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GAMIFYING ACADEMIC ACHIEVEMENT IN MATHEMATICAL PHYSICS THROUGH STUDENT FEEDBACK ON LEADERBOARD PERFORMANCE TRACKING

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Abstract

This study explores the impact of leaderboard systems on student motivation and personal growth within the context of mathematical physics education. While leaderboards are increasingly used in educational settings, their effects on student behavior, particularly in higher education and challenging subjects like mathematical physics, remain underexplored. Existing research on gamification and educational technologies predominantly focuses on primary and secondary education, with limited attention given to higher education, particularly in the Philippines. To address this gap, the study examines the experiences of 45 students enrolled in a public higher education institution in Northern Mindanao, Philippines. Although the relatively small sample size limits the generalizability of the findings, it offers valuable contextual insights into how leaderboard systems function in a real classroom setting. An explanatory sequential mixed-methods approach was employed, combining quantitative data from students' performance records and qualitative data from surveys. The findings revealed a positive correlation between leaderboard rankings and improved academic performance for higher-performing students, while lower-ranking students experienced decreased motivation. Further analysis using a heatmap showed varying motivation levels across subjects, with stronger engagement in the mathematical physics class. The boxplot analysis revealed that lower-ranked students exhibited greater variability in their quiz scores across the prelim to final terms, suggesting potential challenges in maintaining consistent academic performance. The study concludes that leaderboards can enhance student motivation, resilience, and personal growth, although their impact varies depending on individual perspectives and subject contexts. While leaderboards promote achievement and healthy competition, they can also induce stress for lower-ranking students. This research contributes to the understanding of gamified learning in higher education and provides insights for educators and policymakers on optimizing leaderboard systems to balance motivation with emotional well-being.

Keywords – Academic achievement, Gamification, Higher education, Leaderboard system, Performance tracking, Physics education.

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1. Introduction

In recent years, gamification strategies have gained significant attention in educational settings as an effective means of enhancing student engagement, motivation, and academic performance (Hellín, Calles-Esteban, Valledor, Gómez, Otón-Tortosa & Tayebi, 2023; Smiderle, Rigo, Marques, De-Miranda-Coelho & Jaques, 2020). The integration of game-like elements into the learning environment transforms traditional teaching methods into more interactive and dynamic experiences (Dichev & Dicheva, 2017). These elements, such as points, badges, and rankings, encourage students to immerse themselves in their studies while promoting a sense of accomplishment (Zainuddin, Shujahat, Haruna & Chu, 2019). Gamification has been embraced across various disciplines, as it helps foster enthusiasm for learning, particularly in subjects that students may otherwise find challenging or uninteresting (Chen & Liang, 2022).

A key feature of gamification in education is the use of leaderboards, which track and display students' progress in real time (Cigdem, Ozturk, Karabacak, Atik, Gürkan & Aldemir, 2024). These leaderboards introduce an element of competition, motivating students to perform better by comparing their achievements with those of their peers (Balci, Secaur & Morris, 2022). As students monitor their progress and see their rankings rise, they are often motivated to push themselves further, striving to attain higher positions on the leaderboard (Li, Liang, Fryer & Shum, 2024). This sense of competition is designed to stimulate both intrinsic and extrinsic motivation, compelling students to engage actively with course material in order to improve their academic standing (Ratinho & Martins, 2023).

Leaderboards provide immediate feedback to students, allowing them to assess their academic performance and adjust their learning strategies accordingly (Cigdem, Korkusuz & Karaçaltı, 2023; Li et al., 2024). This feedback mechanism is crucial in promoting continuous improvement, as students are able to see the direct impact of their efforts on their rankings (Meng, Zhao, Pan, Pan & Bonk, 2024). The visibility of their progress not only drives motivation but also encourages a growth mindset, where students understand that effort and persistence lead to tangible results (Hellín et al., 2023). As students continue to see their names move up the ranks, they may experience an increased sense of accomplishment, which reinforces positive academic behaviors and fosters further dedication to their studies (Krath, Schürmann & Von-Korflesch, 2021).

Furthermore, gamification elements like leaderboards have the potential to create a more inclusive and engaging learning environment (Cigdem et al., 2023). Unlike traditional grading systems, which can sometimes feel impersonal, leaderboards make progress visible and tangible for all students (Ortiz-Rojas, Chiluiza, Valcke & Bolanos-Mendoza, 2025). This visibility can serve as a catalyst for peer collaboration, as students may share strategies or discuss ways to improve their rankings (Hellín et al., 2023). Additionally, the competitive yet supportive atmosphere created by leaderboards encourages students to not only compete against one another but also celebrate each other's successes (Wang & Tahir, 2020). In doing so, gamification nurtures both individual achievement and a sense of community within the classroom, further enhancing the overall learning experience (Christopoulos & Mystakidis, 2023; Smiderle et al., 2020).

1.1. Research Gaps

Although gamification has been widely studied in various educational settings, there remains a notable gap in research related to the impact of leaderboards on academic performance in specialized subjects, such as Mathematical Physics, at the university level. While gamification is a common strategy in introductory and general education courses, its implementation in more advanced subjects—especially those that require high-level conceptual understanding and problem-solving skills—has been underexplored. Mathematical Physics, as a subject that requires complex analytical skills, offers a unique opportunity to investigate the effects of leaderboard-based gamification in a challenging academic environment.

In addition, much of the existing research on gamification focuses on quantitative outcomes, such as changes in student performance, but overlooks the qualitative aspect of students' experiences. The

emotional and cognitive impact of leaderboard systems on students—whether they feel motivated, stressed, or even disengaged—has not been adequately explored. There is a lack of research that integrates both quantitative performance data and qualitative feedback from students to provide a more holistic understanding of how leaderboard systems affect learning. Moreover, previous studies have primarily focused on the impact of gamification on younger students, with limited attention paid to how it may function within the context of adult learners in higher education. The dynamics of gamification in university settings, where students are often more self-directed and experience higher levels of academic pressure, may differ significantly from those observed in K-12 education.

1.2. Research Questions

The research questions for this study are designed to explore the impact of leaderboard-based gamification on student performance and their perceptions of the learning experience. The use of leaderboards, a key component of gamification, has been shown to influence student motivation and engagement by providing real-time feedback and fostering a competitive yet supportive learning environment. However, the specific effects of these leaderboards on academic performance, particularly in a specialized subject such as Mathematical Physics, remain underexplored. This study aims to bridge that gap by examining both quantitative data, such as quiz scores and rankings during different course periods, and qualitative data, including student feedback about their experiences with the leaderboards. Hence, this study aims to address the following questions:

1. How do students' scores during the prelim, midterm, and final periods relate to their rankings on the leaderboard?
2. What patterns in student performance are observed in relation to their leaderboard positions over the course of the class?
3. How do students describe their personal growth and learning strengths in relation to their experiences with the leaderboard system?
4. What adjustments did students make during the course to improve their understanding, and how do they perceive these adjustments in relation to their leaderboard rankings?
5. What impact do students believe the leaderboard system had on their motivation, and what recommendations do they have for improving its use in the classroom?
6. What insights do students provide about their personal growth and the lessons learned throughout the course, and how do these relate to their experiences with the leaderboard system?

2. Literature Review

The literature review provides a comprehensive examination of the existing research and theoretical underpinnings relevant to the use of gamification in education. This section delves into the specific themes of student motivation, the impact of leaderboards on academic performance, classroom dynamics, and students' perceptions of and emotional responses to gamification. These themes collectively illuminate the multidimensional nature of gamification as an educational strategy and its implications for pedagogical practices.

2.1. Gamification and Student Motivation

Gamification has been extensively studied for its potential to enhance student motivation by integrating game-like elements into educational settings (Dichev & Dicheva, 2017; Khaldi, Bouzidi & Nader, 2023). Motivation, whether intrinsic or extrinsic, is a critical factor in shaping learning behaviors and outcomes. According to Ryan and Deci's (2000) Self-Determination Theory, intrinsic motivation thrives in environments that satisfy students' psychological needs for autonomy, competence, and relatedness. Gamification elements such as points, badges, and challenges align with these principles by fostering a sense of achievement and competence (Kaya & Ercag, 2023; Smiderle et al., 2020).

Studies have demonstrated that gamification can enhance engagement by transforming traditional academic tasks into more interactive and enjoyable experiences. Alsadoon, Alkhawajah and Suhaim (2022) found that students exposed to gamified learning environments exhibited higher levels of participation and enthusiasm compared to those in conventional settings. The use of rewards, such as badges and points, not only motivates students to complete tasks but also helps sustain their interest in long-term learning activities (Meng et al., 2024; Ratinho & Martins, 2023).

However, researchers also caution against over-reliance on extrinsic motivators in gamification (Baah, Govender & Subramaniam, 2023; Mekler, Brühlmann, Tuch & Opwis, 2015). While rewards and leaderboards may boost engagement in the short term, there is a risk of diminishing intrinsic motivation if students become overly focused on external incentives (Cigdem et al., 2024; Ryan & Deci, 2001). Educators are encouraged to strike a balance between gamification mechanics and meaningful learning experiences to ensure that students remain intrinsically motivated (Christopoulos & Mystakidis, 2023; Dichev & Dicheva, 2017; Hellín et al., 2023).

2.2. Impact of Leaderboards on Academic Performance

Leaderboards are among the most widely used gamification tools in educational contexts, designed to visually represent students' performance rankings (Balci et al., 2022; Cigdem et al., 2024). Their primary purpose is to encourage competition and drive academic improvement (Alsadoon et al., 2022). Research has shown that leaderboards can positively influence academic performance by providing students with real-time feedback and a clear understanding of their progress (Mekler et al., 2015; Jaramillo-Mediavilla, Basantes-Andrade, Cabezas-González & Casillas-Martín, 2024; Smiderle et al., 2020).

The competitive aspect of leaderboards often motivates students to strive for higher rankings, which can lead to improved performance in tasks and assessments (Do, Jin, Priest, Meredith & Landers, 2024). For example, studies by Koivisto and Hamari (2018), as well as, Licorish, Owen, Daniel and George (2018) indicate that students who regularly interacted with leaderboard systems demonstrated increased effort and persistence in achieving academic goals. Moreover, leaderboards can facilitate goal-setting behaviors, with students aiming to reach specific milestones or outperform their peers (Hellín et al., 2023; Park & Kim, 2021).

Nevertheless, the effectiveness of leaderboards varies depending on individual differences. While some students thrive in competitive environments, others may feel demotivated if they consistently rank low (Balci et al., 2022; Gao, Rogers & Li, 2024). This disparity highlights the need for educators to implement leaderboards with caution, ensuring that all students feel supported and encouraged. Tiered systems or individual progress tracking may help mitigate the potential negative effects of leaderboards (Li et al., 2024).

2.3. Competitiveness, Collaboration, and Classroom Dynamics

Gamification not only fosters competitiveness but also influences collaboration and the overall dynamics of the classroom (Smiderle et al., 2020). Competitive gamified elements, such as leaderboards and time-based challenges, can instill a sense of urgency and excitement, prompting students to actively engage with course materials (Kalogiannakis, Papadakis & Zourmpakis, 2021). This dynamic environment often leads to heightened participation and interaction among students (Oliveira, Hamari, Joaquim, Toda, Palomino, Vassileva et al., 2022).

However, competition is not always conducive to effective learning, particularly when it leads to heightened stress or divisive classroom dynamics (Cao, Gong, Wang, Zheng & Wang, 2022). Research by Liu, Zhou, Li and Ye (2022) emphasizes the importance of balancing competition with collaboration to create a harmonious learning environment. Gamified systems that incorporate team-based challenges can encourage cooperative learning, where students work together to achieve common goals (Christopoulos & Mystakidis, 2023; Smiderle et al., 2020). Such collaborative activities not only reduce the pressure of

individual competition but also promote the development of interpersonal skills (Prieto, Rodrigo & Vieites, 2021).

Educators can design gamified interventions that alternate between competitive and collaborative tasks to cater to diverse student preferences (Latorre-Cosculluela, Sierra-Sánchez & Vázquez-Toledo, 2025). This approach ensures that the classroom remains inclusive and supportive, fostering both individual achievement and group cohesion.

2.4. Student Perceptions and Emotional Responses to Gamification

Students' perceptions of and emotional responses to gamification play a critical role in determining its effectiveness (Chan & Lo, 2022). Positive perceptions of gamified learning environments are often associated with increased satisfaction, engagement, and willingness to participate (Hebbar, Manohar & Hungund, 2024). In a study by Aldalur and Perez (2023), students reported that gamified elements made learning more enjoyable and helped reduce the monotony of traditional educational practices.

Emotional responses to gamification, however, can be mixed. While many students experience excitement and motivation, others may feel frustration or anxiety, particularly if they struggle to perform well in gamified tasks (Smiderle et al., 2020). The visibility of rankings on leaderboards, for example, can lead to feelings of inadequacy or competition-related stress among lower-performing students (Koivisto & Hamari, 2018; Schlömmer, Spieß & Schlögl, 2021). These emotional challenges highlight the need for thoughtful implementation of gamified elements to ensure that they are both effective and inclusive (Xiao & Hew, 2024).

Educators should consider incorporating features that allow students to personalize their gamified experiences, such as setting individual goals or focusing on self-improvement rather than peer comparison (Hong, Saab & Admiraal, 2024). This approach can help mitigate negative emotions and foster a more positive perception of gamification, ultimately enhancing its impact on learning outcomes (Aguilos & Fuchs, 2022; Oliveira, Hamari, Shi, Toda, Rodrigues, Palomino et al., 2023).

3. Methodology

3.1. Research Design

This study employed an explanatory sequential mixed-methods design (Creswell & Plano-Clark, 2018), combining quantitative and qualitative approaches to analyze the impact of leaderboard gamification on student performance and engagement. In the first phase, quantitative data comprising students' scores were analyzed using descriptive and inferential statistics, such as correlation analysis, to identify trends and relationships between leaderboard rankings and academic performance. This phase provided a foundation for understanding the measurable effects of the leaderboard system.

In the second phase, qualitative data from student exit feedback forms were analyzed using thematic analysis (Braun & Clarke, 2006) to explore perceptions, experiences, and attitudes toward the leaderboard. Themes such as motivation, competition, and stress were identified, offering insights into the factors influencing the quantitative findings. The integration of both datasets facilitated a deeper understanding of how leaderboards impact academic success and engagement, supporting actionable recommendations for gamification in education.

3.2. Participants and Study Context

The study involved the entire section of the SED129 (Mathematical Physics for Teachers) course comprising 45 students from a public higher education institution in Northern Mindanao, Philippines. While the program is primarily designed for students from the STEM strand, most of the participants were from the Accountancy, Business, and Management (ABM) and other academic strands, as STEM students typically preferred engineering or pure science degrees over teaching. Of the 45 participants, 11 were male (24.44%) and 34 were female (75.56%). Regarding their senior high school strands, 19 students

(42.22%) came from ABM, 14 (31.11%) from STEM, 5 (11.11%) from HUMSS, 5 (11.11%) from Technical-Vocational-Livelihood (TVL), and 2 (4.44%) from the General Academic Strand (GAS). Most participants were first-year students (41 or 91.11%), reflecting the typical enrollment pattern for the course, which is foundational in the physics teacher education program. However, a small number of participants were from higher year levels, including one second-year student (2.22%), one third-year student (2.22%), and two fourth-year students (4.44%). These upper-year students were likely shiftees or returning students who transitioned into the program at different stages of their academic journey.

Consequently, the majority of students lacked a rigorous mathematics background, which prompted the integration of gamification as a pedagogical approach. This study was conceptualized to address the observed mismatch between student preparedness and program requirements. Although the Bachelor of Secondary Education (BSED) Physics program necessitates prior knowledge in STEM-specific mathematics, none of the participants had such a background. This created a significant challenge, as students struggled with algebraic skills foundational to the course, particularly in vector algebra and differential calculus. Recognizing this, the study aimed to provide a scaffolding mechanism through immediate feedback, fostering student accountability for their own learning progress.

Given the unfamiliarity of the subject to non-STEM students, the course content posed a dual challenge: navigating both the algebraic underpinnings and the specific concepts of mathematical physics. To alleviate this, the gamified classroom strategy was implemented for the entire semester, integrating weekly performance feedback. The design of the gamified environment drew inspiration from Tolentino and Roleda's (2019) work, which demonstrated the efficacy of non-digital gamified feedback in improving motivation and performance among underprepared students.

Students' consent was obtained prior to the study, allowing their performance data and exit feedback to be utilized under the assurance of anonymity. The study adhered to the ethical standards outlined in the Declaration of Helsinki and the provisions of Republic Act 10173 (Data Privacy Act of 2012). Gamification elements included (1) in-game names, (2) avatars, (3) scores, (4) levels, (5) perks, (6) group visualization graphs, and (7) individual portfolios. These were tailored to align with the students' characteristics and their familiarity with digital tools.

The central focus of the study was on improving students' algebraic skills as a gateway to enhancing their overall performance in mathematical physics. The approach emphasized tracking progress and fostering engagement, addressing both academic and motivational challenges unique to the context.

3.3. Instrument and Data Collection

This study focused on the design and implementation of a gamified classroom in a Mathematical Physics class during the first semester of SY 2024-2025, which spanned from August to December 2024. The implementation covered 18 weeks, with two weekly meetings totaling 54 instructional hours. The gamified design integrated video lectures, quizzes, and three major examinations as the primary instructional tools, ensuring alignment with the course objectives. The gamified classroom framework was carefully developed to provide a dynamic and engaging learning environment. To ensure accuracy and reliability, member checking was employed during the data entry process and in verifying the assessment outputs and results, which involved students and instructors reviewing recorded scores and leaderboard updates to confirm their correctness (Birt, Scott, Cavers, Campbell & Walter, 2016).

The quizzes and examinations were further enhanced through a gamified leaderboard system, which was designed to provide detailed visual feedback on student performance. Each quiz was graded promptly, with scores immediately reflected on the leaderboard. This timely feedback ensured that students remained informed of their progress throughout the semester, fostering motivation and engagement. The leaderboard included percentage performance and allowed students to locate their relative standing among peers, adding an element of competition that encouraged self-improvement. This visualization aimed to create a structured yet motivating atmosphere where students could track their incremental achievements

and their collective ranking. The implementation of member checking in this process added a layer of credibility and transparency to the reporting system, as students validated their scores and standings before they were finalized.

At the conclusion of the semester, following the final examination, an exit interview was conducted to collect qualitative feedback. Open-ended questions were delivered through a Google Form to capture students' perceptions of the gamified system and its impact on their learning experience. Prior to deployment, the survey questionnaire underwent face and content validation by a panel of experts in science education and gamification, ensuring that the questions were appropriate, relevant, and clear (Boateng, Neilands, Frongillo, Melgar-Quiñonez & Young, 2018). The validation process included iterative reviews to refine the questionnaire, ensuring it accurately captured the intended dimensions of student feedback. This combination of rigorously validated instruments and the use of member checking created a robust framework for assessing both quantitative and qualitative aspects of the gamified classroom.

3.4. Data Analysis

A mixed-methods approach was employed to analyze the quantitative and qualitative data collected in the study. Quantitative data, derived from students' performance records, were analyzed using descriptive statistics, correlation analysis, and visualization techniques to identify patterns and relationships. A scatterplot, generated using Pearson's correlation coefficient, revealed a positive correlation between leaderboard rankings and academic performance for higher-ranking students, while lower-ranking students showed less consistent performance improvements. Heatmap analysis, created using normalized data, illustrated variations in motivation levels across subjects, with stronger engagement observed in mathematically intensive areas such as math and science compared to more subjective topics. Boxplot analysis, performed to assess score distributions, demonstrated greater variability in performance among lower-ranking students, indicating potential challenges in maintaining consistent academic progress.

Qualitative data were collected through open-ended survey questions that explored students' perceptions of the gamified classroom experience. Thematic analysis identified recurring themes such as motivation, competition, stress, and personal growth. Integrating these qualitative insights with the quantitative results provided a comprehensive understanding of how gamification influenced both academic performance and student engagement. This mixed-methods approach aligns with prior studies highlighting the importance of combining statistical analyses with students' perspectives to examine the complex effects of gamified learning environments (Deterding, Dixon, Khaled & Nacke, 2011). The findings contribute to the body of knowledge on gamification by offering practical evidence for its application in higher education, particularly in challenging courses like mathematical physics.

4. Results and Findings

This study explored how gamification strategies could enhance student engagement and performance in a challenging academic subject. Specifically, it examined the implementation of a leaderboard system designed to provide an interactive, motivating, and transparent platform for tracking student progress. The system was tailored to students' technological contexts, aiming to uncover insights into performance tracking and its effects on academic achievement and class experience.

The leaderboard was developed with accessibility and inclusivity in mind, using Google Sheets to minimize technological barriers, particularly for students using Android devices. Students could scroll, search, and view performance data while data integrity was preserved through restricted editing permissions. To promote privacy, students used in-game names (IGNs) and self-chosen avatars that adhered to positive representation guidelines (Figure 1). These features fostered anonymity and inclusivity, allowing participation without fear of judgment.

The leaderboard included several features to sustain engagement. The scores display showed detailed raw scores linked to IGNs in random order to protect privacy. Rank details presented progression milestones (e.g., wondering warrior, elite, beckoning master, force grandmaster), each accommodating five students

(Figure 2). The stats section visualized ratings, levels, and ranks, enabling students to monitor performance across tasks. A profile summary allowed students to compare progress anonymously by selecting IGNs from a drop-down list, while tab-based navigation simplified access to features. Unlike conventional systems that highlight only individual or group results, this leaderboard offered a holistic view of student progress, promoting motivation and inclusion as reflected in the exit feedback.

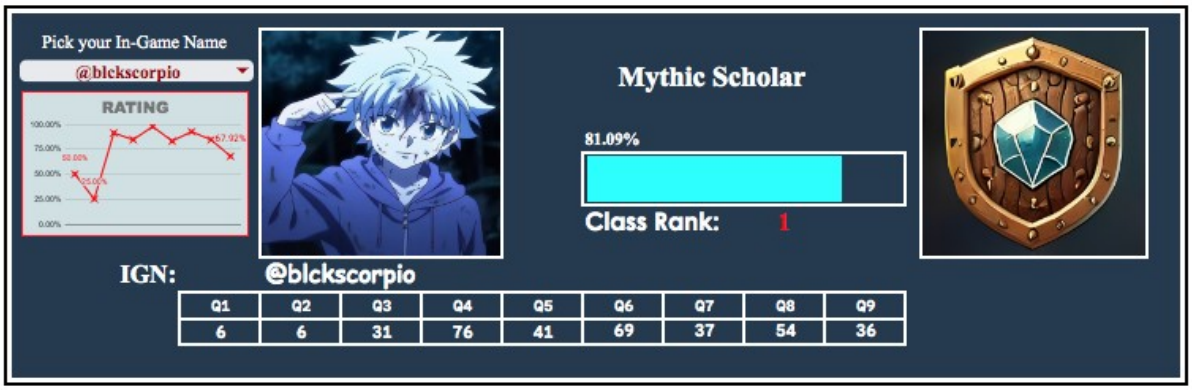

Figure 1. Students' profile summary including IGN, performance scores, and statistical overview

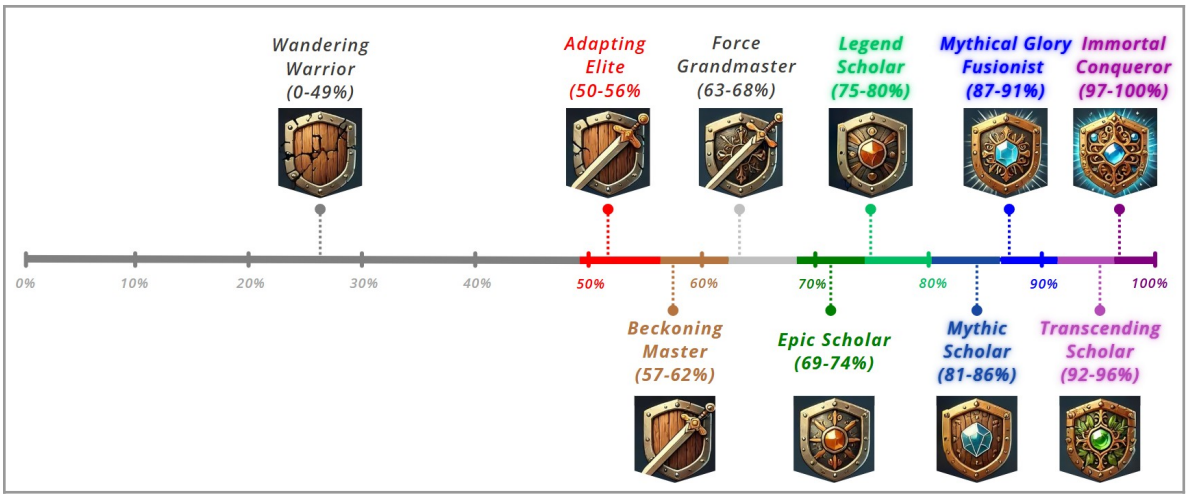

Figure 2. Progression of ranks and badges in the gamified leaderboard system

4.1. Leaderboard Rankings Across Assessment Periods

The dataset (Figure 3) presents quiz performance and rankings across Prelim, Midterm, and Final terms. Scores are expressed as percentages, with ranks indicating relative standing. Overall leaderboard averages summarize cumulative achievements, showcasing diverse academic outcomes. The data reveal both individual variations and patterns linking term-specific scores to overall standings.

The scatter plot illustrates the relationship between quiz scores during the Prelim, Midterm, and Final terms and leaderboard rankings. Each data point represents a student, with the x-axis showing quiz scores for a specific term and the y-axis displaying the corresponding leaderboard rank. A clear trend emerges, indicating that higher scores across terms correlate with better (lower) rankings, $r = -0.993$, $p<0.001$. These findings confirm a strong negative relationship between quiz scores and leaderboard positions and suggest that consistent high performance across terms leads to better rankings, emphasizing the importance of sustained academic effort. The near-perfect negative correlation underscores the reliability of quiz scores as a predictor of leaderboard success, where small variations in scores can significantly impact ranks, especially for top performers.

However, some students deviate from this general trend. For example, Student 1, with an above-average quiz performance (+25.73 deviation), ranks 21 places higher than expected, while Student 2, with a lower performance (−16.32 deviation), ranks 15 places lower. Such outliers, like Student 15 (+20.10 deviation, 17 ranks higher) and Student 17 (−20.69 deviation, 17 ranks worse), suggest that factors beyond quiz scores —such as participation, engagement, or other academic contributions—may influence rankings. These deviations emphasize the impact of performance fluctuations on rankings. For example, Student 39 (with a +24.37 deviation and 20 ranks higher in the Final term) demonstrates how strong performance in a single term can boost rankings, while Student 9 (−24.24 deviation, 20 ranks worse) and Student 24 (−23.05 deviation, 19 ranks worse) show how poor performance in earlier terms can adversely affect overall standing.

Figure 3. Relationship between quiz performance and leaderboard rankings across terms

4.2. Patterns in Student Performance Relative to Leaderboard Position

The heatmap, as shown in Figure 4, offers a comprehensive and visually intuitive overview of student performance trends across the three assessment periods: prelim, midterm, and final term. Leveraging a gradient color scale, this visualization effectively illustrates rankings, with lighter shades indicating higher ranks (closer to 1) and darker shades representing lower ranks (closer to 45). The gradient design ensures that patterns in performance, such as consistent high ranks or significant fluctuations, are easily discernible even at a glance. Students with stable performance across all assessments appear in uniform color bands, while those with variable rankings show transitions in shade intensity. This visualization aids in identifying students' trajectories over time, revealing key moments of growth, consistency, or struggle throughout the course.

During the prelim assessment, the heatmap displays a broad spectrum of rankings, reflecting the diverse levels of preparedness among students at the start of the course. High-ranking students demonstrate a strong initial grasp of the material, suggesting prior knowledge or effective study habits. On the other hand, students in lower tiers may have encountered challenges in understanding foundational concepts or adjusting to the course's demands. The distribution of rankings also indicates areas where instructional support could be targeted, especially for students who began the course with difficulties. This initial snapshot provides valuable insights into how students enter the learning process and establishes a baseline for tracking progress.

As the course progresses into the midterm period, the heatmap uncovers noticeable shifts in student rankings, signaling the dynamic nature of academic performance. Several students achieve significant improvements, with their rise in rankings reflecting their ability to adapt to the course material or refine their learning strategies. However, some students experience declines, potentially due to increased

academic demands or external challenges affecting their focus and engagement. These shifts highlight the midterm as a pivotal period where student performance begins to diverge, separating those who build on their initial efforts from those requiring additional support. This phase of the heatmap also underscores the influence of instructional strategies and course design on student outcomes.

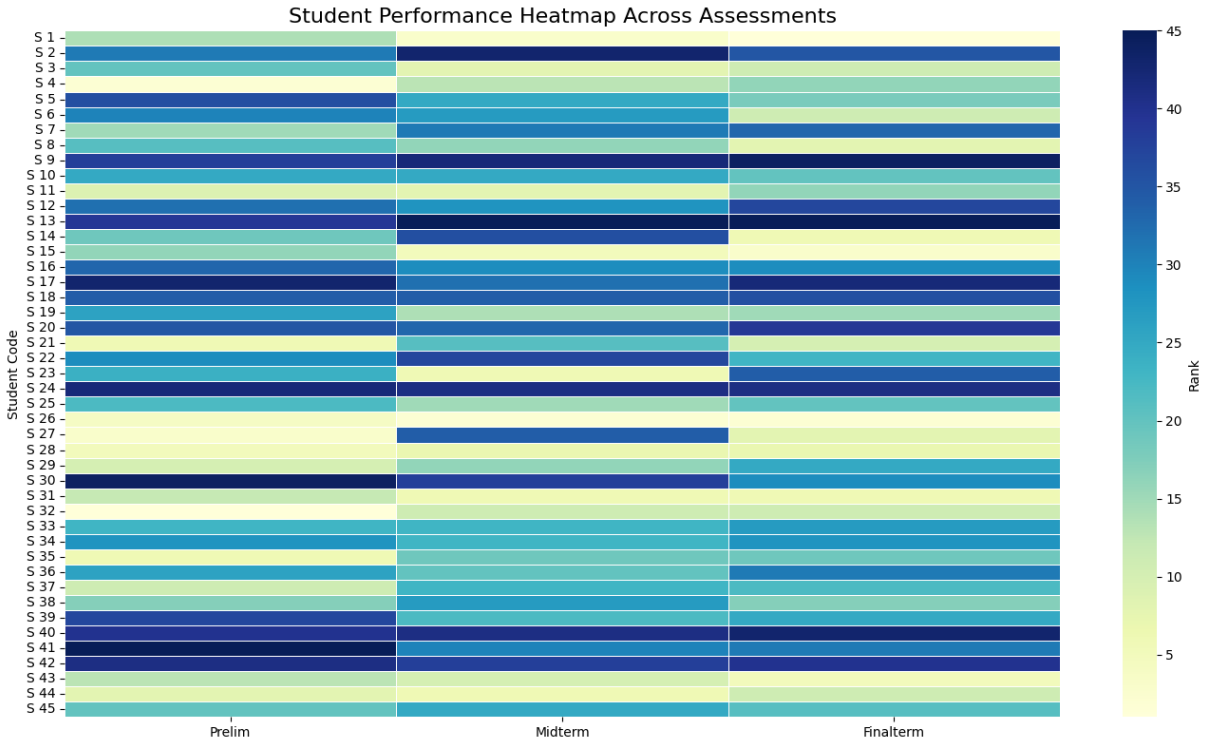

Figure 4. Student performance patterns across assessment periods

Final term rankings showcase the culmination of students' efforts and persistence, as depicted in the heatmap's patterns. Students with consistent high performance maintain their top rankings, emphasizing their sustained engagement and mastery of the material. In contrast, students with fluctuating rankings reveal varying levels of adaptability, with some achieving last-minute improvements while others face continued struggles. The heatmap further illustrates the lasting impact of early performance, as students who started strong tend to retain their advantage. These patterns underscore the importance of both resilience and long-term effort in academic success. The visualization provides instructors with a comprehensive understanding of how students conclude the course and helps identify those who might benefit from targeted interventions.

The box plot (see Figure 5) complements the heatmap by offering a statistical breakdown of individual student rankings. Each student, labeled from "S1" to "S45," is plotted on the y-axis, while their rankings are displayed along the x-axis, ranging from 1 (highest) to 45 (lowest). This visualization delves deeper into the nuances of student performance, highlighting the range and consistency of their rankings. Students with narrow interquartile ranges (IQRs), such as Student 1 and Student 3, demonstrate steady performance, indicating a reliable understanding of course material across all assessments. Wider IQRs, observed in students like Student 20 and Student 35, suggest greater variability, pointing to external factors or content-specific challenges that influenced their rankings.

Outliers, evident for certain students, represent instances where performance deviated significantly from their usual trends. For example, an outlier for Student 15 might indicate a remarkable achievement or an unusually low performance during a specific assessment period. These deviations offer opportunities to investigate the reasons behind sudden changes, providing valuable insights into student experiences and potential barriers to learning. The box plot's horizontal layout ensures clarity in interpreting these patterns,

facilitating comparisons between students' consistency and variability. Together, the heatmap and box plot provide a comprehensive narrative of student performance, enabling educators to evaluate the efficacy of leaderboard systems and identify actionable strategies for fostering improvement.

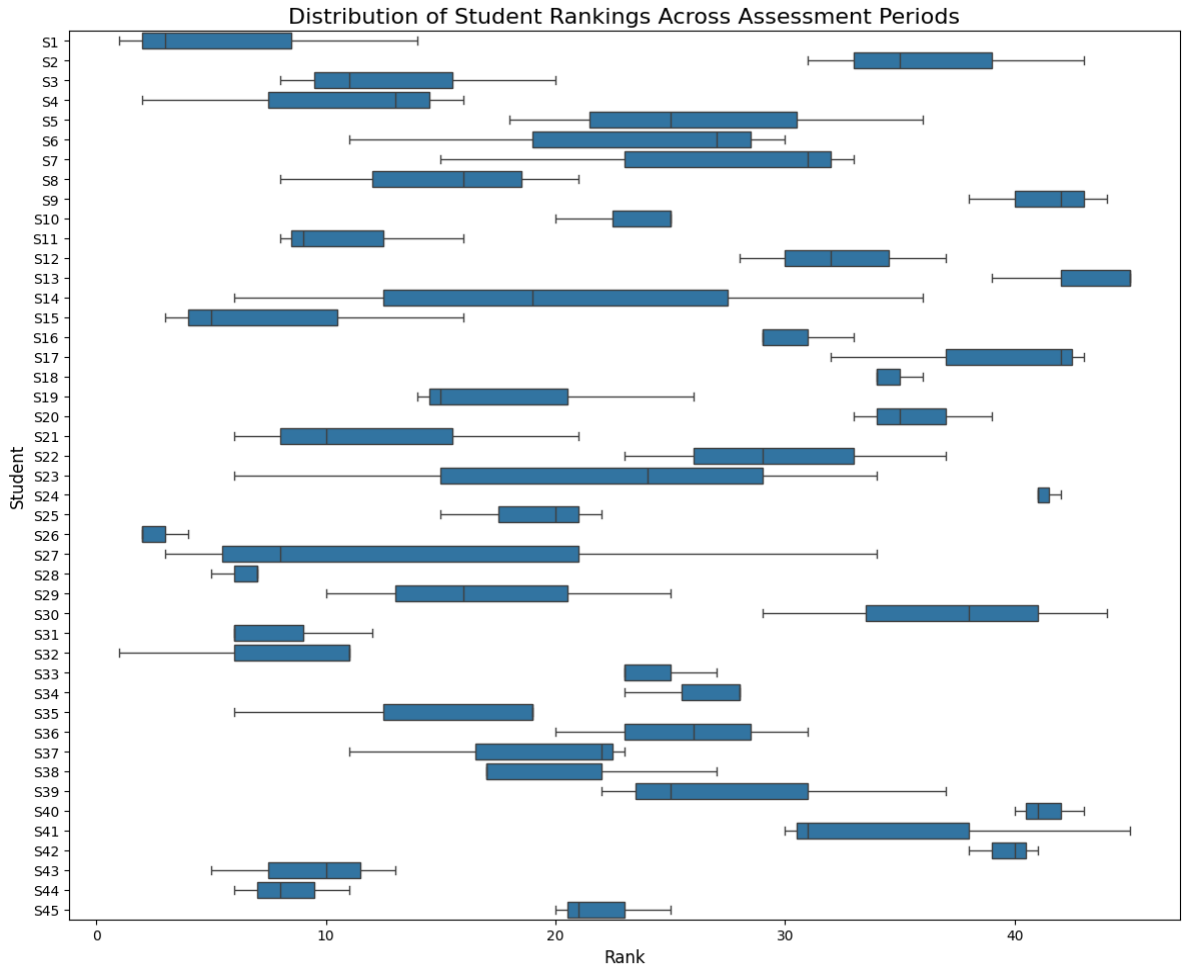

Figure 5. Distribution of rankings visualized by consistency and variability

4.3. Self-Perceptions of Growth and Learning Strengths

This section explores how students describe their personal growth and learning strengths in relation to their experiences with the leaderboard system. The analysis focuses on themes derived from their reflections, capturing the nuanced ways the system influenced their academic journeys.

4.3.1. Motivational Drivers and Goal Orientation

Students repeatedly highlighted how the leaderboard system motivated them to strive for excellence. Many described setting specific goals tied to their performance. For example, Student 3 mentioned, *"Seeing my name climb higher on the leaderboard pushed me to work harder every week. I wanted to stay in the top five, and that kept me focused."* This sense of goal orientation extended beyond academic tasks, encouraging students to manage their time better and maintain consistent effort.

Similarly, Student 8 reflected, *"The leaderboard gave me a reason to go beyond my comfort zone. I wasn't just competing with others; I was competing with myself to improve."* This combination of external recognition and internal drive underscored how the system fostered both competitiveness and self-improvement among students.

4.3.2. Resilience and Adaptive Learning

The leaderboard system also taught students how to handle setbacks and adapt their learning strategies. For instance, Student 2 shared, *"When I didn't do well on one task, I felt disappointed, but I realized I needed to try a different approach. I started asking for feedback and focused on improving."* These experiences encouraged students to develop resilience and experiment with new learning methods.

Another student emphasized persistence despite challenges. Student 9 stated, *"It was tough to see myself drop in rank, but it made me push harder the next time. I learned not to give up, even when things didn't go my way."* Such reflections highlight the system's role in cultivating a growth-oriented mindset, helping students embrace challenges and actively seek solutions.

4.3.3. Self-Awareness of Strengths and Areas for Improvement

Engagement with the leaderboard prompted students to reflect critically on their strengths and weaknesses. For example, Student 5 noted, *"Seeing my scores compared to others helped me realize that I was good at problem-solving but needed to improve my writing skills."* This process of self-reflection became a tool for identifying personal growth areas.

Student 7 echoed this sentiment, explaining, *"The leaderboard acted like a mirror. It showed me what I excelled at and where I needed more work. It pushed me to take action to improve myself."* These insights fostered accountability, as students took ownership of their learning journeys.

4.3.4. Peer Influence and Collaborative Dynamics

Although the leaderboard system introduced an element of competition, it also fostered collaboration among students. Student 4 shared, *"When I saw my classmates doing well, I felt inspired to ask for their advice. They were always willing to share tips, and it turned the competition into an opportunity for teamwork."* This dynamic helped students leverage peer relationships to enhance their learning.

Others emphasized how collaboration emerged naturally. Student 1 explained, *"We formed study groups to help each other. It wasn't about just one person succeeding; we wanted to make sure everyone improved together."* These collaborative dynamics illustrate how the system encouraged both individual and collective success.

4.3.5. Confidence Building Through Achievement Milestones

Achieving high ranks or improving their standings on the leaderboard boosted students' confidence significantly. Student 10 stated, *"Reaching a new rank made me feel accomplished. It reminded me that I could succeed if I put in the effort."* These small victories often had a lasting impact, helping students stay motivated.

Another student reflected on how these milestones shaped their mindset. Student 6 shared, *"Every time I moved up in the rankings, it was like proof that hard work pays off. It made me believe in myself more, not just in school but in everything I do."* These moments of success exemplify how the leaderboard acted as a tool for building self-efficacy and fostering a growth mindset.

4.4. Adjustments Made to Improve Understanding and Leaderboard Rankings

In their journey through mathematical physics, students faced various challenges, requiring significant adjustments in their study habits and learning strategies. Their reflections highlight a spectrum of experiences, from overcoming difficulties with abstract concepts to finding specific topics easier to understand. The following subthemes delve into the students' adjustments, challenges, strategies, and areas of confidence, providing a comprehensive view of their learning experiences.

4.4.1. Adjustments in Study Habits

Faced with the demands of mathematical physics, students adopted new study habits to enhance their understanding. Student 29 reflected, *"I shifted from passive reading to actively solving problems and explaining*

concepts to my classmates, which improved my comprehension." Similarly, Student 30 shared, *"I started breaking down problems into manageable steps and practicing daily to build my confidence."*

Online resources played a significant role in students' learning strategies. Student 33 said, *"Watching tutorial videos on YouTube has been my go-to method for understanding complicated lessons, as they often simplify the explanations."* Student 37 added, *"I downloaded apps that generate practice problems, and this helped me apply what I learned during class."*

The importance of peer learning was also evident. Student 34 stated, *"Discussing difficult topics with my classmates during group study sessions allowed me to see different approaches, which helped me understand better."* These adaptations highlight the students' proactive approaches to mastering the subject.

4.4.2. Challenges in Specific Topics

Abstract and multi-step topics proved to be significant challenges for many students. Student 26 admitted, *"Gradient, divergence, and curl were the hardest for me because they required an understanding of abstract concepts that I initially couldn't grasp."* Student 28 echoed this sentiment, saying, *"I struggled with partial derivatives. The multiple steps involved often made me lose track of what I was doing."*

Student 31 highlighted difficulties with implicit differentiation: *"I found implicit differentiation particularly challenging because it requires a completely different approach compared to standard derivatives."* Meanwhile, Student 32 shared, *"The formulas for implicit partial derivatives were overwhelming, and I had to revisit the basics to make sense of them."*

These struggles were not limited to derivatives. Student 38 reflected, *"Integrals with boundaries were difficult for me because I kept forgetting how to apply the limits correctly."* These accounts demonstrate the abstract and technical nature of mathematical physics, which often requires deeper conceptual understanding and repeated practice.

4.4.3. Strategies for Overcoming Difficulties

To address their challenges, students adopted diverse strategies. Student 30 shared, *"I joined study groups where I could discuss and clarify concepts with classmates. Their perspectives sometimes made the lessons easier to understand."* Similarly, Student 35 said, *"I started attending tutoring sessions and realized that having someone guide me through the process step-by-step was incredibly helpful."*

Others relied heavily on external resources. Student 28 stated, *"Watching tutorial videos on YouTube became my routine for tackling difficult topics."* S36 found online practice quizzes helpful: *"The quizzes helped me test my understanding and pinpoint areas I needed to work on."*

Technology also played a role. Student 32 explained, *"I used AI tools to generate random problems related to the lesson and solved them to test my knowledge."* Meanwhile, Student 34 emphasized the importance of repetition: *"I practiced every single day, especially on topics I found hardest, until I became more confident."* These strategies underscore the students' resilience and resourcefulness in overcoming academic hurdles.

4.4.4. Topics Students Found Easy

While many topics were challenging, students identified certain areas they found manageable. Student 30 remarked, *"I felt confident with vectors and their 3D representations because the visualization made it easier to understand."* Student 29 agreed, saying, *"Vectors were straightforward for me because I could easily relate them to real-world scenarios."*

Matrices also emerged as a topic of strength for some students. Student 34 shared, *"Matrices were the easiest for me to understand because the steps to solve them were systematic and logical."* Student 38 echoed this sentiment: *"I enjoyed working on matrices because they were more structured compared to other topics."*

For Student 27, basic Cartesian planes stood out as manageable: *"I understood Cartesian planes quickly because they were less abstract and more intuitive."* These reflections indicate that students often excelled in topics with clear, logical frameworks or those that lent themselves to visualization.

4.5. Impact of the Leaderboard System on Motivation

Leaderboards have become an increasingly common tool in educational settings, serving as a means of tracking academic progress and fostering motivation. While they can be a powerful source of inspiration for some students, their impact varies depending on how they are used and the students' individual perspectives. In this section, we explore the varied student experiences and opinions regarding the use of leaderboards in learning. The following subthemes highlight different aspects of leaderboards, such as their motivating effects, the pressures they can create, recommendations for their use in other subjects, and ideas for applying leaderboards across different subjects.

4.5.1. Motivational Impact Of Leaderboards

Leaderboards serve as a significant motivator for many students, providing a clear picture of their academic progress. For some, seeing their position on the leaderboard drives them to work harder and focus on areas of improvement. Student 24 shared, *"Leaderboards had a significant impact on my experience as a student. They motivated me to work harder because I wanted to see my name at the top,"* illustrating how competition can inspire effort. Similarly, Student 43 noted, *"Leaderboards have had a positive impact on my experience as a student. They helped me track my progress and motivated me to work harder."* The visual representation of one's progress can fuel the determination to climb higher on the rankings, making it particularly effective in subjects where measurable progress is easily tracked.

Other students echoed similar sentiments, with Student 27 highlighting how leaderboards help students *"identify my strengths and weaknesses, allowing me to adjust my study habits."* The clarity provided by leaderboards not only encourages students to excel but also reinforces their sense of responsibility toward their own learning. In subjects like math or science, where performance is easily measurable, students often feel that the use of leaderboards helps them *"track progress more effectively"* (Student 30), fostering a sense of accomplishment and achievement.

4.5.2. Stress and Pressure from Leaderboards

Despite their positive impact on motivation, leaderboards can also introduce stress and pressure, particularly for students who do not fare as well in comparison with their peers. Student 32 revealed, *"The leaderboards made me very anxious... it motivated me to try harder, but I also questioned my performance and wondered if I would make it to the top."* This anxiety is a common concern among students, as rankings may cause self-doubt or feelings of inadequacy, especially when students find themselves near the bottom of the list. Student 42 expressed a similar sentiment, saying, *"Seeing my name below on the ranks made me question my worth as a student... it lost a little confidence in me."*

The competitive nature of leaderboards can sometimes overshadow the intended purpose of learning. Student 28 acknowledged, *"Many students, including me, are not really okay when they know their standing in the class because they might feel sad or worried about the overall rating."* This suggests that for some, the leaderboard's focus on comparison could shift their attention away from personal growth and instead place undue emphasis on relative performance. As Student 39 pointed out, *"Some students may become disappointed or anxious upon seeing their ranking on a leaderboard, which might result in unhealthy competition."*

4.5.3. Recommendations for Improving Leaderboards

While leaderboards are appreciated for their motivational benefits, many students offer suggestions for improving their impact. Some recommend focusing on individual progress rather than direct comparison. Student 29 shared, *"My recommendation is to use leaderboards focusing on personal progress rather than public competition."* This approach could help students track their development without feeling the pressure of being compared to others. Similarly, Student 30 suggested, *"Anonymity... keeps our privacy while giving us a clear picture of where we stand,"* which would allow students to focus on self-improvement without the added pressure of public competition.

Students also proposed integrating leaderboards with other supportive elements. Student 37 suggested that students could review their graded papers along with leaderboard rankings, enabling them to *"check for grading errors that might affect our rank"* and *"understand where we made mistakes."* Incorporating feedback alongside leaderboards could enhance their educational value, making them tools for growth rather than mere competition. Student 31 recommended pairing leaderboards with *"collaborative learning activities"* to encourage both individual excellence and teamwork, thereby fostering a more supportive learning environment.

4.5.4. Broader Implications Across Subjects

The potential for applying leaderboards across various subjects elicited both enthusiasm and caution among students. Many, like Student 38, expressed optimism about their use in subjects such as chemistry, where assessments typically have clear right or wrong answers: *"Leaderboards are very beneficial to me, and I believe my fellow blockmates would agree too if our other subjects will use it, especially in our major subjects like chemistry."* In disciplines where performance can be objectively measured, leaderboards offer an effective way to motivate students and track their progress.

However, students also recognized the limitations of applying leaderboards in more subjective or creative fields. As Student 26 noted, *"I don't think leaderboards are good for all subjects. For things like math or science, where there's a clear right answer, maybe. But for subjects that need more creativity or discussion, leaderboards could be unfair."* The concern here is that in subjects such as literature or the arts, where creativity and critical thinking are central, leaderboards might hinder intellectual risk-taking and collaboration. Some students suggested adapting leaderboards by focusing on individual progress or incorporating group contributions, which could make the tool more inclusive and suitable for a wider range of disciplines.

4.6. Personal Growth And Lessons From The Leaderboard System

Engaging with mathematical physics fosters personal growth, especially when combined with innovative tools like leaderboards. This system motivates students to push beyond their limits, fostering resilience, adaptability, and collaboration. Students navigate challenges and transform setbacks into opportunities for growth. This section explores how the leaderboard system shaped students' development and key life lessons.

4.6.1. Personal Growth and Resilience

Students reflected on their learning experiences, emphasizing significant personal growth and resilience when tackling challenging topics in mathematical physics. Many expressed how their struggles with complex concepts, such as derivatives, curl, and divergence, pushed them to develop perseverance and adapt their study habits. As one student shared, *"Even if something seems impossible at first, consistent practice makes a difference. I also discovered that I understand concepts better when I visualize them or relate them to real-life problems"* (Student 29). Similarly, another student remarked on their newfound resilience, stating, *"The more difficult the obstacles we face, the more resilient and determined we become. In the end, it will all be worthwhile, despite the difficulties often seeming insurmountable"* (Student 39).

These reflections underline the transformative power of perseverance in academic settings. Another student elaborated, *"Initially, I felt scared of hard problems, but I learned to take things step by step. Even when I made mistakes, I kept trying, and it paid off. This subject taught me to stay curious and not give up"* (Student 40). These sentiments reveal that overcoming academic challenges not only enhances subject comprehension but also builds self-confidence and a positive attitude toward learning.

4.6.2. Adaptation and Strategic Learning

A recurring theme in students' responses was their realization of the importance of strategic learning and adaptability. For instance, one student shared how they discovered the need for a proactive approach to mastering difficult concepts: *"Simply attending lectures wasn't enough; I needed a more proactive approach. This*

involved identifying effective study methods, such as consistent practice and seeking out supplementary resources like online tutorials and practice problems" (Student 27). This proactive stance proved instrumental in their academic success and boosted their confidence in overcoming obstacles.

Others highlighted the value of breaking down complex problems into manageable parts to foster understanding. *"When facing a complex derivative problem, I began to identify the components and tackle them one at a time, which not only helped clarify the steps but also improved my confidence"* (Student 28). Another student noted how technological tools supported their learning process: *"I've discovered that being patient and focusing on the process is important for me. I also found that I learn best when I can break things down and see them clearly, which is why I ask AI to generate random questions and solve them"* (Student 32). These insights demonstrate the role of adaptability and innovative strategies in overcoming academic difficulties.

4.6.3. Discovering Strengths And Potential

The journey through mathematical physics also allowed students to uncover hidden strengths and unlock their potential. For example, one student reflected, *"I discovered that I am capable of more than I initially thought. The challenges I faced pushed me to develop better problem-solving skills and taught me the importance of seeking help when needed"* (Student 31). Similarly, another student shared, *"I realized that I could overcome my fear of numbers, especially with a teacher who explains concepts clearly and creates a fun, light atmosphere in class"* (Student 43).

This self-discovery often translated into a broader appreciation for learning and personal growth. As one student succinctly put it, *"This experience taught me that with patience and hard work, I can overcome challenging ideas. It also showed me the importance of teamwork and asking for assistance when necessary"* (Student 36). Collectively, these reflections underscore the transformative impact of challenging coursework in fostering resilience, adaptability, and confidence in students.

5. Discussion

The findings of this study provide valuable insights into how the leaderboard system influenced academic performance and highlighted individual variations in student progress. Leaderboard rankings across assessment periods revealed that consistent high scores strongly correlated with top rankings, emphasizing the importance of sustained effort throughout the course. This aligns with the principle of cumulative performance as a determinant of academic success, a concept supported by prior research on the benefits of ongoing engagement in gamified learning environments (Lampropoulos & Sidiropoulos, 2024; Smiderle et al., 2020). However, deviations in rankings, particularly among students who exhibited improvement only in the final term, suggest that additional factors, such as participation and engagement, may also influence leaderboard standings. These patterns can be better understood through Self-Determination Theory proposed by Ryan and Deci (2000), which emphasizes that intrinsic motivation thrives when learners experience autonomy, competence, and relatedness. The leaderboard system may have fostered a sense of competence and relatedness among students, driving them to sustain their efforts and achieve higher rankings (Li et al., 2024). Moreover, the visible tracking of progress likely enhanced their intrinsic motivation by providing tangible evidence of improvement, reinforcing their sense of accomplishment and commitment to learning (Urhahne & Wijnia, 2023). Conversely, lower-ranking students may have experienced frustration in these psychological needs, which could explain the decline in motivation observed in some cases. Students who persisted and improved toward the latter part of the course also demonstrated characteristics aligned with Dweck's (2006) growth mindset, viewing challenges as opportunities for mastery rather than fixed limitations. The visibility of progress through the leaderboard may thus have supported both intrinsic motivation and growth-oriented behaviors, offering a more holistic explanation of the diverse motivational responses among students.

In addition, the heatmap visualization offered a dynamic perspective on student trajectories, underscoring patterns of stability, improvement, and decline across the three assessment periods. The prelim rankings revealed varying levels of preparedness, with high-performing students demonstrating a strong grasp of foundational concepts. Conversely, students in lower ranks highlighted potential gaps in prior knowledge

or difficulty adapting to the course demands. These results are consistent with findings by Kraft, Atieh, Shi and Stains (2024), which noted that initial academic preparedness plays a critical role in students' ability to navigate complex STEM courses. The midterm period emerged as a pivotal phase, with significant ranking shifts reflecting students' ability to adapt and refine their strategies. Such trends align with the concept of formative feedback loops, which underscore the importance of mid-course adjustments in improving student outcomes (Wickramasinghe & Timpson, 2006). Additionally, these shifts provide critical insights for educators to identify at-risk students and tailor instructional interventions to support their progress (Russell, Smith & Larsen, 2020). This phase also highlights the importance of fostering resilience and adaptability, skills that are essential for overcoming academic challenges in demanding courses like mathematical physics (Yang & Wang, 2022).

Moreover, the final-term rankings revealed the culmination of resilience and effort, with consistently high-performing students maintaining their top leaderboard positions. However, the data also pointed to late-stage surges by some students, suggesting the importance of adaptive learning strategies and the role of timely interventions. These patterns highlight the dual importance of early preparedness and sustained engagement, mirroring observations from studies on persistence and performance in gamified learning systems (Hellín et al., 2023). The heatmap's ability to capture transitions in student performance also offered instructors actionable insights for tailoring support to students who exhibited mid-course challenges. Furthermore, these late-stage improvements emphasize the value of fostering a growth mindset, as students who remained engaged despite early struggles demonstrated the potential for significant progress. This aligns with the work of Limeri, Carter, Choe, Harper, Martin, Benton et al. (2020), who argued that the belief in the ability to grow through effort and perseverance can lead to academic success, especially in challenging courses.

Notably, the box plot analysis complemented the heatmap by providing a detailed statistical breakdown of ranking variability and consistency. Students with narrow interquartile ranges demonstrated steady performance, indicating a reliable mastery of the course material. Meanwhile, wider IQRs and outliers revealed the diverse challenges faced by students, including sudden shifts in rankings. For example, students with high variability might have encountered external factors such as increased workloads or personal challenges, as discussed by Thi and Duong (2024) in their work on learning burnout and academic performance. Outliers offered further insights into exceptional achievements or setbacks, underscoring the need to understand individual experiences within the broader academic framework. These outliers also suggest that academic performance is not solely determined by academic effort but can be influenced by non-academic factors, such as personal motivation and emotional well-being (Gbollie & Keamu, 2017; Palardy, 2019). Additionally, examining these variations allows instructors to provide more personalized support, addressing both academic and personal challenges that may affect student learning outcomes.

Furthermore, the students' self-perceptions of growth and learning strengths suggest that the leaderboard system played a significant role in shaping their academic and personal development. As noted by the students, the system acted as both a motivational tool and a means of fostering resilience and self-reflection, driving goal orientation and persistence despite setbacks. Previous studies align with these observations, emphasizing the positive effects of gamified elements like leaderboards on intrinsic motivation and goal-setting (Ratinho & Martins, 2023). The competitive yet self-reflective nature of the system encouraged students to focus on both personal improvement and peer collaboration, further reinforcing the benefits of adaptive learning strategies (Zainuddin et al., 2019). Moreover, the students' accounts of increased confidence and self-efficacy through achievement milestones resonate with Bandura's (1997) work on self-efficacy, which posits that mastery experiences, such as improving rankings, are crucial in building belief in one's abilities. These results also highlight the dual role of the leaderboard in fostering competition while encouraging collaboration, a balance that has been shown to promote both individual and collective success in educational settings (Riar, Morschheuser, Zarnekow & Hamari, 2022).

Students also employed a range of strategies to overcome challenges in mathematical physics, adapting their study habits to improve both their understanding and leaderboard rankings. The shift from passive reading to active problem-solving, as highlighted by students, aligns with research indicating that active learning techniques, such as peer discussions and problem-based learning, significantly enhance comprehension and retention in STEM subjects (Ješková, Lukáč, Šnajder, Guniš, Klein & Kireš, 2022; Pinar, Panergayo, Sagcal, Acut, Roleda & Prudente, 2025). Additionally, the use of online resources, such as tutorial videos and apps for practice, reflects the growing role of technology in facilitating learning, as supported by studies showing that digital tools can provide personalized learning experiences and improve students' problem-solving skills (Aguanta, Augusto, Bajenting, Buayaban, Cruz, Fantonial et al., 2024; Celestino-Salcedo, Malayao, Salic-Hairulla, Castro & Mordeno, 2024; Guden, Alguno, Sayson, Magsayo & Malayao, 2024; Haleem, Javaid, Qadri & Suman, 2022). The reliance on peer learning and tutoring also resonates with findings by Tan and Jung (2024), who highlighted the importance of collaborative learning in deepening understanding and fostering academic resilience. However, the challenges faced by students with abstract concepts, such as gradients, divergence, and curl, align with literature that underscores the difficulty of mastering abstract mathematical concepts in physics without sufficient foundational knowledge (Mordeno, Sedurifa, Malayao & Nalipay, 2024; Rach & Ufer, 2020). Finally, students' success in topics like vectors and matrices, which offer clearer logical frameworks, supports research suggesting that students tend to perform better in topics with structured, visualizable content (Adipat, Laksana, Busayanon, Ausawasowan & Adipat, 2021). These results reflect students' adaptive strategies and the diverse learning paths required to succeed in complex STEM courses.

The findings also underscore the dual impact of leaderboards on student motivation, with both positive and negative consequences depending on individual perspectives and subject contexts. On one hand, leaderboards serve as powerful motivators, offering a clear representation of academic progress that drives students to improve and track their performance. This is consistent with studies highlighting that gamified elements like leaderboards can enhance student engagement and effort, particularly in subjects with measurable outcomes like math and science (Legaki, Xi, Hamari, Karpouzis & Assimakopoulos, 2020; Smiderle et al., 2020). However, the competitive nature of leaderboards can also induce stress and anxiety, particularly for students who perform poorly compared to their peers. This aligns with research suggesting that while competition can increase motivation for some, it may undermine confidence and well-being for others, potentially leading to negative psychological effects (Gilabert, 2023). Students' recommendations for more personalized leaderboards and integrating feedback echo findings by Cavalcanti, Barbosa, Carvalho, Freitas, Tsai, Gašević et al. (2021), who argue that providing individualized progress tracking and supportive feedback can help mitigate the adverse effects of competition. The suggestion to tailor leaderboard use to more objective subjects like mathematical physics while adjusting their design for subjective fields, such as the arts, further supports the idea that leaderboards should be adapted to the nature of the subject and the learning goals, ensuring they remain a tool for growth rather than a source of undue stress (Do et al., 2024).

Significantly, the significant role of the leaderboard system in fostering personal growth, resilience, and adaptability, particularly in the challenging domain of mathematical physics is highlighted. Students' reflections on overcoming academic difficulties align with research emphasizing the importance of perseverance in learning, with studies suggesting that facing and overcoming challenges cultivates resilience and boosts self-confidence (Bandura, 1997; Dweck, 2006). The students' realization of the value of strategic learning and proactive approaches mirrors the findings of Antonio and Prudente (2021), who argue that successful learners develop metacognitive skills and adapt their strategies to meet academic demands. The discovery of personal strengths through overcoming obstacles also mirrors previous studies on self-efficacy, where students' belief in their capabilities increases as they experience success in challenging tasks (Aikens & Kulacki, 2023). Furthermore, the integration of technology, such as AI, to support learning reflects recent trends in educational research, which highlight the role of digital tools in fostering innovative and personalized learning strategies (Funa & Gabay, 2024). Together, these insights

demonstrate that the combination of perseverance, adaptability, and innovative learning strategies can lead to significant personal growth, reinforcing the transformative power of education.

5.1. Practice and Policy Implications

The results of this study reveal important insights into the use of leaderboards as a tool for fostering student motivation, personal growth, and resilience, especially within the context of mathematical physics. Educators and policymakers can leverage these findings to enhance learning environments by incorporating leaderboards that emphasize personal progress over competitive rankings, thereby minimizing the potential negative effects of comparison and anxiety. In practice, this could involve adapting leaderboards to focus on individual improvement or providing anonymity, allowing students to focus on their own academic growth rather than comparing themselves to their peers. Moreover, pairing leaderboards with constructive feedback and collaborative learning activities could further promote a supportive environment that encourages resilience, adaptability, and the development of strategic learning habits. For policymakers, these results suggest that educational frameworks could integrate innovative tools like leaderboards into curricula in a way that promotes positive motivation while addressing the potential stress that could arise from unhealthy competition. Future guidelines for leaderboard implementation should prioritize personalization and inclusivity, particularly in subjects where performance is not strictly measurable, like the humanities and arts.

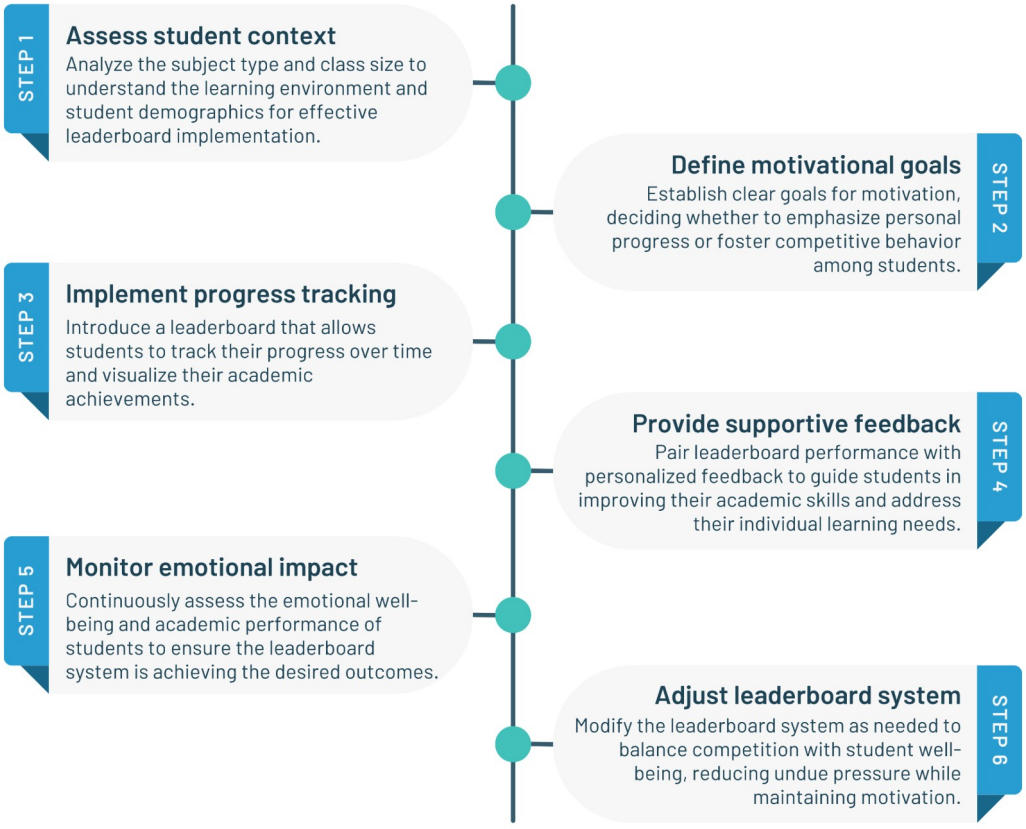

Figure 6. Suggested process for implementing leaderboards effectively in educational settings

5.2. Limitations and Future Directions

While this study provides valuable insights into the impact of leaderboards on student motivation and personal growth, there are several limitations that should be acknowledged. Firstly, the study was limited to a specific group of students within the field of mathematical physics, which may not fully capture the broader applicability of leaderboards across various disciplines. Additionally, the subjective nature of student experiences means that some of the effects of leaderboards, such as stress and anxiety, may not be

uniformly experienced across all students. The sample size, while representing the entire class, was relatively small, and future studies could expand the participant pool to include students from different educational levels and fields of study. Furthermore, this study primarily focused on the immediate effects of leaderboards on motivation and personal growth, with little exploration of their long-term impact on academic performance or student well-being. Future research could investigate how the use of leaderboards over time influences not only academic achievement but also broader psychological outcomes, such as self-esteem and attitudes toward learning. Exploring different leaderboard models and their potential impact across a wider range of subjects would also be valuable, as would investigating the role of teacher involvement in moderating the effects of leaderboards.

6. Conclusion

This study has explored the multifaceted impact of leaderboards on student motivation, personal growth, and resilience within the context of mathematical physics. It contributes to the growing body of research on gamified learning in higher education by providing empirical evidence on how leaderboard design influences both motivation and emotional well-being. The findings highlight that while leaderboards can serve as a powerful motivational tool, their impact is highly dependent on how they are implemented and the individual perspectives of students. On the positive side, leaderboards offer a clear and visual representation of progress, fostering a sense of accomplishment and encouraging students to push themselves further. They promote healthy competition, self-reflection, and strategic learning among students who respond positively to performance visibility. However, the competitive nature of leaderboards can also generate stress, anxiety, and a sense of inadequacy, particularly for lower-ranked students. These drawbacks underscore the need for careful moderation to ensure leaderboards remain motivating rather than discouraging.

The study underscores that adaptability and resilience are key mediating factors in how students experience gamified environments. The insights gained from this research offer valuable guidance for educators and policymakers looking to incorporate leaderboards into their teaching practices. Effective leaderboard design should emphasize personal progress over peer comparison, include formative feedback, and foster collaboration to balance motivation with well-being. In conclusion, leaderboards hold strong potential to enhance motivation and learning when implemented with attention to individual differences, subject context, and psychological safety. When designed thoughtfully, they can cultivate essential competencies such as resilience, adaptability, and self-directed learning. Future research should examine the long-term motivational effects of leaderboard use, their adaptability to diverse disciplines, and how design variations (e.g., anonymous, team-based, or personalized leaderboards) influence student engagement and equity.

Declaration of Conflicting Interests

The authors declare that there are no conflicts of interest related to the research, authorship, or publication of this study. No financial or personal relationships have influenced the work presented in this paper, and the authors affirm their commitment to ensuring the integrity and transparency of the study.

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References

Adipat, S., Laksana, K., Busayanon, K., Ausawasowan, A., & Adipat, B. (2021). Engaging Students in the Learning Process with Game-Based Learning: The Fundamental Concepts. *International Journal of Technology in Education,* 4(3), 542-552. https://doi.org/10.46328/ijte.169

Aguanta, C.B., Augusto, M.A.T., Bajenting, J.V., Buayaban, K.C., Cruz, E.J.P., Fantonial, N.F. et al. (2024). Factors affecting students' concept retention in learning science online using instructional videos. *Journal of Education and Learning,* 18(2), 499-511. https://doi.org/10.11591/edulearn.v18i2.21117

Aguilos, V., & Fuchs, K. (2022). The Perceived Usefulness of Gamified E-Learning: A study of Undergraduate students with implications for Higher education. *Frontiers in Education,* 7. https://doi.org/10.3389/feduc.2022.945536

Aikens, M.L., & Kulacki, A.R. (2023). Identifying group work experiences that increase students' Self-Efficacy for quantitative biology tasks. *CBE—Life Sciences Education,* 22(2). https://doi.org/10.1187/cbe.22-04-0076

Aldalur, I., & Perez, A. (2023). Gamification and discovery learning: Motivating and involving students in the learning process. *Heliyon,* 9(1), e13135. https://doi.org/10.1016/j.heliyon.2023.e13135

Alsadoon, E., Alkhawajah, A., & Suhaim, A.B. (2022). Effects of a gamified learning environment on students' achievement, motivations, and satisfaction. *Heliyon,* 8(8), e10249. https://doi.org/10.1016/j.heliyon.2022.e10249

Antonio, R.P., & Prudente, M.S. (2021). Metacognitive argument-driven inquiry in teaching antimicrobial resistance: Effects on students' conceptual understanding and argumentation skills. *Journal of Turkish Science Education,* 18(2), 192-217. https://doi.org/10.36681/tused.2021.60

Baah, C., Govender, I., & Subramaniam, P.R. (2023). Exploring the role of gamification in motivating students to learn. *Cogent Education,* 10(1). https://doi.org/10.1080/2331186x.2023.2210045

Balci, S., Secaur, J.M., & Morris, B.J. (2022). Comparing the effectiveness of badges and leaderboards on academic performance and motivation of students in fully versus partially gamified online physics classes. *Education and Information Technologies,* 27, 8669-8704. https://doi.org/10.1007/s10639-022-10983-z

Bandura, A. (1997). *Self-efficacy: The exercise of control.* WH Freeman/Times Books/Henry Holt & Co.

Birt, L., Scott, S., Cavers, D., Campbell, C., & Walter, F. (2016). Member checking. *Qualitative Health Research,* 26(13), 1802-1811. https://doi.org/10.1177/1049732316654870

Boateng, G.O., Neilands, T.B., Frongillo, E.A., Melgar-Quiñonez, H.R., & Young, S.L. (2018). Best Practices for developing and Validating scales for health, Social, and Behavioral Research: A primer. *Frontiers in Public Health,* 6. https://doi.org/10.3389/fpubh.2018.00149

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology,* 3(2), 77-101. https://doi.org/10.1191/1478088706qp063oa

Cao, Y., Gong, S., Wang, Y., Zheng, Q., & Wang, Z. (2022). How to provide competitors in educational gamification: The roles of competitor level and autonomous choice. *Computers in Human Behavior,* 138, 107477. https://doi.org/10.1016/j.chb.2022.107477

Cavalcanti, A.P., Barbosa, A., Carvalho, R., Freitas, F., Tsai, Y., Gašević, D. et al. (2021). Automatic feedback in online learning environments: A systematic literature review. *Computers and Education Artificial Intelligence,* 2, 100027. https://doi.org/10.1016/j.caeai.2021.100027

Celestino-Salcedo, R.K.M., Malayao, S.O., Jr., Salic-Hairulla, M.A., Castro, E.J., & Mordeno, I.C.V. (2024). Vodcast embedded with physics education technology simulation in learning projectile motion. *Journal of Education and Learning,* 18(3), 1047-1055. https://doi.org/10.11591/edulearn.v18i3.21434

Chan, S., & Lo, N. (2022). Teachers' and students' perception of gamification in online tertiary education classrooms during the pandemic. *SN Computer Science,* 3(3). https://doi.org/10.1007/s42979-022-01117-w

Chen, J., & Liang, M. (2022). Play hard, study hard? The influence of gamification on students' study engagement. *Frontiers in Psychology,* 13. https://doi.org/10.3389/fpsyg.2022.994700

Christopoulos, A., & Mystakidis, S. (2023). Gamification in education. *Encyclopedia,* 3(4), 1223-1243. https://doi.org/10.3390/encyclopedia3040089

Cigdem, H., Korkusuz, M.E., & Karaçaltı, C. (2023). Gamified learning: Assessing the influence of leaderboards on online formative quizzes in a computer programming course. *Computer Applications in Engineering Education,* 32(2), e22697. https://doi.org/10.1002/cae.22697

Cigdem, H., Ozturk, M., Karabacak, Y., Atik, N., Gürkan, S., & Aldemir, M.H. (2024). Unlocking student engagement and achievement: The impact of leaderboard gamification in online formative assessment for engineering education. *Education and Information Technologies,* 29, 24835-24860. https://doi.org/10.1007/s10639-024-12845-2

Creswell, J.W., & Plano-Clark, V.L. (2018). *Designing and Conducting Mixed Methods Research* (3rd ed.). SAGE Publications.

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From Game Design Elements to Gamefulness: Defining Gamification. In *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments* (9-15). ACM. https://doi.org/10.1145/2181037.2181040

Dichev, C., & Dicheva, D. (2017). Gamifying education: what is known, what is believed and what remains uncertain: a critical review. *International Journal of Educational Technology in Higher Education,* 14, 9. https://doi.org/10.1186/s41239-017-0042-5

Do, N., Jin, T., Priest, R., Meredith, L.N., & Landers, R.N. (2024). A longitudinal quasi-experiment of leaderboard effectiveness on learner behaviors and course performance. *Learning and Individual Differences,* 116, 102572. https://doi.org/10.1016/j.lindif.2024.102572

Dweck, C.S. (2006). *Mindset: The New Psychology of Success.* New York: Random House Publishing Group.

Funa, A.A., & Gabay, R.A.E. (2024). Policy guidelines and recommendations on AI use in teaching and learning: A meta-synthesis study. *Social Sciences & Humanities Open,* 11, 101221. https://doi.org/10.1016/j.ssaho.2024.101221

Gao, F., Rogers, K.C., & Li, L. (2024). Understanding students' perceived need satisfaction, enjoyment, and participation intention in a leaderboard-based math practice game. *E-Learning and Digital Media.* https://doi.org/10.1177/20427530241251407

Gbollie, C., & Keamu, H.P. (2017). Student academic performance: The role of motivation, strategies, and perceived factors hindering Liberian junior and senior high school students learning. *Education Research International,* 1. https://doi.org/10.1155/2017/1789084

Gilabert, P. (2023). Self-esteem and competition. *Philosophy & Social Criticism,* 49(6), 711-742. https://doi.org/10.1177/01914537221150464

Guden, J.M., Alguno, A.C., Sayson, N.L.B., Magsayo, J.R., & Malayao, S.O., Jr. (2024). Vodcast as ideating medium in STEM lesson plan in teaching heat transfer. *International Journal of Evaluation and Research in Education,* 13(4), 2562-2572. https://doi.org/10.11591/ijere.v13i4.28362

Haleem, A., Javaid, M., Qadri, M.A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers,* 3, 275-285. https://doi.org/10.1016/j.susoc.2022.05.004

Hebbar, S., Manohar, S., & Hungund, S. (2024). Examining gamification's impact on perceived satisfaction through learning parameters: a preliminary perception-based study among prospective users. *Interactive Learning Environments,* 1-20. https://doi.org/10.1080/10494820.2024.2417719

Hellín, C.J., Calles-Esteban, F., Valledor, A., Gómez, J., Otón-Tortosa, S., & Tayebi, A. (2023). Enhancing Student Motivation and Engagement through a Gamified Learning Environment. *Sustainability,* 15(19), 14119. https://doi.org/10.3390/su151914119

Hong, Y., Saab, N., & Admiraal, W. (2024). Approaches and game elements used to tailor digital gamification for learning: A systematic literature review. *Computers & Education,* 212, 105000. https://doi.org/10.1016/j.compedu.2024.105000

Jaramillo-Mediavilla, L., Basantes-Andrade, A., Cabezas-González, M., & Casillas-Martín, S. (2024). Impact of Gamification on Motivation and Academic Performance: A Systematic review. *Education Sciences,* 14(6), 639. https://doi.org/10.3390/educsci14060639

Ješková, Z., Lukáč, S., Šnajder, Ľ., Guniš, J., Klein, D., & Kireš, M. (2022). Active Learning in STEM Education with Regard to the Development of Inquiry Skills. *Education Sciences,* 12(10), 686. https://doi.org/10.3390/educsci12100686

Kalogiannakis, M., Papadakis, S., & Zourmpakis, A. (2021). Gamification in Science Education. A Systematic Review of the literature. *Education Sciences,* 11(1), 22. https://doi.org/10.3390/educsci11010022

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(8), 10053-10078. https://doi.org/10.1007/s10639-023-11585-z

Khaldi, A., Bouzidi, R., & Nader, F. (2023). Gamification of e-learning in higher education: a systematic literature review. *Smart Learning Environments,* 10, 10. https://doi.org/10.1186/s40561-023-00227-z

Koivisto, J., & Hamari, J. (2018). The rise of motivational information systems: A review of gamification research. *International Journal of Information Management,* 45, 191-210. https://doi.org/10.1016/j.ijinfomgt.2018.10.013

Kraft, A.R., Atieh, E.L., Shi, L., & Stains, M. (2024). Prior experiences as students and instructors play a critical role in instructors' decision to adopt evidence-based instructional practices. *International Journal of STEM Education,* 11, 18. https://doi.org/10.1186/s40594-024-00478-3

Krath, J., Schürmann, L., & Von-Korflesch, H.F. (2021). Revealing the theoretical basis of gamification: A systematic review and analysis of theory in research on gamification, serious games and game-based learning. *Computers in Human Behavior,* 125, 106963. https://doi.org/10.1016/j.chb.2021.106963

Lampropoulos, G., & Sidiropoulos, A. (2024). Impact of gamification on students' learning outcomes and academic performance: a longitudinal study comparing online, traditional, and gamified learning. *Education Sciences,* 14(4), 367. https://doi.org/10.3390/educsci14040367

Latorre-Cosculluela, C., Sierra-Sánchez, V., & Vázquez-Toledo, S. (2025). Gamification, collaborative learning and transversal competences: analysis of academic performance and students' perceptions. *Smart Learning Environments,* 12, 2. https://doi.org/10.1186/s40561-024-00361-2

Legaki, N., Xi, N., Hamari, J., Karpouzis, K., & Assimakopoulos, V. (2020). The effect of challenge-based gamification on learning: An experiment in the context of statistics education. *International Journal of Human-Computer Studies,* 144, 102496. https://doi.org/10.1016/j.ijhcs.2020.102496

Li, C., Liang, L., Fryer, L.K., & Shum, A. (2024). The use of leaderboards in education: A systematic review of empirical evidence in higher education. *Journal of Computer Assisted Learning,* 40(6), 3406-3442. https://doi.org/10.1111/jcal.13077

Licorish, S.A., Owen, H.E., Daniel, B., & George, J.L. (2018). Students' perception of Kahoot!'s influence on teaching and learning. *Research and Practice in Technology Enhanced Learning,* 13, 9. https://doi.org/10.1186/s41039-018-0078-8

Limeri, L.B., Carter, N.T., Choe, J., Harper, H.G., Martin, H.R., Benton, A. et al. (2020). Growing a growth mindset: characterizing how and why undergraduate students' mindsets change. *International Journal of STEM Education,* 7, 35. https://doi.org/10.1186/s40594-020-00227-2

Liu, Y., Zhou, Y., Li, Q., & Ye, X. (2022). Impact Study of the learning effects and motivation of competitive modes in gamified learning. *Sustainability,* 14(11), 6626. https://doi.org/10.3390/su14116626

Mekler, E.D., Brühlmann, F., Tuch, A.N., & Opwis, K. (2015). Towards understanding the effects of individual gamification elements on intrinsic motivation and performance. *Computers in Human Behavior,* 71, 525-534. https://doi.org/10.1016/j.chb.2015.08.048

Meng, C., Zhao, M., Pan, Z., Pan, Q., & Bonk, C.J. (2024). Investigating the impact of gamification components on online learners' engagement. *Smart Learning Environments,* 11*,* 47. https://doi.org/10.1186/s40561-024-00336-3

Mordeno, I.G., Sedurifa, E.N., Malayao, S.O., Jr., & Nalipay, M.J.N. (2024). What keeps students from learning physics? Development and validation of the Physics Amotivation Scale. *North American Journal of Psychology,* 26(3), 551-569.

Oliveira, W., Hamari, J., Joaquim, S., Toda, A.M., Palomino, P.T., Vassileva, J. et al. (2022). The effects of personalized gamification on students' flow experience, motivation, and enjoyment. *Smart Learning Environments,* 9*,* 16. https://doi.org/10.1186/s40561-022-00194-x

Oliveira, W., Hamari, J., Shi, L., Toda, A.M., Rodrigues, L., Palomino, P.T. et al. (2023). Tailored gamification in education: A literature review and future agenda. *Education and Information Technologies,* 28*,* 373-406. https://doi.org/10.1007/s10639-022-11122-4

Ortiz-Rojas, M., Chiluiza, K., Valcke, M., & Bolanos-Mendoza, C. (2025). How gamification boosts learning in STEM higher education: a mixed methods study. *International Journal of STEM Education,* 12(1). https://doi.org/10.1186/s40594-024-00521-3

Palardy, G.J. (2019). School peer non-academic skills and academic performance in high school. *Frontiers in Education,* 4. https://doi.org/10.3389/feduc.2019.00057

Park, S., & Kim, S. (2021). Leaderboard Design principles to Enhance learning and Motivation in a Gamified Educational Environment: Development Study. *JMIR Serious Games,* 9(2), e14746. https://doi.org/10.2196/14746

Pinar, F.I.L., Panergayo, A.A.E., Sagcal, R.R., Acut, D.P., Roleda, L.S., & Prudente, M.S. (2025). Fostering scientific creativity in science education through scientific problem-solving approaches and STEM contexts: a meta-analysis. *Disciplinary and Interdisciplinary Science Education Research,* 7, 18. https://doi.org/10.1186/s43031-025-00137-9

Prieto, G.A.S., Rodrigo, M.J.M., & Vieites, A.R. (2021). Competitive Debate: A successful inter-team gamification experience in the human resources subject. *Frontiers in Psychology,* 12. https://doi.org/10.3389/fpsyg.2021.708677

Rach, S., & Ufer, S. (2020). Which Prior Mathematical Knowledge Is Necessary for Study Success in the University Study Entrance Phase? Results on a New Model of Knowledge Levels Based on a Reanalysis of Data from Existing Studies. *International Journal of Research in Undergraduate Mathematics Education,* 6(3), 375-403. https://doi.org/10.1007/s40753-020-00112-x

Ratinho, E., & Martins, C. (2023). The role of gamified learning strategies in student's motivation in high school and higher education: A systematic review. *Heliyon,* 9(8), e19033. https://doi.org/10.1016/j.heliyon.2023.e19033

Riar, M., Morschheuser, B., Zarnekow, R., & Hamari, J. (2022). Gamification of cooperation: A framework, literature review and future research agenda. *International Journal of Information Management,* 67*,* 102549. https://doi.org/10.1016/j.ijinfomgt.2022.102549

Russell, J., Smith, A., & Larsen, R. (2020). Elements of Success: Supporting at-risk student resilience through learning analytics. *Computers & Education,* 152*,* 103890. https://doi.org/10.1016/j.compedu.2020.103890

Ryan, R.M., & Deci, E.L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist,* 55(1), 68-78. https://doi.org/10.1037/0003-066X.55.1.68

Ryan, R.M., & Deci, E.L. (2001). On happiness and human potentials: A review of research on hedonic and eudaimonic well-being. *Annual Review of Psychology,* 52*,* 141-166. https://doi.org/10.1146/annurev.psych.52.1.141

Schlömmer, M., Spieß, T., & Schlögl, S. (2021). Leaderboard Positions and Stress–Experimental Investigations into an Element of Gamification. *Sustainability,* 13(12), 6608. https://doi.org/10.3390/su13126608

Smiderle, R., Rigo, S.J., Marques, L.B., De-Miranda-Coelho, J.A.P., & Jaques, P.A. (2020). The impact of gamification on students' learning, engagement and behavior based on their personality traits. *Smart Learning Environments,* 7, 3. https://doi.org/10.1186/s40561-019-0098-x

Tan, S.E., & Jung, I. (2024). Unveiling the dynamics and impact of emotional presence in collaborative learning. *International Journal of Educational Technology in Higher Education,* 21, 44. https://doi.org/10.1186/s41239-024-00477-y

Thi, T.D.P., & Duong, N.T. (2024). Investigating learning burnout and academic performance among management students: A longitudinal study in English courses. *BMC Psychology,* 12, 219. https://doi.org/10.1186/s40359-024-01725-6

Tolentino, A.N., & Roleda, L.S. (2019). Gamified physics instruction in a reformatory classroom context. In *Proceedings of the 10th International Conference on E-Education, E-Business, E-Management and E-Learning* (135-140). ACM. https://doi.org/10.1145/3306500.3306527

Urhahne, D., & Wijnia, L. (2023). Theories of Motivation in Education: an Integrative Framework. *Educational Psychology Review,* 35, 45. https://doi.org/10.1007/s10648-023-09767-9

Wang, A.I., & Tahir, R. (2020). The effect of using Kahoot! for learning - A literature review. *Computers & Education,* 149, 103818. https://doi.org/10.1016/j.compedu.2020.103818

Wickramasinghe, S., & Timpson, W. (2006). Mid-Semester student feedback enhances student learning. *Education for Chemical Engineers,* 1(1), 126-133. https://doi.org/10.1205/ece06012

Xiao, Y., & Hew, K.F. (2024). Personalized gamification versus one-size-fits-all gamification in fully online learning: Effects on student motivational, behavioral and cognitive outcomes. *Learning and Individual Differences,* 113, 102470. https://doi.org/10.1016/j.lindif.2024.102470

Yang, S., & Wang, W. (2022). The role of academic resilience, motivational intensity and their relationship in EFL learners' academic achievement. *Frontiers in Psychology,* 12. https://doi.org/10.3389/fpsyg.2021.823537

Zainuddin, Z., Shujahat, M., Haruna, H., & Chu, S.K.W. (2019). The role of gamified e-quizzes on student learning and engagement: An interactive gamification solution for a formative assessment system. *Computers & Education,* 145, 103729. https://doi.org/10.1016/j.compedu.2019.103729

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