion among 11th grade students. The findings revealed that students who participated in computer simulations had a better knowledge of the idea than those who obtained traditional face-to-face education. Furthermore, Khalid et al. (2025) conducted an in-depth examination of the utilisation of digital simulators in STEM education over the five prior years. The study found that interactive simulations greatly improved learning results and student engagement in both general and special education settings. Overall, these research demonstrate that simulation-based teaching approaches can be more effective than traditional ways for increasing students' learning results and attitudes towards Newton's laws. However, further study is needed to determine the long-term consequences of these educational tactics and the most effective approaches to incorporate simulations into physics curriculum.

1.2 Objectives of the study

The main objective is to explore the influence of simulation-based teaching on students' learning outcomes and attitudes towards Newton's Laws. Specifically, the study aims to:

- To compare the effectiveness of simulation-based and traditional teaching approaches in improving students' understanding of Newton's Laws.
- To evaluate the impact of both teaching methods on students' attitudes toward learning physics.
- To determine whether simulation-based learning enhances student engagement and motivation compared to traditional instruction.
- To identify common misconceptions about Newton's Laws and assess how effectively each teaching method addresses them

1.3 Questions of the study

Based on the study's objectives, the following research questions are formulated:

- How does simulation-based teaching impact students' learning outcomes and attitudes toward Newton's Laws?
- How does simulation-based learning compare to traditional teaching in enhancing students' understanding of Newton's Laws?
- What effect do simulation-based and traditional teaching methods have on students' attitudes toward learning physics?
- What are the common misconceptions about Newton's Laws, and how effectively does each teaching method address them?

2. Literature Review

2.1 Traditional Teaching Methods in Physics Education

Traditional techniques to teaching physics, particularly Newton's Laws, have relied mainly on lecture-based learning. This teacher-centered method often consists of the instructor teaching the content, providing examples, and having pupils work through textbook problems. While this strategy has been beneficial for many years, research indicates that it may not always fully engage pupils or promote a deep knowledge, particularly with abstract concepts like forces, acceleration, and inertia. For example, Mazur (1997) contends that the typical "chalk-and-talk" strategy fails to promote active learning, resulting in a shallow comprehension of physics fundamentals. In the case of Newtonian mechanics, students frequently memorise formulas ($F = ma$) without fully understanding the fundamental ideas. According to Hake's (1998) study, typical lecture-based education produces relatively poor advances in conceptual understanding of mechanics, as measured by methods such as the Force Concept Inventory. Traditional physics education approaches include lectures, texts, and problem-solving activities. While these approaches emphasise theoretical training, they provide little hands-on exercises, which can prevent students from obtaining a thorough conceptual understanding. These approaches also fail to successfully develop critical thinking skills (Carter et al., 2016). Nurutdinova et al. (2016) discovered that the traditional teaching technique resulted in weaker critical thinking skills when compared to alternative education methods. Some experts, such as Balliu (2017), claim that traditional lectures are still useful in circumstances when written materials, such as textbooks, are absent. Traditional instructional techniques have long been the foundation of classroom instruction, based on a deductive model in which the instructor serves as the primary source of knowledge. The teacher teaches topics, writes content on the board, and expects students to remember and recollect the information. In this technique, students are often expected to follow the teacher's guidance with little autonomy, which hinders their capacity to make decisions or solve problems independently. In this technique, students are frequently required to follow the teacher's guidance with little autonomy, which hinders their capacity to make decision or answer problems autonomously. As a result, students are more concerned with passing exams over fully learning the subject matter (Mehta, 2019). Nonetheless, research indicates that complementing traditional approaches with interactive and experimental activities might improve student understanding and memory of physics concepts. According to research, typical teaching techniques have severe difficulties in correcting conceptual errors in physics.

2.2 Simulation-based in Physics Education

Simulation-based learning in physics education uses interactive digital tools to improve conceptual comprehension and engagement among students. According to research, simulations enable students to visualise abstract concepts, alter variables, and perform virtual experiments in ways that traditional educational settings do not allow (Bui et al., 2023). PhET Engaging Simulations, for example, have been widely utilised to teach Newton's Laws by giving students with real-time feedback and opportunity to test ideas in a safe setting (AlArabi et al., 2022). According to recent studies, pupils who use simulations have higher recall rates and better problem-solving skills than those who are taught using traditional approaches (Serhane et al., 2023). Furthermore, learning through simulations promotes a more inquiry-driven approach, enabling students to actively investigate topics rather than passively absorb knowledge (Putri et al., 2021). Although these benefits, issues such as technical accessibility and teacher preparation remain substantial barriers to wider adoption. Many students concentrate on formula memorisation rather than developing a thorough understanding of Newtonian mechanics (Serhane et al., 2023). Simulation-based instruction, which employs technologies such as PhET simulations, enables students to see and modify physical settings, resulting in increased conceptual comprehension and involvement (Bui et al., 2023). Multiple investigations have found that students who learn using simulations have higher problem-solving skills and long-term memory of physics topics than those who are taught traditional methods (AlArabi et al., 2022). Newton's Laws is especially relevant since students may visualise forces in action, manage mass, see acceleration, and apply theoretical knowledge to interactive settings, resulting in greater comprehension. Furthermore, the PhET simulations built by the University of Colorado, for example, allow students to alter variables like as force and mass in real time to examine the impacts on acceleration, thereby cementing their comprehension of Newton's Second Law.

2.3 Comparing Simulation-based to Traditional Teaching

A number of studies investigated the efficacy of simulation-based learning vs traditional teaching approaches. Zacharia & Olympiou (2011) investigated the effectiveness of physical manipulatives against virtual simulations for teaching physics concepts and discovered that simulations frequently resulted in a greater degree of understanding. Specifically, when teaching Newton's Laws, students who used simulations were better able to visualise the link between force and motion, resulting in higher performance on conceptual evaluations. However, the research also identified certain limits to simulation-based learning, such as a lack of hands-on experience and the possibility of pupils becoming overly reliant on technology. When comparing simulation-based learning to traditional approaches, numerous significant distinctions emerge. Traditional physics training often consists of textbook lectures, readings, and problems-solving assignments to teach Newton's Laws. While this strategy provides an organised learning structure, it may not adequately address students' conceptual issues or actively include them in the learning process. Simulation-based training, on the other hand, provides an immersive learning environment in which students may observe forces, motion, and interactions in real time. According to research, learners who use simulation-based learning have a higher comprehension of concepts because they can alter variables, test hypotheses, and receive instant feedback (Agyei and Agyei, 2021). Traditional approaches, on the other hand, remain critical for reinforcing theoretical knowledge and guiding structured problem-solving efforts. Another significant distinction between the two approaches is student engagement. Traditional instruction is occasionally passive, with students receiving knowledge rather than actively contributing in building their comprehension. Simulation-based learning, on the other hand, produces a more dynamic, inquiry-driven environment, which has been found to increase motivation and generate more positive attitudes towards physics (Serhane et al., 2023). Nonetheless, both teaching techniques have obstacles. Traditional techniques may lack the interaction required to engage all pupils, whereas simulations necessitate access to technological resources and teacher training for successful deployment. Combining the theoretical depth of traditional training with the interactive benefits of simulation-based learning could result in the best learning experience possible.

3. Methodology

3.1 Research Design

The study employs a quasi-experimental approach, with a control group (conventional teaching) and an experimental group (simulation-based learning). The quasi-experimental approach is useful because it allows for a comparison of two different teaching approaches while retaining some control over variables such as class size and instruction duration. Both groups will be taught Newton's Laws of Motion over the course of three weeks. The main difference between the two groups is that the control group will be taught using standard lecture-based methods, whereas the experimental group will be taught using interactive simulations.

3.2 Participants

This study includes 10th-grade pupils from two different classes at a secondary school in Vientiane province, Laos, during the first semester of the 2024-2025 school year. The school is located in an urban region and serves a varied student population. Based to the initial assessment, each class has about 34 students, and both groups have similar academic achievement and previous understanding of physics.

3.3 Instruments

Pre-test: pupils will be given a conceptual test on Newton's Laws to determine their basic comprehension. The test will consist of multiple-choice and short-answer questions designed to assess understanding of force, mass, acceleration, and Newton's three laws. Post-test: Following the three-week teaching period, students will take a post-test that is similar to the pre-test in format but includes more difficult application questions to assess greater comprehension and remember. Engagement Survey: Both groups will be given a student engagement survey to assess their level of involvement during lessons. The survey will include Likert-scale items to assess curiosity about the subject, assessed difficulty, and reported enjoyment of the teaching approach. Teacher Interviews: Following the intervention, teachers from both groups will be questioned to provide qualitative feedback on their experiences with traditional approaches versus simulations. These interviews will shed light on the possibility and perceived efficiency of each technique from the teacher's perspective.

3.4 Procedure

The study will last three weeks, with each group obtaining three two-hour lectures per week on Newton’s Theory of Motion.

Control Group: The control group will be instructed Newton’s Laws by standard lecture-based methods, with the teacher employing diagrams, textbook explanations, and problem-solving tasks. Students will also finish homework assignments from their physics texts. Classroom experiments (such as employing spring scales or carts on inclined planes) will be utilised sparingly to demonstrate certain topics, but the majority of instruction will be theoretical and example-based.

The experimental group will learn Newton’s Laws through lectures and interactive simulations. In particular, the PhET simulation-based Forces and Motion will be used. Learners will engage with the simulation to learn about concepts like how altering the force affects acceleration and how varied mass impacts item motion. The instructor will take students through various simulation-based tasks, encouraging them to alter variables and predict outcomes prior to running the simulation. This group will also finish problem sets, but the emphasis will be on applying their skills in simulated scenarios.

The two groups will get instructed by the same teacher to reduce disparities in instructional style. The teacher will use the same broad lesson plans for both groups, focusing on Newton’s First, Second, and Third Laws throughout the course of three weeks.

3.5 Data Collection

- Pre-test and Post-test: Students will complete the pre-test in the first week of the study and the post-test in the final week. The scores from these tests will be compared to measure improvement in conceptual understanding between the two groups.
- Surveys: The student engagement survey will be administered during the last week of the study. Both quantitative (Likert-scale) and qualitative (open-ended) questions will be used to assess students’ perceptions of the teaching method.
- Interviews: Teacher interviews will be conducted in the week following the intervention. Teachers will be asked about their experiences, challenges, and any noticeable differences in student engagement or understanding between the two groups.

3.6 Data Analysis

The data were analyzed using both quantitative and qualitative methods:

- Quantitative Analysis:

1) The pre-test and post-test scores will be analyzed using t-tests to determine whether there is a statistically significant difference in the improvement of the experimental group versus the control group.
2) The engagement survey responses will be analyzed using descriptive statistics (mean scores) and compared between groups using t-tests to assess differences in engagement and perceived enjoyment.

- Qualitative Analysis:

1) Open-ended responses from the student surveys will be coded for recurring themes (e.g., interest, frustration, perceived difficulty).
2) Teacher interview transcripts will be analyzed thematically, with attention to differences in how the two teaching methods impacted the teachers’ instructional experience and student engagement.

4. Results of the study

The results section will present the findings from the achievement tests and attitude surveys, highlighting the differences between the experimental and control groups.

4.1 Results of the pre-test and post-test

The implementation of the experimental teaching method and the traditional teaching method yielded pre-test and post-test results for students’ achievement, as shown in Table 1 below:

Table 1. Pre-test and post-test results of the experimental (N=34) and the control group (N=34)

Group	Pre-test	Post-test
Experimental	29.00	80.82
Control	29.29	74.21

From Table 1, it is evident that the average pre-test scores of the experimental group and the control group were relatively close, with averages of 29.00 and 29.29, respectively. The average post-test score of the experimental group was higher than that of the control group, with scores of 80.82 and 74.21, respectively.

Table 2**.** T-test analysis results for pre and post-test scores of the experimental group (N=34)

Analyze	Mean	SD	df	t	p
Pre-test	29.00	17.60	33	14.721	0.000
Post-test	80.82	9.66			

According to Table 2, the average pre-test score of the experimental group was 29.00 (+/-17.60), and the average post-test score was 80.82 (+/-9.66), this shows a statistically significant difference between the pre- and post-test scores in the experimental group, t (33) = 14.721, $p < 0.05$.

Table 3**.** T-test analysis results for pre and post-test scores of the control group (N=34)

Analyze	Mean	SD	df	t	p
Pre-test	29.29	14.17	33	18.021	0.000
Post-test	74.21	11.10			

According to Table 3, the average pre-test score of the control group was 29.29 (+/-14.17), and the average post-test score was 74.21 (+/-11.10), this indicating a statistically significant difference between pre- and post-test scores, t (33) = 18.021, $p < 0.05$.

Table 4. T-test analysis for pre-test scores between the experimental group (N=34) and control group (N=34)

Group	Mean	SD	df	t	p
Experimental	29.00	17.60	33	0.116	0.909
Control	29.29	14.17			

According to Table 4, the average pre-test score of the experimental group was 29.00 (+/-17.60) and that of the control group was 29.29 (+/-14.17), showing no significant difference between the two groups before the intervention, t (33) = 0.116, $p > 0.05$.

Table 5. T-test analysis for post-test scores between the experimental group (N=34) and control group (N=34).

Group	Mean	SD	df	t	p
Experimental	80.82	9.66	33	2.662	0.012
Control	74.21	11.10			

According to Table 5, the average post-test score of the experimental group was 80.82 (+/-9.66), while the control group's average post-test score was 74.21 (+/-11.10), indicating a statistically significant difference between the two groups after the intervention, t (33) = 2.662, $p < 0.05$.

4.2 Students' attitudes

The implementation of the experimental teaching method and the traditional teaching method yielded post-test results for students' attitudes, as shown in table 4 below:

Table 4. T-test results comparing student attitudes in the experimental group (N=34) and control group (N=34)

Group	Mean	SD	df	t	p
Experimental	4.15	0.17	33	17.854	0.000
Control	3.25	0.30			

According to Table 4, the average attitude score of students in the experimental group was 4.15 (+/-0.17), while the average score for the control group was 3.25 (+/-0.30). This indicates that the experimental group had a significantly higher attitude score than the control group, with a statistically significant difference between the two groups, t (33) = 17.854, $p < 0.05$.

4.3 Students' feedback

Feedback from students in both groups provided valuable insights into their learning experiences. Below are some examples of student feedback:

Simulation-Based Group:

- *"I found it easier to understand Newton's Laws because I could see how the forces acted in real-time."*
- *"Simulation-base made learning fun and interactive. I liked experimenting with different scenarios."*
- *"It helped me visualize concepts that were hard to understand from the textbook."*
- *"Being able to manipulate the variables myself made me feel more involved in my learning."*
- *"I learned more from making mistakes in the* simulation-based *and seeing the effects than just reading about it."*
- *"I feel more confident in solving physics problems after using the* simulation-based*."*

Traditional Teaching Group:

- *"The lectures were helpful, but I sometimes struggled to imagine how the forces work in real life."*
- *"I liked solving problems step by step, but I think seeing the concepts in action would have helped."*
- *"It was harder to stay engaged compared to other interactive activities we have done."*
- *"I understand the formulas well, but I still find it difficult to apply them to real-world."*
- *"Physics felt more like memorization than exploration, which made it a bit challenging."*

5. Discussion

The findings of this study illustrate the benefits of simulation-based learning for students' cognitive grasp and engagement with Newton's Laws of Motion. These findings support previous research indicating that, while traditional lecture-based methods are effective at conveying structured knowledge of theory, they may fall short of addressing students' conceptual difficulties and fostering active engagement (Mazur, 1997; Hake, 1998; Johnson & Brown, 2022). Simulations, on the other hand, provide interactive, inquiry-based learning experiences that aid in deeper comprehension and student involvement (Bui et al., 2023; Serhane et al., 2023).

5.1 Conceptual Understanding and Academic Performance

The quantitative data from the pre-test and post-test scores show a significant improvement in academic achievement for both groups. However, the experimental group, which used simulation-based learning, exhibited a higher increase in post-test scores than the control group (80.82 vs. 74.21, $p < 0.05$). This finding complements previous study (Zacharia & Olympiou, 2011), which shows that students who use interactive simulations have a higher conceptual comprehension of Newtonian mechanics than those who are taught using traditional techniques. The capacity to visualise forces, control variables, and see real-time results most certainly contributed to this improved comprehension. Furthermore, the ability to follow objectives for learning and receive instant feedback in a virtual environment likely strengthened the learning process while reducing misconceptions (Putri et al., 2021). While the control group improved in their post-test scores, their conceptual improvements were significantly lower than those of the experimental group. This shows that traditional physics training frequently promotes rote memorisation over significant conceptual understanding. While traditional approaches are still useful for reinforcing theoretical knowledge and organised problem-solving, their limits in addressing abstract physics topics highlight the need for interactive technologies to improve learning outcomes (Agyei & Agyei, 2021).

5.2 Student Engagement and Attitudes

The outcomes of the student involvement survey and qualitative feedback show that simulation-based instruction improved students' attitudes towards physics. Students in the experimental group indicated higher involvement levels, with an average attitude score of 4.15, compared to 3.25 in the control group ($p < 0.05$). This outcome is consistent with earlier research, which has found that interactive and inquiry-based learning settings increase motivation and develop favourable attitudes towards physics (Serhane et al., 2023). The qualitative feedback highlights these findings. Learners in the simulation-based group deemed the interactive approach most helpful in grasping Newton's Laws. They appreciated the real-time visualisation of forces, having a chance to experiment with various scenarios, and the fact that the concepts were easier to understand than typical textbook study. Hands-on interaction with variables boosted their interest and sense of involvement. Furthermore, learning by using trial and error in simulations increased their confidence in tackling physics challenges. In contrast, students in the traditional instruction group valued lectures and in stages problem-solving, but they struggled to visualise forces in real-world scenarios. They reported feeling less interested than when taking part in interactive activities, and they found it difficult to apply mathematics to real-world circumstances. Some students saw physics as more about memorisation than investigation, making it difficult to gain a deeper knowledge of the principles. The feedback indicates that simulation-based learning increases conceptual knowledge, engagement, and confidence in applying physics principles. Simulations' interactive nature enables learners to explore and experiment with many scenarios, rendering instruction more intuitive and pleasant. Traditional teaching methods, on the other hand, are good at giving organised explanations and problem-solving skills, but they may fall short of meeting students' needs for visualisation and real-world application.

5.3 Challenges and Limitations of Simulation-based

While the study verifies the benefits of simulation-based physics teaching, it also identifies several barriers to its implementation. One major concern is technical accessibility. According to prior research (Pang et al., 2025), not all schools have the necessary infrastructure to facilitate extensive usage of digital technologies. Schools that have limited computer access or inconsistent internet connections may struggle to properly incorporate simulation-based learning into their curriculum. Furthermore, the study reinforces concerns regarding the importance of sufficient teacher training. To successfully integrate simulation-based learning, educators must be adept in using these technologies and incorporating them meaningfully into lesson plans. Without sufficient training, teachers might have trouble effectively support collaborative learning experiences, limiting the benefits of simulation-based learning. Another disadvantage of simulation-based learning is the potential absence of hands-on experimental development of skills. Standard experiments in laboratories allow students to interact with tangible things, conduct measurements, and gain procedural knowledge that simulations cannot mimic (González-Pavón et al., 2023). An appropriate approach that incorporates both simulation-based and traditional hands-on experimentation may result in the most thorough instructional experience.

5.4 Implications for Physics Education

The outcomes of this study imply that a combination of strategies, combining conventional instructional techniques with interactive simulation-based learning, may be the most successful strategy for teaching Newton's Laws. While traditional techniques give a solid theoretical foundation and an organised learning environment, simulation-based learning improves the conceptual comprehension, engagement, and application of physics principles. Future study should focus on determining the best ways to merge these two methodologies while addressing issues such as technological accessibility and teacher training. Furthermore, curriculum authors and educators should consider updating standardised assessment systems to include more participatory, application-based evaluations. Because many physics courses focus on problem solving and theoretical knowledge, evaluation techniques should evolve to better measure students' abilities to apply their knowledge in dynamic, real-world circumstances.

6. Conclusion

This research investigation presents persuasive evidence that simulation-based learning improves students' conceptual knowledge and engagement compared to standard lecture-based training. The findings show that learners in the experimental group who used interactive simulations had higher post-test scores and more positive views towards physics. These findings highlight the importance of technology-based teaching strategies in promoting deeper learning and enhancing student enthusiasm in physics education. Beyond academic achievement, the study emphasises the potential of simulation-based learning to solve common misconceptions in Newtonian mechanics by providing real-time feedback and interactive problem-solving experiences. Despite these benefits, problems persist in terms of technological accessibility, the necessity for considerable training for educators, and the potential absence of hands-on experimental skill development. Without sufficient facilities and teaching assistance, the full benefits of simulation-based learning may not be realised across a variety of educational contexts. To maximise the impact of simulation-based learning, a hybrid strategy combining traditional teaching approaches with interactive simulations is proposed. Such an approach assures that students receive structured theoretical instruction while also participating in exploratory, inquiry-based learning activities.

7. Recommendations

Based on the findings of this study, the following recommendations are proposed:

1) Future studies should include a larger and more diverse sample size to improve the general characteristics of the findings.

2) Longitudinal research should be conducted to examine the long-term effects of simulation-based learning on students' outcomes and attitudes towards Newton's Laws.
3) The integration of simulation-based learning should be expanded to other physics topics to evaluate its overall effectiveness in science education.
4) Schools should provide adequate technological infrastructure, including access to computers and reliable internet connectivity, to maximize the benefits of simulation-based learning.
5) Teachers should receive proper training on the effective implementation of simulation-based learning to enhance student engagement and learning outcomes.
6) Further research should explore the impact of blended learning approaches, combining simulation-based learning with traditional methods, to determine the most effective instructional strategies.

8. Limitations

While the findings of this study are promising, several limitations must be acknowledged:

1) The study was conducted with a relatively small sample size from two schools, which may limit the general characteristic of the results.
2) The duration of the intervention was limited, preventing an analysis of the long-term impact of simulation-based learning on student achievement and attitudes.
3) The study focused only on Newton's Laws; further research is needed to determine whether similar effects occur in other physics topics.
4) Variability in students' prior knowledge and technological proficiency may have influenced the outcomes.
5) External factors such as access to devices, internet connectivity, and teacher expertise in implementing simulation-based learning were not controlled.

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