From Perception to Participation: A Case Study of Gamified Learning in Engineering Education

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Abstract: This study examines the relationship between gamification and Motivation, Perceived Learning, Teamwork, and Flow—a state of deep focus and enjoyment—among first and third semester university engineering students. Student responses were measured using the Motivation for Cooperative Learning Play Strategies (CMELAC) questionnaire at the semester's start and this feedback was used to inform and refine the implementation of gamified strategies in the courses to foster greater motivation and learning. Results showed a significant positive response, with 94% of students participating. On a Likert scale ranging from 1 to 5, where higher scores indicate greater agreement, the average ratings were as follows: 4.59 for Motivation, 4.27 for Perceived Learning, 4.32 for Teamwork, and 3.96 for Flow. Students were divided into two groups. First-semester students showed a moderately positive Spearman's correlation ($\rho = 0.675$) between Motivation and Perceived Learning, while third-semester students exhibited an even stronger correlation ($\rho = 0.778$) between these variables, suggesting that academic experience may be associated with increased responsiveness to gamified activities when highly motivated. Analysis revealed a consistent positive association between Motivation and Perceived Learning, while these findings do not establish causality, they indicate that well-structured gamification strategies tend to align with higher perceived learning when motivation is elevated. The stronger associations among advanced students point to the importance of tailoring gamification to students' academic level and familiarity with such strategies. These findings highlight the need for adaptable gamification approaches, requiring educators to adjust course design based on students' needs and levels. The study underscores the importance of structured, engaging activities with frequent feedback, especially for less advanced students, and shows that familiarity with gamification enhances its effectiveness. By measuring perceived effectiveness, educators can make informed pedagogical decisions and implement gamification from a holistic, evaluative perspective. Overall, the study provides insights on optimizing gamification to achieve educational goals through engaging, adaptive, and effective learning experiences.

Keywords: Educational innovation, Gamification, Motivation, Perceived learning, Personalized education, Engineering course engagement, Higher education

1. Introduction

Gamification is defined by Detering et al (2011) as "the use of game design elements in non-game contexts". This concept highlights the intent to apply the motivational dynamics and elements from games to influence user behavior across various domains, including education and training. Essentially, gamification seeks to foster participation, enhance engagement, and facilitate learning by simulating mechanisms that keep players immersed in gaming environments. In the context of engineering education, the relevance of gamification becomes clear when the unique demands of engineering courses are considered. Engineering courses are structured to integrate both theoretical knowledge and practical applications, equipping students with the technical skills required to solve real-world problems. As Sheppard et al (2008) note, effective engineering education must not only cover foundational theory but also encourage creativity, critical thinking, and adaptability—skills that align with the immersive and interactive nature of gamified strategies.

The course design principles applied in engineering education aim to support this multifaceted learning experience. Heywood (2005) emphasizes that course design in engineering education should follow principles like constructive alignment, therefore ensuring that learning objectives, instructional activities, and assessments are cohesively structured to facilitate deep learning. Further, he suggests incorporating collaborative learning experiences and leveraging educational technologies to enhance engagement and comprehension. These principles are particularly critical during the initial years of engineering education, as thoughtfully structured courses have been shown to improve student retention and motivation. Studies indicate that early exposure to design-focused, project-based learning enhances self-efficacy and professional skills, which allow for students' persistence in engineering programs (Sperling et al, 2024). Additionally, integrating interdisciplinary approaches, such as incorporating artistic elements into STEM curricula, can reinforce students' commitment to their studies, as highlighted by Mena-Avilés et al (2023). Understanding and applying effective educational strategies within engineering courses is key to shape versatile, competent professionals. As Anil Yasin and Abbas (2021) note, integrating both technical and non-technical skills into engineering programs equips graduates to meet industry demands and societal needs, addressing competencies like communication and teamwork alongside technical expertise. Moreover, active learning strategies have demonstrated effectiveness in enhancing student engagement and retention, ultimately leading to better academic outcomes (Berna t-Maso, 2024).

Recent research strongly supports tailoring gamification to meet the diverse needs of students. For instance, a review on adaptive gamification in education (Hallifax et al, 2019) notes that aligning game elements with individual learning preferences and abilities leads to enhanced engagement and academic performance, as it strengthens students' connection to the material. Moreover, Ortiz-Rojas et al (2019) demonstrate that customized leaderboard dynamics, adapted to student preferences, increase competitiveness and engagement.

Gamification has been implemented in engineering courses through various innovative approaches. In an e-learning course on agile methods (John and Fertig, 2024), elements such as quizzes, videos, and badges were utilized to enhance intrinsic motivation, resulting in improved engagement and comprehension among students. Additionally, the "UBI Journey" mobile game (Santos et al, 2024) promoted socialization and exploration among students by employing geofencing and rewards to support integration and engagement within a university setting. In a matrix modeling course for engineering students (Santos-Guevara, Rincon-Flores and Méndez, 2024), a reward-based system was designed to reduce anxiety and improve motivation, leading to positive shifts in students' emotional responses to challenging content.

To evaluate the effectiveness of the gamification strategies implemented in this study, the Questionnaire on Motivation for Cooperative Learning Play Strategies (CMELAC), developed by Manzano-León et al. (2021), was employed. This psychometrically validated instrument, specifically designed for university contexts involving gamified dynamics, enables the analysis of four key factors that influence student engagement. The first task motivation assesses the extent to which students feel driven to actively participate in the proposed activities, recognizing their value and relevance. The second, perceived learning, measures how students interpret their own process of knowledge acquisition within gamified environments. The third factor, teamwork, evaluates the quality of peer collaboration—an essential component of the gamified educational model and a cornerstone for developing collaborative competencies. Finally, the flow experience refers to the sense of immersion and enjoyment during the activity, which has been identified as a key predictor of sustained engagement. These constructs not only capture students' perceptions of gamified activities but also provide a robust framework for exploring the transition from intention to action in gamified settings, aligning with the goal of understanding which motivational and experiential elements drive genuine student involvement.

Recent studies, such as Abd Wahid et al. (2025), have demonstrated that interactive gamification through Wordwall significantly enhances student engagement and comprehension in literary contexts. Although conducted in secondary education, their findings support the broader applicability of gamified strategies in fostering motivation, focus, and collaborative learning—dimensions also explored in engineering education through instruments like CMELAC

The Questionnaire on Motivation for Cooperative Learning Play Strategies (CMELAC), developed by Manzano-León et al. (2021), was selected for its conceptual and methodological relevance in assessing key dimensions within gamified environments in higher education. This instrument features a concise structure of 16 items and demonstrates high internal consistency (Cronbach Index $\alpha > 0.78$), allowing for efficient administration without compromising psychometric validity. It employs a five-point Likert scale ranging from 1 (Strongly disagree) to 5 (Strongly agree), enabling accurate data collection on student perceptions. Its robustness lies in its ability to capture the transition from initial perception to actual student involvement through the correlation of its four constructs: task motivation, perceived learning, teamwork, and flow experience. As the authors note, "the instrument allows for the evaluation of students' perceptions regarding the impact of playful strategies on their motivation and learning," which aligns directly with the aim of this study—to understand how such perceptions translate into active participation in gamified contexts. The items used in this study, translated into English, were:

1. In general, I enjoyed this playful activity
2. I would repeat these types of activities
3. I have felt motivated
4. I improved my knowledge of the subject
5. My interest in the subject has increased
6. This activity format has been appropriate to check my knowledge of the subject
7. Helped me identify my weaknesses in the subject
8. It helped me understand the content of the subject
9. With these types of activities, I learn more than in traditional classes
10. I feel like I was able to connect with my teammates to learn
11. I learned from my classmates during the activity
12. I found the game elements fun
13. The game elements have motivated me to carry out the activity
14. While playing I was not aware of what was happening around me
15. I felt capable of carrying out the proposed activities
16. I found the activities comforting and valuable to me

In accordance with the classification proposed by Manzano-León et al. (2021) in the Development and Validation of a Questionnaire on Motivation for Cooperative Playful Learning Strategies, the CMELAC instrument groups its items into four key factors: Motivation for the task (items 1, 2, 3, and 13), Perceived Learning (items 4 through 9), Teamwork (items 10, 11, and 12), and Flow experience (items 14, 15, and 16). This categorization was used to analyze student responses and interpret their engagement with gamified learning activities.

2. Methodology

Building on evidence that supports the implementation of gamified strategies in engineering education, this study examines the impact of these educational innovation strategies on students' perceptions. The study proposes administering the CMELAC diagnostic questionnaire at the beginning of courses to evaluate students' perceptions regarding gamification. This approach enables the design of courses tailored to the specific needs of the student body, thereby promoting more active participation. Additionally, the aim is to strengthen students' connection with the course material, leading to enhanced learning and competencies development.

2.1 Research Approach

This descriptive study explores how first- and third-semester engineering students perceive gamified courses, focusing on examining the correlation between motivation, perceived learning outcomes, teamwork development, and flow experience during these activities.

2.2 Context of the Participants and Course Enrollment

The study was conducted in 2024 with first and third-semester engineering students (99 and 68 respectively) at a private university in Mexico. The sample comprised 115 men and 52 women (69% and 31% respectively). The students were enrolled in courses such as Differential and Integral Calculus, Physics on Conservation Laws, and Electrical Systems, where gamification was implemented as an educational innovation strategy. In Mexican engineering programs, the first three semesters are dedicated to general engineering education, with students from all disciplines interacting in shared courses. The subsequent five semesters focus on specialized training according to each student's chosen field. Therefore, selecting students from the first and third semesters was a strategic decision to capture perceptions during the foundational stage of their academic trajectory.

2.3 Data Collection Instruments

The CMELAC, previously validated in the Spanish university context, was utilized. This instrument assesses student motivation and learning perception in the implementation of playful strategies in the classroom. Since this genre of activities are defined as educational innovation tools, their use often implies that these methods differ from students' previous learning experiences. Therefore, implementing this questionnaire at the initial stage allowed for the tailoring of gamified activities designed to enhance learning through active participation.

2.4 Procedure

At the course outset, students were briefed on the educational innovation methodology to be employed, including the disciplinary and transversal competencies to be developed. They were informed about the project's objectives, scope, implications, confidentiality guarantees, and study limitations. Participation was voluntary, with students providing digital consent via an informed consent form.

During the first week, students completed the CMELAC, leading to adjustments in the instructional design of gamified activities. The study analyzed perception differences between first and third-semester students, with third-semester students having more prior experience in gamification. Figure 1 provides an illustration of the entire process and compares it with the actions undertaken to diagnose students' academic knowledge in an ordinary course.

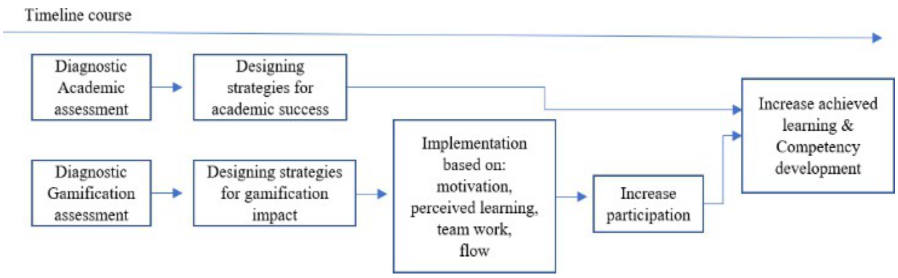

Figure 1: Procedure and CMELAC diagnosis timeline within a given course

2.5 Data Analysis

Statistical analysis methods, including frequency-based descriptive analysis and Spearman’s correlation analysis, were utilized to interpret the collected data.

3. Results and Discussion

The analysis of data from the CMELAC revealed several key patterns in students' perceptions. The data analysis uncovered some compelling relationships between key variables for both 1st and 3rd semester students. To validate significant monotonic correlations, Spearman's analyses (95%) were conducted on the responses to each segment, as illustrated in Figure 2 and Figure 3.

Pairwise Spearman Correlations		N	Correlation	95% CI for ρ
perceived learning 1st	motivation 1st	99	0.675	(0.536, 0.778)
team work 1st	motivation 1st	99	0.678	(0.540, 0.781)
flow 1st	motivation 1st	99	0.546	(0.378, 0.679)
team work 1st	perceived learning 1st	99	0.559	(0.393, 0.689)
flow 1st	perceived learning 1st	99	0.550	(0.383, 0.682)
flow 1st	team work 1st	99	0.541	(0.373, 0.675)

Figure 2: Motivation, perceived learning, teamwork, and flow, Spearman’s correlation coefficient. 1st semester engineering students with 95% CI

Pairwise Spearman Correlations		N	Correlation	95% CI for ρ
perceived learning erd	motivation 3rd	68	0.778	(0.642, 0.866)
team work 3rd	motivation 3rd	68	0.721	(0.563, 0.829)
flow 3rd	motivation 3rd	68	0.715	(0.555, 0.824)
team work 3rd	perceived learning erd	68	0.727	(0.571, 0.833)
flow 3rd	perceived learning erd	68	0.730	(0.575, 0.834)
flow 3rd	team work 3rd	68	0.695	(0.528, 0.811)

Figure 3: Motivation, perceived learning, teamwork, and flow, Spearman’s correlation coefficient. 3rd semester engineering students with 95% CI

Considering this study aims to anticipate students' level of participation and identify which motivational and experiential elements facilitate the transition from intention to action, we analyzed the constructs with the highest Spearman correlation coefficients across semesters. Among first-semester students, the strongest positive correlations were observed between motivation and teamwork ($\rho = 0.678$) and motivation and perceived learning ($\rho = 0.675$) as depicted in Figure 4, both indicating moderate associations. These findings are particularly relevant for instructional design, as they suggest that when students feel motivated by gamified activities, they are more likely to perceive meaningful learning and engage collaboratively. To leverage this insight, we implemented weekly gamified activities—primarily team-based and supplemented with immediate feedback—to sustain motivation and provide tangible evidence of learning progress, whether students were engaging with new content or reinforcing prior knowledge.

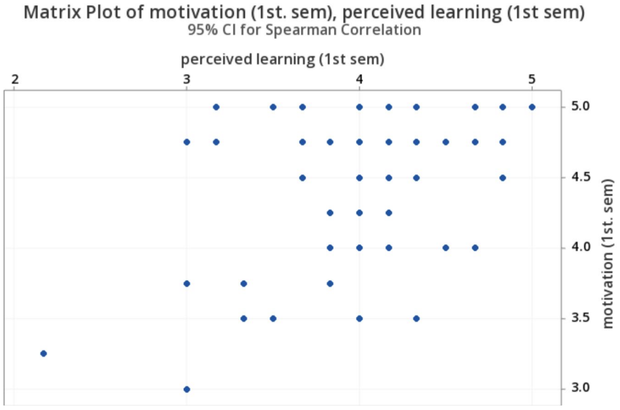

Figure 4: Correlation between Motivation and Perceived Learning among first-semester students

In contrast, the analysis for 3rd semester students revealed an even stronger Spearman's correlation of 0.778 between Motivation and Perceived Learning (IC 95%; 0.642, 0.866), as illustrated in Figure 5. This result indicates that more experienced students not only respond well to gamified activities but also experience greater learning benefits when they are highly motivated.

Additionally, we found a strong correlation of 0.730 between Perceived Learning and Flow (IC 95%; 0.575, 0.834), emphasizing the critical role of immersive and engaging experiences. To optimize these benefits, we refined our activities to ensure that they not only motivated but also fully engaged students, thereby enhancing both learning retention and interest through gamification.

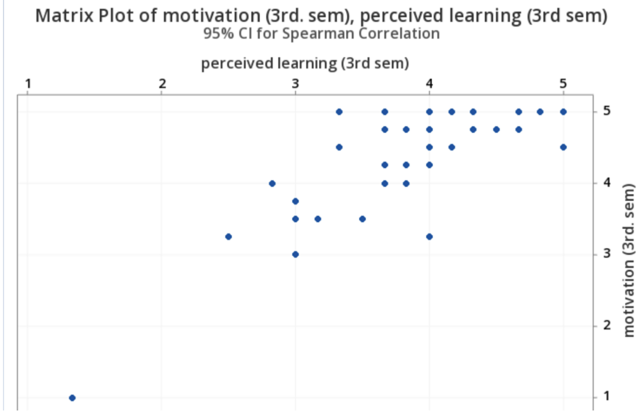

Figura 5: Correlation between Motivation and Perceived Learning among third-semester students

When analyzing the combined data from both groups, we found a consistent positive link between Motivation and Perceived Learning, as shown in Figure 6. This pattern suggests that well-designed gamification strategies can enhance perceived learning across the board when motivation is high. However, the stronger impact seen among more advanced students implies that the benefits of gamification increase as students advance academically.

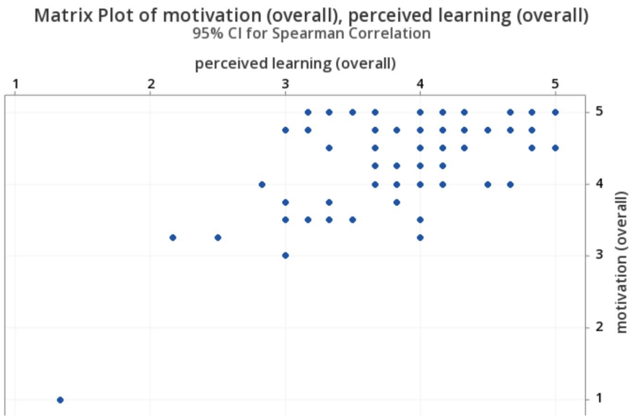

Figure 6: Correlation between Motivation and Perceived Learning among all students of both semesters

To further support these strategies, we developed an updated Activities and Competency Development Matrix (Table 2), based on the professional judgment and teaching experience of the academic team involved in this project. With over two decades of experience in university-level education, the team categorized various gamified activities—such as quizzes, team debates, interactive simulations, and gamified homework—according to their perceived impact on four key areas: Motivation, Perceived Learning, Teamwork, and Flow. While this matrix was not derived from statistical analysis, it reflects informed pedagogical reasoning and classroom experience across four student cohorts. Interactive simulations and team debates were considered particularly effective for fostering learning, teamwork, and engagement, making them suitable for immersive and collaborative environments. Quizzes and gamified homework, though less impactful for teamwork, were seen as useful tools for reinforcing learning and sustaining motivation through immediate feedback. Table 2 provides a practical framework for educators to design or select gamified activities aligned with specific instructional goals. Future studies may empirically validate this matrix to further refine its applicability across diverse educational contexts.

Table 2: Activities and Competency Development Matrix

Category	Quiz Challenges	Team Debates	Interactive simulations	Gamified Homework
Motivation	High	Medium	High	High
Teamwork	Low	Medium	Low	Low
Comprehension	Medium	High	High	Medium
Engagement	High	Medium	Medium	Low

Note: Ratings are based on expert consensus and prior teaching experience; empirical validation is recommended in future research.

Overall, these insights highlight the need for a thoughtful and adaptable approach to gamification. Professors should be prepared to adjust their course design and teaching methods based on students' needs, academic levels, and classroom dynamics. Much like academic assessments require adjustments to course content and schedules, gamification also demands flexibility. Although the matrix presented is grounded in expert judgment rather than empirical data, it underscores the importance of having a set of pre-designed gamified activities that can be seamlessly integrated into lesson plans to support effective learning outcomes.

The analysis also showed that 3rd semester students exhibited stronger correlations across all variables, suggesting that they have more confidence in the benefits of gamification. This observation is supported by the higher correlations in Figure 3, which indicates that as students become more familiar with gamified learning methods, they tend to appreciate and respond to these approaches more. Therefore, when designing gamified educational activities, it is important to consider generational differences and create immersive experiences for advanced students.

The integration of gamification into educational settings has been extensively researched, with studies affirming its potential to enhance student motivation, engagement, and learning outcomes. For example, Dichev and Dicheva (2017) found that incorporating game design elements into education can significantly increase learners' motivation and engagement. Sailer (2020) expanded on this by proposing the theory of gamified learning, which outlines how instructional content, behaviors, game characteristics, and learning outcomes are interlinked in gamified environments. Additionally, Oliveira et al. (2023) conducted a systematic review that highlighted the versatility of gamification across various educational contexts, emphasizing its widespread applicability. Further research by Daineko et al. (2023) demonstrated that tailored gamification strategies could improve students' concentration, engagement, and performance while reducing frustration and demotivation.

In summary, our study identifies a consistent association between students' experience levels and their reported Motivation and Perceived Learning in gamified environments. To support educational outcomes, strategic and flexible planning with a diverse range of activities remains essential. The observed generational differences suggest that students' responsiveness to gamification may evolve over time, reinforcing the need for continuous innovation and adaptation in instructional design.

4. Conclusion

The study's findings emphasize that gamification, when thoughtfully implemented, may inform the transformation of instructional strategies. Like academic diagnostics, which requires professors to adapt their approaches based on students' knowledge levels, this gamification diagnostic approach necessitates flexible and data-driven course design. The moderate correlation observed among 1st semester students highlights the relevance of implementing structured and engaging activities with frequent feedback to sustain student motivation and enhance perceived learning.

The much stronger correlations found among 3rd semester students are associated with greater appreciation and trust in these learning methods. This suggests that gamified strategies may become more impactful as students' progress and gain familiarity with them, reinforcing the idea that a gradual introduction to gamification could yield long-term benefits. Educators can use this insight to scaffold gamified activities throughout the curriculum, increasing complexity and immersion as students advance.

The combined analysis supports the use of gamification across different academic levels but also underscores the need for tailored approaches. Understanding these relationships enables teachers to design more effectively gamified activities. For instance, if students respond well to team-based projects, continuing this approach may help sustain motivation and support perceived learning. Additionally, the matrix serves as a practical guide for selecting activities that align with desired competencies, emphasizing that strategic planning is essential to maximize the impact of gamification.

Moreover, these findings highlight the value of measuring the effectiveness of gamification with specific instruments. By assessing whether gamified activities are perceived to support learning, educators can make informed decisions about implementing or refining these strategies. This approach ensures that gamification is not just an engaging tool but also a pedagogically sound method that may contribute to meaningful learning experiences. The segmentation analysis further suggests that generational differences in responsiveness to gamification should be considered, with more immersive and reinforcing experiences being particularly effective for advanced students.

Overall, the study contributes to the understanding of how gamification can be optimized to support educational goals, providing educators with actionable insights for designing engaging, adaptive, and effective learning experiences.

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AI declaration: No AI tools were used in the development of this paper.

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