Design and Evaluation of the Educational Board Game for Teaching Conservation of Momentum

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Abstract
This paper presents preliminary findings on an educational board game designed by the researchers. The game aims to enhance students' understanding of the concept of conservation of momentum through engaging and interactive gameplay, emphasizing hands-on learning. Tested in a classroom setting with undergraduate students, results show the game effectively improves understanding of conservation of momentum and boosts interest in physics. Students found the game satisfying and useful. Overall, the study emphasizes the potential of custom-designed board games as innovative tools for teaching complex scientific concepts.

Keywords: Educational Board Game, Game-Based Learning, Momentum

Introduction

The conservation of momentum is a fundamental principle in physics, essential for understanding the behavior of objects in motion and their interactions during collisions. Despite its importance, many students face challenges in comprehending this abstract concept due to its reliance on mathematical equations and theoretical explanations. Traditional teaching methods often fail to engage students effectively, resulting in gaps in conceptual understanding and limited ability to apply the knowledge in practical situations (Singh, 2010; Doolittle, 1997).

Educational board games have emerged as an innovative tool for active learning, offering an interactive and engaging approach to teaching complex scientific concepts. By combining problem-solving scenarios, hands-on activities, and collaborative gameplay, these games provide students with opportunities to explore and apply theoretical knowledge in a practical context (Plass et al., 2015; Akl et al., 2013). The integration of educational games in physics education has shown promise in fostering deeper understanding, enhancing motivation, and improving learning outcomes (Clark et al., 2016).

This study focuses on the design and evaluation of an educational board game titled "The Momentum" aimed at teaching the principles of momentum and collision. The game is designed to address common learning challenges by providing a structured yet engaging platform for students to actively participate in the learning process (Banfield & Wilkerson, 2014; Zimbardo et al., 2003).

Research Objectives

This study aims to achieve two primary objectives:

1. Development of an Educational Board Game: To design and create an educational board game titled "The Momentum" with the primary purpose of enhancing students' understanding of physics concepts related to momentum and collision. This objective focuses on developing a game that provides an interactive, engaging, and hands-on learning experience while reinforcing theoretical knowledge.
2. Investigation of the Educational Board Game's Effectiveness: To evaluate the effectiveness of the board game in improving students' conceptual understanding of the conservation of momentum. The investigation includes assessing learning gains through pre-test and post-test comparisons, analyzing students' feedback regarding their gameplay experience, and conducting focus group discussions to gather in-depth insights about their learning experiences, suggestions for improvement, and the perceived impact of the game on their understanding of momentum.

Methodology

A mixed-methods approach was employed to design, implement, and evaluate the educational board game. The study involved two main phases: game design and classroom implementation with evaluation.

Game Design and Development

1. Identification of Learning Objectives: The first step in developing the game was to clearly define the learning objectives. This serves as the foundation for the

educational purpose of the game. In this case, the primary objective was to enhance students' understanding of the principle of conservation of momentum. This objective was established based on its importance in the physics curriculum and the need for students to apply this knowledge to real-world scenarios.

2. Game Conceptualization: Once the objectives were identified, the next step was to conceptualize the game. The researchers designed scenarios that involved problem-solving and hands-on activities to engage students in active learning. These scenarios were crafted to encourage participation and exploration, ensuring that players were actively involved in solving challenges related to the conservation of momentum. The game's concept emphasized experiential learning by integrating physics concepts into interactive gameplay.
3. Expert Review: Before creating the prototype, the game concept underwent a thorough review by experts in physics education and instructional design. These experts assessed the accuracy of the content, the pedagogical effectiveness, and the feasibility of implementation in a classroom setting. Their feedback provided valuable insights that were incorporated to refine the game's design, ensuring that it was both educationally sound and engaging for students.
4. Prototype Development: Following the expert review, an initial prototype of the game was developed. This prototype included key components such as game mechanics and problem scenarios related to momentum. It was then informally tested with a small group of students and educators. This pilot testing helped identify areas for improvement, including usability, content clarity, and the overall engagement level of the game. The insights gained from this phase were used to enhance the prototype, making it more suitable for practical use in educational settings.

Classroom Implementation

Once the board game was finalized and ready for use, it was introduced to a group of science teacher students in a classroom environment. This phase was critical for evaluating the game's effectiveness in conveying the intended learning objectives.

1. Introduction to the Game and Rules: The session began with a brief introduction to the game. Instructors explained the purpose of the game, highlighting its focus on the principle of momentum conservation. Students were given a clear and concise overview of the rules, objectives, and gameplay mechanics. This ensured that all participants had a baseline understanding of how to play and what was expected during the session. The introduction also emphasized how the game's activities were designed to relate directly to real-world physics concepts, helping to establish a meaningful connection between the gameplay and academic learning.
2. Group Division and Gameplay Session: To maximize engagement and facilitate collaborative learning, the class was divided into smaller groups. Each group had the opportunity to play the game during a 30-minute session. This structured gameplay period allowed students to explore the game mechanics, solve problems, and engage in discussions with their peers. By working in groups, students could share ideas, clarify their understanding, and collectively apply the principle of momentum conservation to the game's scenarios.
3. Instructor Facilitation: During the gameplay session, instructors actively facilitated the process. Their role was to observe the students' interactions, answer questions, and provide clarifications as needed. Instructors ensured that students were not only engaged in playing the game but also making connections between the gameplay activities and the underlying physics concepts. For example, they might guide

students to reflect on how their in-game decisions demonstrated the conservation of momentum or prompt them to discuss how the concept applied to real-life examples.
4. Focus on Conceptual Understanding: The facilitation emphasized linking the game experience to the learning objective. By contextualizing the gameplay within the framework of momentum conservation, instructors reinforced the educational value of the activity. This approach ensured that the session was not just an exercise in gaming but a meaningful learning experience where students could apply theoretical knowledge in a simulated, hands-on environment.

This method of implementation allowed students to actively engage with the concept of momentum conservation in an interactive and collaborative way. The structured yet flexible format of the session provided opportunities for both experiential learning and reflection, helping to deepen their understanding of the topic.

The Research Tools

The research instruments in this study consisted of:

1. The educational board game "The Momentum": The custom-designed board game served as the central teaching tool for the study to deliver an interactive and engaging method for teaching conservation of momentum, fostering active participation, and reinforcing theoretical knowledge through hands-on learning:
   Playing time: 20-30 minutes
   Number of players: 2-6
   Subject: Physics
   Content: Momentum and collision
2. Conceptual Test (Pre-Test and Post-Test): The test focused on assessing students' understanding of the conservation of momentum before and after playing the game. To measure learning gains and the effectiveness of the board games in enhancing conceptual understanding.
3. Student Feedback Survey: A structured questionnaire with Likert-scale and open-ended questions to evaluate students' perceptions of the game.
4. Focus Group Discussion (FGD) Guide: A semi-structured discussion guide to facilitate in-depth conversations with a subset of students after gameplay. Questions focused on: Learning experiences, Suggestions for improving the game, The perceived impact of the game on understanding momentum.

Result

The study found a significant improvement in students' understanding of conservation of momentum, with post-test scores showing a statistically significant increase compared to pre-test scores ($p < 0.05$). Students demonstrated better comprehension of fundamental concepts, including momentum equations, collision types, and real-world applications. Survey feedback revealed that most participants found the game engaging, enjoyable, and effective in facilitating learning, with a majority agreeing it made physics more accessible. Focus group discussions underscored the game's strengths in simplifying complex ideas and fostering peer-to-peer learning. Overall, the game successfully enhanced conceptual understanding, boosted interest in physics, and provided an interactive.

Conclusion

This study demonstrates the power of educational board games in transforming complex physics concepts into engaging, hands-on learning experiences. The game significantly improved students' understanding of the conservation of momentum while fostering collaboration, critical thinking, and enthusiasm for physics. Students found the game not only effective but also enjoyable, making learning both interactive and accessible.

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References

Akl, E. A., Kairouz, V. F., Sackett, K. M., Erdley, W. S., Mustafa, R. A., Fiander, M., Gabriel, C., & Schunemann, H. (2013). *Educational games for health professionals.* Cochrane Database of Systematic Reviews, 3, 1–46.

Banfield, J., & Wilkerson, B. (2014). *Increasing student intrinsic motivation and self-efficacy through gamification pedagogy.* Contemporary Issues in Education Research (CIER), 7(4), 291.

Clark, D., O'Neill, P., & Johnson, R. (2016). *The impact of educational games on learning outcomes in science education.* Journal of Educational Psychology, 108(3), 312–324.

Doolittle, P. (1997). *Vygotsky's zone of proximal development as a theoretical foundation for cooperative learning.* Journal on Excellence in College Teaching, 8(1), 83–103.

Plass, J. L., Homer, B. D., & Kinzer, C. K. (2015). *Foundations of game-based learning.* Educational Psychologist, 50(4), 258–283.

Singh, S. (2010). *Understanding momentum and collisions: Challenges and strategies.* Physics Education, 45(6), 701–710.

Zimbardo, P. G., Butler, L. D., & Wolfe, V. A. (2003). *Cooperative college examinations: More gain, less pain when students share information and grades.* The Journal of Experimental Education, 71(2), 101–125.

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