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Enhancing Student Motivation and Learning in Engineering Mathematics through Challenge-Based and Game-Based Learning

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***Abstract*– Challenge-Based Learning (CBL) and Game-Based Learning (GBL) have emerged as effective pedagogical strategies to enhance student engagement, motivation, and deep learning in engineering education. This study explores the impact of integrating CBL and GBL in an undergraduate integral calculus course within an engineering program, using a space exploration narrative to contextualize mathematical concepts. The intervention was structured around an eight-week mission where students applied definite and indefinite integrals, areas, volumes of revolution, optimization, and differential equations to solve real-world space navigation challenges. A total of 104 first-year engineering students, divided into an experimental group (CBL + GBL) and a control group (traditional learning), participated in the study.**

Quantitative results indicate a significant increase in motivation (+48%), interest in the course (+45%), and teamwork perception (+42%) in the experimental group compared to the control group. The most notable effect was a 70% increase in interest in space and orbital mechanics, demonstrating the effectiveness of thematic and problem-driven learning. Although students found the game-based approach more challenging, they also rated it as significantly more enjoyable. Qualitative feedback highlighted greater engagement, deeper conceptual understanding, and improved collaboration among peers.

These findings suggest that embedding interactive, problem-driven learning experiences into engineering mathematics instruction enhances motivation, academic interest, and real-world application competencies. The study provides evidence supporting the integration of game-based challenges and thematic narratives in STEM education, reinforcing the role of active and immersive learning strategies in shaping future engineers.

Keywords-- Challenge-Based Learning, Game-Based Learning, Engineering Education, Mathematics Education, Student Engagement.

I. Introduction

Contemporary higher education faces the challenge of providing students not only with conceptual knowledge but also with the practical competencies and mindset necessary to address complex real-world problems. Traditional lecture-based instruction, while effective in transmitting theoretical content, often fails to engage students in ways that promote deep learning, critical thinking, and sustained motivation. To bridge this gap, innovative pedagogical frameworks such as Game-Based Learning (GBL) and Challenge-Based Learning (CBL) have emerged, offering dynamic approaches that foster student engagement and enhance the application of knowledge in meaningful contexts [1,2].

GBL integrates game mechanics, including narratives, point systems, leaderboards, and role-playing, to create immersive and interactive learning experiences. These elements enhance motivation, facilitate deeper cognitive engagement and improve problem-solving competency. Recent research highlights the positive impact of game-based learning strategies on higher-order thinking competencies in mathematics, showing that students engaged in structured gaming experiences perform significantly better in analytical and problem-solving tasks [2]. Furthermore, the integration of educational games into teaching has been shown to improve self-efficacy among educators, making them more confident in adopting innovative instructional strategies [3].

CBL, in turn, builds upon the principles of Project-Based Learning (PBL) by engaging students in real-world challenges that require interdisciplinary problem-solving and collaboration. Unlike traditional PBL, where problems are predefined by instructors, CBL encourages students to identify, analyze, and address issues that hold societal relevance. This approach fosters a sense of agency in learners while promoting deep engagement with the subject matter. Studies have demonstrated that CBL-based frameworks, when supported by digital and e-learning strategies, contribute to the development of transversal competencies such as teamwork, leadership, and adaptive problem-solving [4].

This study presents a pedagogical model that integrates CBL and GBL through an educational role-playing game (RPG) centered on space exploration. At the beginning of the course, students are introduced to a real-world inspired scenario in which a fellow astronaut is stranded in an orbit between Earth and the Moon. Their mission is to apply the mathematical and physical concepts learned throughout the semester to plan and execute a successful rescue operation. Each class session introduces new theoretical content, which is immediately applied to mission-related challenges. Students earn points and unlock strategic advantages that affect the trajectory of their mission, reinforcing engagement and collaborative problem-solving.

The integration of game mechanics within a challenge-based framework not only facilitates knowledge acquisition but also fosters essential transversal competencies such as teamwork, decision-making under uncertainty, and adaptive problem-solving—competencies that are critical in 21st-century education [8]. The effectiveness of this approach has been recognized in recent European initiatives, such as the DIFUCH Erasmus+ Project, which leverages CBL methodologies to enhance student-centered learning experiences in higher education [5].

By merging the strengths of CBL and GBL, this study proposes a structured, narrative-driven methodology that transforms abstract course objectives into tangible, real-world problem-solving experiences. As higher education institutions increasingly adopt innovative pedagogies, this model provides valuable insights into how gamified, challenge-based instruction can empower students to become proactive and trained problem-solvers across diverse disciplines. Additionally, considering the ongoing discussions on digital transformation in education, the findings from this study align with emerging policies advocating for competency-driven learning strategies in higher education [9-11].

II. Materials and Methods

A. Study context and participants

The study was conducted in the Mathematics I course within the Bachelor's Degree in Industrial Electronics and Automation Engineering (Grado en Ingeniería Electrónica Industrial y Automática) at the Polytechnic University of Valencia (Universitat Politècnica de València). The experiment lasted eight weeks, focusing specifically on the Integral Calculus and its applications module during the second semester of the 2023/2024 academic year.

A total of 104 first-year students participated in the study, divided into two groups: the *experimental group* (CBL + GBL approach) formed by 52 students engaged in a game-based challenge-learning approach integrated into their coursework, and the *control group* (traditional approach) consisting of 52 students that received traditional lecture-based instruction on the same topics. All students had already completed a first-semester course on Differential Calculus, providing them with a foundational understanding of derivatives, which is essential for Integral Calculus.

B. Context and game mechanics

For the experimental group, a CBL framework enhanced with GBL mechanics was implemented. The learning experience was framed around a realistic space exploration challenge: an astronaut is stranded in a stable orbit between Earth and the Moon. The mission is to design and execute a rescue plan using mathematical principles, optimizing resources and ensuring a successful return (see Fig. 1).

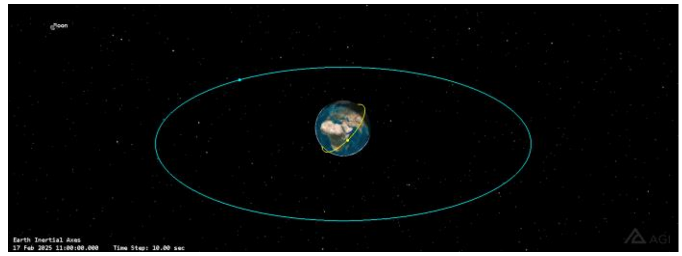

Fig. 1 Setting of the rescue mission employing STK 12 (AGI), a software that helps visualize the entire challenge.

To enhance the realism and engagement of the space exploration scenario, STK 12 (Systems Tool Kit) by AGI was utilized for the visualization and simulation of orbital mechanics. STK provided a dynamic environment where students could analyze trajectories, optimize maneuvers, and visualize orbital changes based on their mathematical computations. This tool allowed the experimental group to bridge theoretical concepts with practical applications by simulating real-world orbital mechanics, making abstract integral calculus problems more tangible. The integration of STK also facilitated a deeper understanding of space mission constraints, reinforcing the challenge-based learning approach by allowing students to test different strategies and visualize their impact in a highly interactive manner.

The methodology was structured around two parallel learning tracks:

1) Fundamental orbital mechanics concepts were introduced at the beginning of the challenge. These included mathematical and physical formulas needed to calculate trajectories, impulses, and maneuvers.
2) Integral calculus topics were progressively developed in parallel throughout the challenge.

Each session was structured as follows: first, a presentation of a mathematical topic is given. These topics include indefinite integrals, definite integrals, areas, volumes of revolution, surface areas of revolution, arc lengths, and a brief introduction to ODEs (Ordinary Differential Equations). Then, a mathematical problem-solving activity is conducted, which could either be directly related to the space rescue challenge or an independent problem. Regardless of its connection to the mission, solving the problem correctly awarded specific advantages for the mission, such as improved spacecraft fuel efficiency (higher specific impulse), increased fuel reserves, and access to advanced calculation tools (e.g., Mathematica).

Throughout the eight weeks, the challenge unfolded in sequential mission phases, each with strict deadlines. Students had to collaborate to complete calculations, optimize trajectories, and make strategic decisions. All work was conducted in fixed teams of four students, reinforcing peer learning, teamwork, and collaborative problem-solving.

C. Educational goals

The primary objectives of this methodology were to enhance student motivation and engagement, foster interest in engineering and develop a stronger academic vocation. Another objective was to encourage curiosity about space exploration and orbital mechanics.

D. Evaluation and data collection

To measure the effectiveness of the methodology, both quantitative and qualitative assessments were conducted.

1. Pre-test and post-test: A multiple-choice test assessed basic integral calculus concepts before and after the intervention. Students selected one or more correct answers per question, allowing for an in-depth evaluation of their comprehension.
2. Student perception survey: A Likert-scale questionnaire (1-5 scale) evaluated the following: motivation, interest in the subject, interest in engineering, interest in space and orbital mechanics, teamwork experience, perception of the game mechanics. Open-ended questions allowed students to suggest improvements and describe what they found most beneficial about the approach.
3. Mission success metrics (experimental group only): Team performance was assessed based on accuracy, efficiency, and creativity in mission problem-solving.

Participation in the survey was voluntary, and students were assured anonymity to encourage honest responses.

E. Data analysis

Data were analyzed using SPSS software, with Excel used for visualization. Shapiro-Wilk and Kolmogorov-Smirnov tests assessed data normality. Wilcoxon signed-rank test compared pre-test and post-test scores to determine learning improvement. Mann-Whitney U test evaluated differences in motivation, engagement, and stress levels between the experimental and control groups. Qualitative responses were coded thematically to identify trends in student perceptions and feedback.

By integrating quantitative performance analysis with qualitative insights, this study tried to provide a comprehensive evaluation of the impact of game-based challenge learning in mathematics education.

III. Results

A. Learning Performance Improvement

To assess the impact of the game-based challenge-based learning (CBL + GBL) methodology, pre-test and post-test results were compared between the experimental group (CBL + GBL) and the control group (traditional instruction). The pre-test and post-test scores were evaluated using a Wilcoxon signed-rank test for within-group comparisons and a Mann-Whitney U test for between-group comparisons.

TABLE I
Pre-test and Post-test comparison

Group	Mean Pre-test score	Mean Post-test score	Score Improvement
Experimental (CBL + GBL)	4.2 ± 1.1	7.8 ± 1.3	+3.6
Control (Traditional)	4.3 ± 1.2	6.5 ± 1.5	+2.2

The results, see Table I, indicate that the experimental group experienced a significantly greater improvement in their understanding and application of integral calculus compared to the control group ($p<0.01$). This suggests that the integration of CBL and GBL provided a more engaging and effective learning environment, leading to apparent better knowledge retention and problem-solving abilities. While the control group also showed progress, the lower gains suggest that traditional instructional methods, though effective in delivering content, were less successful in fostering deep engagement and practical application of mathematical concepts.

B. Motivation and engagement

Student motivation and engagement were assessed using Likert-scale (1-5) responses. Below are the average scores per category:

TABLE II
Perception

Item	Control Group	Experimental Group	% Increase
Motivation to Learn Mathematics	2.9 ± 1.0	4.3 ± 0.9	+48%
Interest in the Course	3.1 ± 1.1	4.5 ± 0.8	+45%
Interest in Engineering Studies	3.0 ± 1.2	4.2 ± 0.9	+40%
Interest in Space and Orbital Mechanics	2.7 ± 1.3	4.6 ± 0.8	+70%
Usefulness of Group Work	3.3 ± 1.0	4.7 ± 0.7	+42%
Perceived Difficulty of the Game	3.9 ± 1.2	4.1 ± 1.1	+5%
Enjoyment of the Activity	3.2 ± 1.1	4.6 ± 0.8	+44%

The study results reveal significant differences between the experimental group (CBL + GBL) and the control group (traditional teaching methods) in terms of motivation, engagement, and perceived learning experience (see Table II).

Students in the experimental group reported a 48% increase in motivation (4.3 ± 0.9) compared to the control group (2.9 ± 1.0). The gamified, mission-driven approach kept students engaged by providing continuous feedback, rewards, and immediate applications for the mathematical concepts covered in class. Unlike traditional instruction, which often feels disconnected from real-world applications, the space mission context created a strong sense of purpose, encouraging students to remain actively involved in problem-solving. These findings align with prior research on game-based learning, where structured gameplay and narrative-driven tasks enhance intrinsic motivation by fostering a sense of achievement and progress [1].

Interest in the mathematics course increased by 45% in the experimental group (4.5 ± 0.8) compared to the control group (3.1 ± 1.1). The combination of context-driven learning and interactive elements made the subject matter more engaging and meaningful. The ability to apply calculus concepts to optimize spacecraft maneuvers provided a clear connection between abstract theory and practical applications. This suggests that integrating theme-based learning into mathematics courses could be a valuable strategy for improving engagement in STEM fields, making the material feel less theoretical and more applicable [2].

A 40% increase in interest in engineering (4.2 ± 0.9 vs. 3.0 ± 1.2) was observed in the experimental group. The hands-on problem-solving approach, coupled with team collaboration and applied challenges, highlighted the interdisciplinary nature of engineering, making the field more attractive to students. The activity helped bridge the gap between theoretical mathematics and its applications in engineering, reinforcing students' perceptions of engineering as a dynamic and problem-solving discipline. This is particularly relevant for first-year students, as early engagement and motivation can influence long-term academic and career choices in engineering.

The most dramatic increase was observed in interest in space and orbital mechanics, which rose by 70% in the experimental group (4.6 ± 0.8) compared to the control group (2.7 ± 1.3). This highlights the power of thematic learning in sparking curiosity about advanced topics. By embedding integral calculus within a realistic space mission framework, students developed a greater appreciation for aerospace applications. The significant interest boost suggests that contextualized challenges can play a critical role in fostering enthusiasm for specialized STEM fields and may even encourage students to pursue careers in aerospace engineering, physics, or applied mathematics [3].

Perceptions of the value of teamwork increased by 42% (4.7 ± 0.7 vs. 3.3 ± 1.0) in the experimental group. The structured group-based approach of the activity required continuous collaboration, where students needed to exchange ideas, strategize, and distribute tasks efficiently. The fact that students could make collective decisions on spacecraft maneuvers, resource management, and optimization problems reinforced peer learning and collaborative problem-solving. The results suggest that CBL and GBL methodologies enhance teamwork competencies, which are critical for engineering and technical careers [4].

Interestingly, students in the experimental group rated the challenge only slightly more difficult (+5%) (4.1 ± 1.1 vs. 3.9 ± 1.2) compared to traditional methods. While gamified learning is often associated with higher cognitive demand, the structured support system—where students could earn better tools, fuel efficiency, and computational resources—helped them manage the complexity of the tasks. This finding suggests that even though CBL can introduce additional challenges, it does not overwhelm students when designed effectively. Instead, the challenge itself becomes a motivating factor, aligning with prior research on constructivist learning theories, which argue that meaningful difficulty enhances learning retention and competencies development [5].

Despite the slightly higher difficulty, students reported a 44% increase in enjoyment (4.6 ± 0.8 vs. 3.2 ± 1.1). This suggests that engaging, interactive, and immersive learning experiences do not sacrifice enjoyment—instead, they can enhance it. The narrative structure, the freedom to make decisions, and the immediate feedback from game mechanics contributed to an enjoyable and rewarding experience. Unlike traditional coursework, which can feel monotonous, the CBL + GBL approach transformed the learning process into an adventure, reinforcing the idea that engagement and fun are not mutually exclusive in education.

The results from this study reinforce the effectiveness of Challenge-Based and Game-Based Learning in improving motivation, subject interest, and teamwork perception. Notably, the significant increase in interest in space and orbital mechanics suggests that theme-based learning can play a transformative role in guiding student aspirations toward specialized STEM fields.

Additionally, the findings indicate that students are not discouraged by increased difficulty—instead, they embrace it when the learning process is structured as an interactive, goal-oriented challenge. The study provides compelling evidence that educators should integrate CBL and GBL methodologies in mathematics and engineering curricula to enhance student engagement, learning retention, and interdisciplinary connections.

Future research could expand this methodology to other STEM disciplines, exploring its long-term impact on student performance, career choices, and problem-solving competencies in real-world scenarios.

C. *Open-ended feedback*

To complement the quantitative findings, qualitative feedback from students was analyzed to gain deeper insights into their experiences with CBL and GBL. Open-ended responses were categorized into four key thematic areas: motivation, peer learning, interest in mathematics, engineering, and space, and negative perceptions and challenges. These reflections help us understand how students perceive the methodology and its broader impact.

1) Motivation & Engagement

"*I usually struggle to stay engaged in math classes, but the game aspect made me want to come to class and actively participate. It felt like I was solving a real challenge rather than just doing exercises*." (ST 2024-21)

"*The idea that every correct answer had an impact on the mission was exciting. I really wanted to get better at solving problems because I knew it would help our team.*" (ST 2024-32)

"*I liked that the course didn't feel like just another set of formulas to memorize. We had a goal, and we worked towards it step by step.*" (ST 2024-18)

The structured nature of the challenge-based activity, where students had a clear mission and immediate rewards, seemed to play a crucial role in increasing intrinsic motivation. Many students reported feeling more invested in learning integral calculus because it had direct applications in the mission, reinforcing prior research suggesting game-based environments enhance engagement by providing a sense of progress and achievement [1]. One significant observation is that gamification elements, such as the ability to unlock tools and improve their spacecraft's performance, fostered a growth mindset, where students felt encouraged to refine their problem-solving competencies rather than merely aiming for correct answers.

2) Peer Learning & Team Collaboration

"*Working in a team helped me understand concepts better because we all had different ways of approaching the problems. Sometimes, I thought I had the right answer, but my teammates would explain a better way*." (ST 2024-19)

"*The group discussions made me realize I learn more when I teach others. I ended up understanding integrals much more deeply because I had to explain things to my teammates.*" (ST 2024-02)

"*I liked that even when I made mistakes, we worked together to fix them. It made me feel more confident to participate.*" (ST 2024-10)

"*Not everyone contributed equally in the team, and sometimes one person ended up doing most of the work.*" (ST 2024-15)

"*If one person didn't understand the topic, it slowed down the whole group, and sometimes we ran out of time to finish the challenge.*" (ST 2024-45)

The results seem to indicate that the collaborative nature of CBL and GBL fostered deeper conceptual understanding by encouraging peer-to-peer explanations and cooperative problem-solving.

However, challenges related to unequal participation and group efficiency were also reported. Some students felt that stronger participants carried more responsibility, while weaker students struggled to keep up. This suggests a need for better facilitation of teamwork dynamics, possibly through structured roles or additional instructor intervention when disparities in participation emerge.

One possible improvement would be to introduce reflection sessions where students discuss their contributions and adjust teamwork strategies. This could ensure that all members remain actively engaged and feel accountable for their role in the challenge.

3) Interest in Mathematics, Engineering & Space Exploration

"*I never thought math could be useful in something as cool as space exploration. I always saw it as a subject with no real use, but this changed my view.*" (ST 2024-37)

"*Before this, I didn't really care about orbital mechanics, but now I want to learn more about how real missions are planned.*" (ST 2024-08)

"*This was the first time I saw a real reason to learn integrals. It made me think about engineering as something more interesting than just equations*." (ST 2024-14)

The most significant increase in student interest was seen in the field of space and orbital mechanics, where students in the experimental group reported a 70% improvement in interest. This underscores the power of thematic learning in sparking curiosity and reframing abstract mathematical concepts into real-world applications. Notably, several students mentioned that the course shifted their perception of engineering as a field, making it more dynamic and problem-solving oriented rather than just theoretical. The implications for curriculum design can be compelling: introducing theme-based challenges (such as aerospace applications, robotics, or environmental engineering) could serve as an effective recruitment tool for STEM disciplines by making abstract concepts more tangible and inspiring.

4) Challenges & Negative Perceptions

"*The activity was fun, but sometimes it was frustrating when we didn't have enough time to figure things out.*" (ST 2024-06)

"*I liked the game aspect, but I found it a bit stressful when we had a deadline to complete a mission. I prefer learning at my own pace.*" (ST 2024-49)

"*At first, I didn't understand why we were doing some of the math problems because they weren't always directly related to the mission.*" (ST 2024-38)

"*Not everyone enjoys learning through games. I think some people preferred the traditional way.*" (ST 2024-33)

While the majority of students responded positively, some challenges emerged that need to be addressed in future implementations. Some students found it difficult to balance the challenge constraints with their learning process, which suggests that pacing adjustments or additional guided support might be necessary.

While a moderate level of challenge increases engagement, some students felt pressured by the deadlines. Implementing optional review sessions or adaptive difficulty levels could help manage this issue.

Also, some students initially struggled to see how every concept related to the mission. Providing clearer connections between the game mechanics and mathematical concepts at the start of each lesson could improve understanding.

On the other hand, a small subset of students felt game-based learning was not their preferred learning style. While not all students engage equally with GBL, offering a degree of flexibility (e.g., optional challenge tracks or alternative exercises) may help accommodate different learning styles.

III. Discussion

The results of this study indicate that the integration of CBL and GBL in teaching integral calculus significantly enhanced student motivation, engagement, teamwork, and conceptual understanding. Compared to the traditional learning approach, the experimental group demonstrated substantial gains in all measured aspects, with interest in space and orbital mechanics showing the most remarkable increase (+70%). These findings reinforce existing literature on the effectiveness of thematic and interactive learning environments in fostering deeper student involvement and retention of knowledge [1].

The experimental group reported a 48% increase in motivation to learn mathematics, with students frequently highlighting that the interactive, goal-oriented structure of the methodology made them more eager to engage with the material. The ability to apply newly learned integral calculus concepts to an overarching mission created a clear and immediate sense of purpose, which is often lacking in traditional instruction. Prior research suggests that motivation is a key determinant of academic success in STEM fields, and our results align with studies demonstrating that CBL and GBL frameworks help sustain student interest by embedding learning within meaningful and immersive contexts [2].

Moreover, the interest in the course itself increased by 45%, reinforcing the idea that shifting from passive learning to active, problem-based learning improves students' perception of the subject matter. This is particularly relevant in mathematics education, where students often struggle to connect theoretical knowledge with practical applications.

A key component of the methodology was collaborative problem-solving, which resulted in a 42% increase in the perceived usefulness of group work. Students reported that working in teams enhanced their ability to approach complex problems from different perspectives, supporting the argument that peer learning environments deepen understanding through discussion and cooperative reasoning [3].

However, some students expressed concerns about unequal participation within groups, with stronger students occasionally taking on a larger workload. This challenge is well-documented in collaborative learning literature and suggests the need for structured roles within teams or instructor intervention to ensure fairer task distribution. Future iterations of this methodology could integrate peer assessment mechanisms to encourage more balanced contributions.

The study found a 40% increase in students' interest in engineering studies, highlighting the potential of contextualized STEM education to influence academic and career aspirations. More notably, interest in space and orbital mechanics rose by an impressive 70%, suggesting that the theme of space exploration was highly effective in capturing student curiosity. This is consistent with prior findings that thematic learning, particularly when tied to real-world challenges, enhances conceptual engagement and fosters long-term interest in specialized fields [4].

These results underscore the potential of game-based and challenge-based approaches as recruitment tools for STEM disciplines, particularly in areas where student enrollment and retention remain a concern. By presenting engineering concepts through narrative-driven problem-solving, students were able to see the relevance and excitement of mathematical applications in real-world contexts, making them more inclined to explore related topics beyond the classroom.

Despite its overall success, the methodology presented some challenges that should be addressed in future implementations: some students found the mission deadlines stressful, which suggests that adjustments to pacing, or more guided interventions could be beneficial. A few students mentioned that they initially struggled to see the direct relevance of every mathematical topic to the game mechanics. Future implementations should clearly articulate connections between new concepts and the mission at the start of each lesson.

While most students responded positively to the game-based approach, a minority expressed a preference for traditional learning. This suggests that a hybrid approach, where students can choose between different types of exercises, might offer a more inclusive experience.

These findings highlight the need for a balanced and adaptable implementation of CBL and GBL, ensuring that all students can engage effectively with the methodology regardless of their preferred learning style.

III. Conclusion

The results of this study demonstrate that integrating Challenge-Based Learning (CBL) and Game-Based Learning (GBL) in mathematics instruction can significantly enhance motivation, engagement, teamwork, and subject interest. The experimental group showed higher improvements across all measured indicators, with interest in space exploration increasing the most (+70%), highlighting the power of real-world, mission-driven learning approaches to inspire students.

Beyond improving mathematical proficiency, the methodology also strengthened collaborative competencies and problem-solving abilities, two key competencies for future engineers. These findings suggest that embedding interactive, narrative-driven challenges into STEM education can make subjects more appealing and relevant, ultimately influencing students' academic trajectories and career choices.

However, some challenges, such as time constraints, varying engagement levels, and ensuring balanced participation within groups, must be carefully managed in future implementations. Providing structured peer collaboration tools, adaptive pacing mechanisms, and clearer concept-mission connections may help maximize the benefits of this methodology.

To further explore the impact of CBL and GBL in STEM education, future studies could:

- Expand the sample size to test effectiveness across different disciplines.
- Compare the long-term retention rates of students who engaged in CBL/GBL versus those who followed traditional methods.
- Investigate the impact of varying game mechanics and challenge structures on learning outcomes.
- Assess how different student learning preferences influence their response to game-based learning interventions.

In conclusion, CBL and GBL represent powerful pedagogical strategies for transforming traditional STEM education. By leveraging narrative-driven missions, collaborative problem-solving, and real-world applications, educators can increase student motivation, reinforce conceptual understanding, and cultivate deeper engagement with engineering and mathematics.

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