International Journal of Modern Education
IJMOE
EISSN: 2637-0905

Volume 7 Issue 28 (December 2025) PP. 01-06
DOI: 10.35631/IJMOE.728001

INTERNATIONAL JOURNAL OF MODERN EDUCATION (IJMOE)
www.ijmoe.com

GLOBAL ACADEMIC EXCELLENCE

# ENHANCING CONCEPTUAL UNDERSTANDING IN FOUNDATIONAL PHYSICS: A MINI REVIEW OF GAMIFICATION'S ROLE IN LINEAR KINEMATICS

Nur Syahida Abdul Rahim[1*], Mohd Muzammir Firdaus Abu Bakar[2], Siti Irma Yuana Sheikh Mohd Saaid[3]

[1] Pusat Asasi STEM, Universiti Malaysia Terengganu, Kuala Terengganu, Malaysia
Email: syahida.rahim@umt.edu.my
[2] Pusat Asasi STEM, Universiti Malaysia Terengganu, Kuala Terengganu, Malaysia
Email: muzammir.firdaus@gmail.com
[3] Pusat Asasi, Universiti Teknologi Mara, Cawangan Selangor, Kampus Dengkil
Email: sitiirma2902@uitm.edu.my
[*] Corresponding Author

**Article Info:**

**Article history:**
Received date: 30.09.2025
Revised date: 10.10.2025
Accepted date: 15.11.2025
Published date: 01.12.2025

**To cite this document:**

Abdul Rahim, N. S., Abu Bakar, M. M. F., & Saaid, S. I. Y. S. M. (2025). Enhancing Conceptual Understanding in Foundational Physics: A Mini Review of Gamification's Role in Linear Kinematics. *International Journal of Modern Education, 7* (28), 01-06.

**DOI:** 10.35631/IJMOE.728001

**Abstract:**

This paper proposes an investigation into the effectiveness of an application-based and gamified approach for teaching the foundational concepts of Linear Kinematics to foundation-level students in physics. A systematic review of current literature confirms a strong and growing trend in the use of gamification in physics education to address common student issues of low motivation, perceived difficulty, and poor conceptual grasp. Research indicates that integrating game mechanisms significantly enhances student engagement, motivation, and academic performance by transforming physics from an abstract, theoretical subject into an appealing, interactive experience. Furthermore, the literature strongly supports the use of interactive simulations and application-based learning to make complex concepts, such as force and energy, tangible and easier to grasp through direct manipulation of variables and real-time observation of outcomes. Specifically targeting foundation or college-level students, gamification has been shown to improve problem-solving skills, critical thinking, and long-term retention of concepts. This mini review paper establishes a solid justification for the proposed application based gamified intervention, highlighting its potential to revolutionise the teaching of Linear Kinematics by fostering active learning and deeper conceptual understanding. The future study aims to empirically validate this approach's impact on learning outcomes compared to traditional teaching methods.

International Journal of Modern Education
EISSN: 2637-0905
IJMOE
Volume 7 Issue 28 (December 2025) PP. 01-06
DOI: 10.35631/IJMOE.728001



**Keywords:**

Gamification, Linear Kinematics, Conceptual Understanding, Foundational Physics, Application-Based Learning

## Introduction

Foundational physics, particularly the study of linear kinematics (motion in one or two dimensions), is a gateway to more complex scientific concepts. However, students at the high school and introductory university levels frequently struggle with grasping core ideas, such as interpreting kinematic graphs (position, velocity, and acceleration vs. time) and understanding the relationship between physical phenomena and their graphical, mathematical, and verbal representations (Dutra et al., 2025). Traditional instruction often fails to bridge the gap between abstract concepts and real-world application, leading to low student engagement and motivation. In response, educational researchers have explored innovative pedagogical approaches. One highly promising strategy is gamification, which involves integrating game design elements such as points, badges, leaderboards, challenges, and immediate feedback into educational settings to drive motivation and engagement (Deterding et al., 2011). The inherent motivational power of games, tapping into core human drives like achievement and competition, makes gamification an ideal candidate for revitalizing difficult subjects like introductory Physics. This paper provides a focused review of the literature concerning gamification's role in enhancing conceptual understanding, specifically within the realm of linear kinematics for foundational-level students. It synthesizes findings on conceptual gains, the effectiveness of application-based gamified approaches, and the impact on student engagement and motivation.

## Literature Review

### *Conceptual Challenges in Linear Kinematics*

A significant researcher confirms that interpreting kinematic graphs is a persistent conceptual hurdle (Thornton & Sokoloff, 1998). Students often fail to differentiate between position-time and velocity-time graphs, or struggle to connect the slope of a position graph to velocity (Dutra et al., 2025). Physics Education Research Central advocates for active learning, collaborative work, and the integration of multiple representations such as linguistic, mathematical, graphical, and experimental to enhance conceptual understanding (Hake, 1998).

### *The Role of Gamification in Physics Education*

Gamification in Physics education involves the incorporation of game design elements into the learning process to enhance student engagement and understanding of complex concepts like linear kinematics. This pedagogical approach is increasingly being recognized for its potential to transform traditional teaching methods by making learning more interactive and enjoyable for students. A meta-analysis by Balci et al. (2024) indicates a statistically significant positive effect of gamification on students' understanding of fundamental physics concepts. Gamification elements are primarily leveraged to increase motivation and engagement, which are considered precursors to deeper learning and persistence in challenging subjects (Ryan & Deci, 2000). Studies have consistently reported that gamified environments lead to higher time-on-task, a greater number of attempts, and higher self-reported motivation compared to non-gamified conditions (Dutra et al., 2025).

International Journal of Modern Education
EISSN: 2637-0905
IJMOE
Volume 7 Issue 28 (December 2025) PP. 01-06
DOI: 10.35631/IJMOE.728001

***Gamification and Kinematics: Application-Based Learning***

A particularly effective approach combines gamification with application-based, embodied learning. The Mission Motion Project exemplifies this, addressing the challenge of kinematic graphs through a gamified physical-computational environment (Dutra et al., 2025). This project uses low-cost sensors to allow high school students to perform physical activities (embodied learning) and see the real-time visualization of their motion graphs. The gamified aspect, which includes challenges and immediate feedback, was found to yield high levels of student satisfaction, perceived learning, and engagement. Students explicitly cited the fun aspect and the clarity of the visual feedback as key motivators (Dutra et al., 2025). Similarly, another study by Richter et al., 2025 shown, using a game like "Basketball Physics Challenge" which teaches concepts like initial velocity and trajectory, found that while quiz performance was not always significantly different, a positive correlation emerged between game scores and quiz performance in the gamified condition, suggesting that the dynamic, application-based learning fostered by the game promotes deeper understanding and retention.

## Methodology

This paper employed a systematic literature synthesis methodology focusing on research published primarily between 2020 and 2025, as gamification in physics education is a very crucial. The selection criteria for the reviewed papers shown in Figure 1.

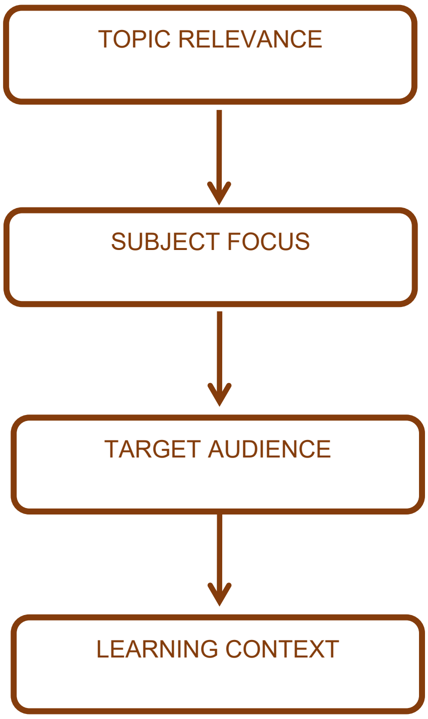


**Figure 1: Overview of Methodology**

Volume 7 Issue 28 (December 2025) PP. 01-06
DOI: 10.35631/IJMOE.728001

Starting with selection of relevance topic, direct discussion on gamification or game-based learning chosen. From that selection, subject focusing on linear kinematics or closely related foundational physics concepts for instant motion, trajectory, graphs. Next, research involving foundation-level students such as high school or introductory undergraduate will be pick. Lastly, learning context will focuses on conceptual understanding and/or application-based learning.

This search was conducted using Google Scholar with key phrases such as "gamification in linear kinematics physics conceptual understanding research foundation level" and "review of gamification's role in conceptual understanding in foundational physics linear kinematics." The findings from the identified papers were then thematically analysed and synthesized to construct the sections of this mini review paper.

**Discussion And Limitation**

The reviewed literature strongly suggests that gamification is a powerful tool for addressing the motivational and engagement deficits often observed in foundational physics. The success of gamification in kinematics appears tied to its ability to facilitate active, embodied learning and the integration of multiple representations (Dutra et al., 2025). By providing real-time, immediate feedback on actions (a core game design element), gamified tools help students quickly correct misconceptions about the connection between physical motion and its abstract graphical representation. The competitive and challenging nature of these environments naturally increases persistence and self-regulation.

However, a recurring limitation across studies is the inconsistent evidence regarding a direct, statistically significant improvement in traditional academic achievement in term of exam scores only compared to non-gamified control groups. While engagement and perceived learning are high, the transfer of skills to standardized assessments is not always immediate or universal. This suggests that the design of the gamified environment is critical; poorly designed activities may lead to distraction or focus on the game goals rather than the learning goals (Huang & Soman, 2013). Furthermore, the positive correlation between game performance and quiz scores indicates that gamification may enhance understanding for students who successfully navigate the game's challenges, but the overall impact needs more robust measurement using standardized conceptual evaluation tools like the Test of Understanding Graphs in Kinematics (TUG-K) (Mubasir et.al., 2021).

According to Ruiz et. al., 2024, a critical practical limitation highlighted by the review is a widespread lack of teacher training in how to effectively implement and design gamification strategies. Only 3% of the reviewed articles focused on this, yet researchers emphasize that regular training is fundamental for maximizing the strategy's impact. In addition, methodological shortcomings in the reviewed studies include short application times, small sample sizes, and a recognized need for more standardized and validated instruments to accurately measure student outcomes when using gamified approaches.

A key challenge identified is the requirement for advanced technology infrastructure, software, and stable internet access for students, which may be a significant barrier in resource-constrained institutions. The solutions proposed include using web-based, cloud-based, or open-source tools to ensure wider accessibility. Integrating gamification effectively is time- and effort-intensive for teachers, who may also lack the necessary technical proficiency. Additionally, some students may resist gamification, viewing it as a distraction from the

International Journal of Modern Education IJMOE
EISSN: 2637-0905
Volume 7 Issue 28 (December 2025) PP. 01-06
DOI: 10.35631/IJMOE.728001
"serious" nature of college physics or simply finding the material uninteresting ( Enaz et. al., 2025).

**Conclusion And Future Works**

Gamification holds significant promise for enhancing conceptual understanding in foundational linear kinematics. By boosting motivation, increasing engagement, and providing a framework for application-based, embodied learning with immediate feedback, it effectively tackles the abstract and often-daunting nature of kinematic concepts. The integration of technology in gamified tools allows for a dynamic connection between physical phenomena and their multiple representations, which is essential for deep conceptual mastery.
Future research should focus on three key areas as shown in Table 1.

**Table 1: Future Works on Finding**

| Focus area | Explanation |
|---|---|
| Long-term conceptual retention | Studies need to assess the longevity of conceptual gains achieved through gamification using standardized pre- and post-tests over extended periods. |
| Optimal gamification design | Research must systematically investigate which specific game elements such as leader boards, narrative, rewards are most effective for improving conceptual understanding in different physics topics. |
| Scalability and Adaptability | Large-scale implementation studies across diverse educational settings are needed to confirm the pedagogical robustness and adaptability of successful gamified kinematics tools. |

**Acknowledgements**

The authors would like to thank STEM Foundation Centre and Universiti Malaysia Terengganu for providing the facilities and support.

**References**

Ab Patar, M. N. A., Ahmad Nazri, N., Razlan, R., Embong, Z., Ahmad, S., & Mahmud, J. (2024). Gamification and its impact on learning fundamental physics: A meta-analysis. *International Journal of Academic Research in Business and Social Sciences*, *14*(9).

Achmad Lutfi, Suyono, & Hidayah, R. (2021). Applying gamification to improve the quality of teaching and learning of chemistry in high schools: A case study of Indonesia. *Asia-Pacific Forum on Science Learning and Teaching*, *20*(2), Article 6.

Balci, S., Secaur, J. M., & Morris, B. J. (2024). *Gamification and its impact on learning fundamental physics: A meta-analysis*. Knowledge Words Publications.

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). *From game design elements to gamefulness: Defining gamification*. Proceedings of the 15th International Academic MindTrek Conference. ACM.

Dutra, M., Abreu, M., Monteiro, M., Sguilla, S., Stari, C., Suárez, Á., & Marti, A. C. (2025). *Enhancing kinematics understanding through a video game based on real-time motion graphs*. (arXiv preprint arXiv:2508.19119). arXiv.org.

**Volume 7 Issue 28 (December 2025) PP. 01-06**
**DOI: 10.35631/IJMOE.728001**
Forndran, F., & Zacharias, C. R. (2019). Gamified experimental physics classes: A promising active learning methodology for higher education. *European Journal of Physics*, *40*(4), 045702.

Gaurina, M., Alajbeg, A., & Weber, I. (2025). The power of play: Investigating the effects of gamification on motivation and engagement in physics classroom. *Education Sciences*, *15*(1), Article 104.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, *66*(1), 64–74.

Huang, W. H., & Soman, D. (2013). *A general model of gamification* (Research Report Series: Behavioral Economics in Action at Rotman). Rotman School of Management.

Kalogiannakis, M., Papadakis, S., & Zourmpakis, A.-I. (2021). Gamification in science education: A systematic review of the literature. *Education Sciences*, *11*(1), Article 22.

Kaya, O. S., & Ercag, E. (2023). The impact of applying challenge-based gamification program on students' learning outcomes: Academic achievement, motivation and flow. *Education and Information Technologies*, *28*, 1–26.

Khaldi, A., Bouzidi, R., & Nader, F. (2023). Gamification of e-learning in higher education: A systematic literature review. *Smart Learning Environments*, *10*, Article 10.

Mahmoud, E., & Taguines, R. (2025). Integration of gamification-based learning into college physics: Digital applications and strategies. *Journal of Information Systems Engineering & Management*, *10*(4), 2304–2315.

Meng, C., Zhao, M., & Pan, Z. (2024). Investigating the impact of gamification components on online learners' engagement. *Smart Learning Environments*, *11*, Article 47.

Mubasir, Y., Supriyadi, S., & Lia, R. M. (2021). Developing physics graph learning media in the concept of kinematics and its assessment using Tug-K (Test of Understanding Graphs in Kinematics). *Periódico Tchê Química*, *18*(38).

Richter, K., & Kickmeier-Rust, M. (2025). Gamification in physics education: Play your way to better learning. *International Journal of Serious Games*, *12*(1), 59–81.

Rohman, S., Irvani, A. I., & Warliani, R. (2024). Gamification in physics education: Trends, impacts, and insights from the last decade.

Ruiz, J. J. R., Sanchez, A. D. V., & Figueredo, O. R. B. (2024). Impact of gamification on school engagement: A systematic review. *Frontiers in Education*, *9*, Article 1466926.

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology*, *25*(1), 54–67.

Tan, D. Y., & Cheah, C. W. (2021). Developing a gamified AI-enabled online learning application to improve students' perception of university physics. *Computers and Education: Artificial Intelligence*, *2*.

Thornton, R. K., & Sokoloff, D. R. (1998). Assessing student learning of Newton's laws: The force and motion conceptual evaluation and the conceptual dynamics test. *The Physics Teacher*, *36*(7), 466–470.