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Impact of Impulse and Impact Force: An Innovative Approach to Teaching Momentum in Physics

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Abstract: Momentum is a fundamental concept in physics that is pivotal for understanding the motion and behavior of objects. However, its abstract nature often makes it challenging for students to grasp. This study investigates an innovative teaching approach that incorporates impulse and impact force as tools to enhance students' comprehension of momentum. Drawing from the pedagogical philosophy of Prof. Yohannes Surya, who emphasizes practical application and interactive learning, we implemented a set of interactive demonstrations and problem-solving exercises to teach the concepts of impulse and impact force. This study was conducted in the Basic Physics course for the Biology Education Program at Mataram University. The results indicate that emphasizing impulse and impact force improves student understanding, enhances engagement, and bridges the gap between theory and real-world applications in physics education. The findings support the integration of hands-on activities and experiential learning as effective pedagogical strategies in teaching classical mechanics.

Keywords: Impulse, Impact force, Momentum, Physics education, Interactive learning, Experiential learning, Impulse-momentum theorem, Physics teaching, Biology education, Mataram University

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Introduction

The concept of momentum is integral to classical mechanics, representing the quantity of motion an object possesses (Corben, 1994). Defined as the product of mass and velocity, momentum plays a crucial role in understanding phenomena such as collisions and impulse transfer(Bryce, 2009). However, teaching this concept often presents challenges due to its abstract nature, particularly in introductory physics courses (Cahyadi, 2007). Traditional approaches (Khalid, 2012; Pandya,2024)) often rely heavily on theoretical explanations and mathematical derivations, leaving students with little practical understanding of how momentum manifests in real-world scenarios (Morrison, 2015).

In response to these challenges, this study explores the use of impulse (the change in momentum) and impact force as effective tools for teaching momentum. Inspired

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by the educational practices of Prof. Yohannes Surya, who emphasizes hands-on learning (Carmichael,2010; Hong, 2012; Hirça,2013; Schwichow,2016) and real-world applications in physics education (Duch,1997; Wieman,2005; Fang, 2013). This research investigates the impact of an interactive learning approach on student comprehension of momentum. Specifically, we examine how the concepts of impulse and impact force can help bridge the gap between theoretical physics and practical understanding, thereby enhancing student engagement and conceptual clarity(Marshman,2015).

The study was conducted in the Basic Physics course for the Biology Education Program at Mataram University, where students were introduced to momentum through a combination of demonstrations, simulations, and problem-solving exercises. We hypothesized that this approach would foster a deeper understanding of momentum by providing students with practical tools to analyze real-world motion and collision events.

Method

This research employed an experimental design to evaluate the effectiveness of an interactive, hands-on teaching approach for the concept of momentum. The study involved two groups of undergraduate students enrolled in the Basic Physics course for the Biology Education Program at Mataram University. The experimental group participated in a series of interactive demonstrations and problem-solving exercises focusing on impulse and impact force, while the control group followed traditional lecture-based teaching methods.

A total of 60 students participated in the study, with 30 students assigned to the experimental group and 30 students assigned to the control group. Both groups had a similar level of prior knowledge about momentum, as indicated by the comparable pre-test scores (Experimental: 50%, Control: 51%).

The intervention for the experimental group included the following activities:

Impact Demonstrations: Students observed real-life impact scenarios, such as dropping balls of different masses and measuring the time it took for the balls to come to rest. These demonstrations provided a hands-on understanding of the relationship between impulse and impact force.

Simulations: Online tools were used to model various collision events, including elastic and inelastic collisions. Students adjusted variables such as mass, velocity, and collision duration to observe changes in momentum and impact force.

Problem-Solving Exercises: Students worked through problems involving the impulse-momentum theorem and impact force calculations, applying these principles to real-world phenomena like car crashes and sports collisions.

The control group followed traditional lecture-based teaching methods, which included theoretical explanations of momentum, impulse, and impact force, along with mathematical derivations.

Data were collected using pre-tests and post-tests to evaluate students' understanding of the concepts of momentum, impulse, and impact force. The tests included both multiple-choice and short-answer questions. Engagement levels were assessed using class observations and student feedback surveys, with scores rated on a 1 to 5 scale.

Result and Discussion

The results of the study are summarized in Table 1, which compares the experimental group (interactive learning approach) with the control group (lecture-based approach). The pre-test scores were comparable for both groups, with the experimental group scoring an average of 50% and the control group scoring 51%, indicating similar levels of prior knowledge.

Tabel 1:Impact of Impulse and Impact Force Study Results

Group	Pre-Test Average Score (%)	Post-Test Average Score (%)	Improvement (%)	Engagement Level (Scale 1-5)
1	50	80	30	4.5
2	51	61	10	3.0

Figure 1 is a visualization of the score trends for the experimental and control groups. The graph compares the pre-test and post-test scores, highlighting the significant improvement in the experimental group after the intervention

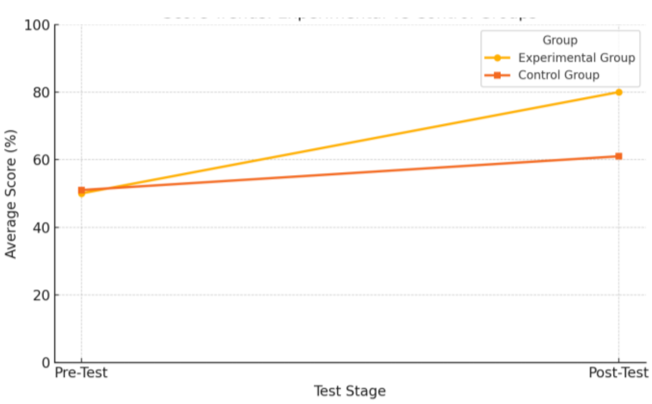

Figure 1. Score Trends: Experimental Vs Control Groups

After the intervention, the post-test scores showed a significant improvement in the experimental group, with an average score of 80%, compared to 61% in the control group. This represents a 30% improvement in the experimental group, compared to only a 10% improvement in the control group. These results highlight the effectiveness of using interactive methods, such as impact demonstrations and simulations, in enhancing student comprehension of momentum, impulse, and impact force.

The level of student engagement during the learning process was also assessed. The experimental group reported an average engagement level of 4.5 on a scale of 1 to 5, compared to 3.0 in the control group. Students in the experimental group expressed a higher level of interest and actively participated in the hands-on activities. Feedback from these students indicated that the interactive demonstrations and simulations helped them visualize and understand the concepts more effectively. For instance, the ability to adjust variables in the simulations allowed students to explore the relationships between mass, velocity, impulse, and impact force in a dynamic and engaging way.

In contrast, students in the control group reported lower levels of engagement and expressed difficulty connecting theoretical concepts to real-world scenarios. This lower engagement level likely contributed to their comparatively smaller improvement in post-test scores.

These findings underscore the importance of incorporating interactive learning methods in physics education. By using hands-on activities and real-world examples, educators can make abstract concepts like momentum and impulse more tangible and relatable for students. The significant improvement in the experimental group's test scores and engagement levels demonstrates the potential of experiential learning approaches to bridge the gap between theory and practice.

Moreover, the results suggest that introducing visual and practical tools, such as simulations and impact demonstrations, can foster a deeper understanding of classical mechanics, particularly for first-year students with limited prior exposure to physics.

Conclusion

This study demonstrates that teaching momentum through the concepts of impulse and impact force significantly enhances student understanding, engagement, and problem-solving skills. By adopting interactive learning methods, such as demonstrations, simulations, and problem-solving exercises, physics educators can help students connect abstract concepts to real-world phenomena. The results suggest that the teaching approach implemented in the Basic Physics course for the Biology Education Program at Mataram University can serve as a model for improving physics education. The integration of hands-on activities into the curriculum fosters deeper learning and a greater appreciation of physics as a practical science.

Future studies should further explore the long-term impacts of such teaching methods on students' retention of momentum concepts and their ability to apply these principles in other areas of physics and everyday life.

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