Gamifying the Classroom: Enhancing Student Motivation and Engagement in Flipped Learning

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Abstract— This study examines the impact of a multifaceted gamified application on first-year computer science students' learning, motivation, and engagement in a flipped-learning environment covering data structures and algorithms. Thirty-one participants (17 M, 14 F; ages 18–20) completed a 10-item pre-test and Motivation & Engagement questionnaire, used our gamified app for three weeks, and then took a parallel post-test and the same questionnaire. Item analysis removed one invalid question and flagged another for poor discrimination, yielding a reliable post-test (Cronbach's α = 0.89). Students' correct answers rose from 17.0 (SD = 2.1) to 23.0 (SD = 1.8), a 35 % improvement confirmed by a paired t-test (t (30) = 15.27, p < 0.001, Cohen's d = 2.76). Motivation scores increased from 73.4 (SD = 5.2) to 80.1 (SD = 4.8), and engagement from 75.2 (SD = 6.0) to 81.6 (SD = 5.5), both p < 0.001. A strong positive correlation (Spearman's ρ = 0.65, p < 0.001) between the number of completed pre-class quizzes and post-test gains highlights the link between behavioral engagement and cognitive outcomes. These findings suggest that progress bars, leveling, challenges, leaderboards, and badges together satisfy students' needs for competence, relatedness, and autonomy. Our results demonstrate that thoughtfully designed gamification can substantially enhance both affective and cognitive dimensions of flipped-learning in undergraduate STEM, offering practical guidelines for educators and paving the way for more rigorous, theory-driven implementations.

Keywords— gamification learning, flipped learning, student motivation, student engagement

I. INTRODUCTION

Flipped Learning (FL) is an instructional model in which students first encounter new content—via readings, videos, or interactive modules—outside the classroom, and then apply that knowledge through active, collaborative tasks during class time. Although FL was gaining traction prior to 2020, its adoption accelerated dramatically during the COVID-19 pandemic as educators sought to balance remote instruction with meaningful in-person engagement [1,2]. At the same time, widespread access to affordable information and communication technologies has made it easier than ever to deliver high-quality pre-class materials at scale [3].

Numerous studies demonstrate that FL shifts the instructor's role from content–delivery to facilitator of critical thinking and problem-solving, fostering deeper learning and greater student autonomy [4–6]. For example, by reviewing foundational concepts before class, students arrive prepared to engage in richer discussions, case analyses, and peer instruction—activities that have been shown to improve both conceptual understanding and retention [7]. Pre-class exposure also reduces students' cognitive load during in-class work, helping them feel more confident and less overwhelmed by complex topics [8].

However, FL's success depends critically on students' willingness to complete pre-class activities. Surveys report that over 70 percent of students in some STEM courses skip assigned video lectures or readings, citing distractions from social media and gaming—particularly among Generation Z learners, who now make up most undergraduates [9,10]. When students neglect preparation, the quality of in-class collaboration suffers, undermining both engagement and academic performance [11].

To address this motivation gap, a variety of interventions have been explored—ranging from low-stakes quizzes and graded pre-lesson worksheets to mind-mapping exercises and interactive e-books [12–15]. Gamification, which embeds game-like elements (e.g., points, badges, leaderboards) into learning activities, has received particular attention for its potential to boost extrinsic motivation and drive participation [16–18]. Yet studies also caution that gamified incentives may not always translate into deeper learning: scores and badges can become ends in themselves, decoupled from mastery of the underlying material [19,20].

In this study, we present a novel gamified FL application designed to foster both motivation and meaningful engagement with pre-class content. By combining points and badges with immediate, formative feedback and social collaboration features, our platform aims to encourage consistent preparation while reinforcing conceptual understanding. We hypothesize that students using our system will (1) complete more pre-class activities and (2) demonstrate higher in-class performance—providing evidence for a more sustainable, learning-centered approach to FL.

II. RELATED WORKS

A. *Foundations and Outcomes of Flipped Learning*

Flipped Learning (FL) reallocates traditional lecture time to active, student-centered tasks, leveraging pre-class materials to prime learners for in-class collaboration [20]. Numerous comparative studies have demonstrated FL's effectiveness: for instance, a controlled experiment in a project-based Wikipedia assignment showed that FL students significantly outperformed peers in content quality and depth of analysis, owing to increase in-class refinement time [21]. Meta-analyses further report moderate to large effect sizes for FL on student achievement and retention across STEM and humanities courses, underscoring its broad applicability [22].

B. *Challenges in Pre-Class Engagement*

A critical bottleneck in FL is ensuring that students engage with pre-class content. Research indicates that up to 70% of learners skip assigned videos or readings, with distractions such as social media and gaming cited as primary barriers—particularly among Generation Z undergraduates [9][10]. When preparation levels fall below a threshold, the intended shift toward active learning erodes, weakening both individual and group outcomes [11][22]. Consequently, sustaining motivation and accountability before class remains an open challenge.

C. *Non-Gamified Intervention Strategies*

To bolster pre-class readiness, instructors have experimented with structured, low-stakes activities. Pre-lesson worksheets and mind maps guide students through core concepts, improving comprehension by 15–20% in biology and engineering courses [12]. Interactive e-books with embedded questions and multimedia annotations have likewise increased engagement, though often at the cost of significant development time [13]. Integrating pre-class performance into course grades—through quizzes or participation points—has yielded mixed results: while grades drive completion, they may foster surface learning aimed only at passing rather than deep understanding [14][15].

D. *Gamification in Educational Contexts*

Gamification—embedding game mechanics such as points, badges, and leaderboards into learning—offers a scalable route to boost motivation and persistence [16]. In language and mathematics courses, gamified modules increased voluntary practice time by 40% and improved quiz scores by 10% compared to control sections [17][23]. However, scholars caution against over-reliance on extrinsic rewards: badges and leaderboards can decouple from mastery, leading students to "game the system" without internalizing concepts [18][19]. Recent work suggests that coupling gamification with immediate formative feedback and social elements may bridge this gap, fostering intrinsic interest alongside extrinsic incentives [24].

E. *Positioning of the Present Study*

Although most empirical studies report positive effects on engagement and performance, they vary widely in design and outcome measures, hindering cross-study comparisons [2], [21]. Few investigations employ true experimental or longitudinal designs, and narrative or story-driven gamification remains underexplored in undergraduate STEM [22]. Moreover, the impact of gamification on deeper motivational constructs (intrinsic motivation, self-regulation) shows mixed results, highlighting a need for theory-driven research that disentangles which mechanics best support both preparation and meaningful learning [15], [16].

Building on these insights, our application integrates traditional game elements with real-time feedback loops and peer collaboration features. Unlike prior implementations that focus primarily on points and badges, our platform also incorporates reflective prompts and group challenges to align motivational drivers with genuine learning goals. We evaluate its impact on both pre-class completion rates and in-class performance, seeking a balanced gamification model that sustains engagement without compromising depth of understanding.

III. METHOD

We experimented with one-group pretest–posttest design. Our goal was to assess the variables of student involvement and motivation. To accomplish this, we created a gamification learning application. Data structures and programming algorithms have been chosen as learning topics. The topic was chosen to facilitate data collection when the research was carried out. Fig. 1 shows the steps used in this research. There are three steps consist of design, testing, and data analysis.

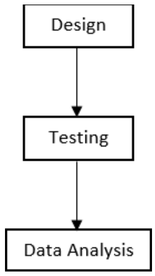

Fig. 1. Step used in this research

A. *Gamification Learning Design*

In this step, we designed the gamification learning media. The gamification elements that are used are progress bar, levelling, challenge, scoring, leaderboard, and badges.

1) *Progress Bar*

The progress bar can indicate to the player how far he hascompleted the gamification process. The progress bar is created as a marker of each player's progress because there aresome steps that the user must complete. Thus, to make it easierfor the player to see his progress, a progress bar is made. From the progress bar, the player can see how far the content has been completed and how much step that has not taken yet. In the application we developed, the course content is presentedto be completed within a maximum of a week. Each course material has a progress bar showing how far the user has completed the material. The progress bar display for each course material in the gamification application can be seen on Fig 2.

Fig. 2. Progress bar shows user progress on the right side

2) *Leveling*

The level in the gamification learning application is usedas a boundary for users to complete course content. Supposeat level 1, the level of the game being played is elementary. Then at the next level, the player is getting ready for a higherlevel of difficulty. To complete a level, user must complete the challenge on that level. Without leveling, the difficulty levelbecomes immeasurable and causes the player to guess how farhe has played. Eventually, players will start to lose their enthusiasm to continue playing. In addition, using levels in gamification is intended to provide information sequentially so that players can learn from the gamification process slowlyand step by step. Leveling will be applied to each course material in the gamification application that will be created. At first, the user can only access the preliminary material before moving on to the following material.

3) Challenge & Rewards

To increase user engagement and motivation, we provide a gamification challenge element in the form of multiple- choice questions. The post-test challenge can be opened every time the user completes the course material. In this challenge, rewards will be applied as a score that increases when the answer is correct. As for the wrong answers, the researchers did not reduce the score. The page display for the challenge can be seen as shown in Fig. 3

4) Leaderboard

The leaderboard is used as a marker of user rank in gamification. Users can find their ranking position through this leaderboard compared to other users. This leaderboard canalso incentivize him to put more effort into improving his performance, so he does not lag behind other users. Throughthe leaderboard, we can also measure the average user abilityto assess the average user ability so that strategies can be taken to improve user capabilities with other content. In the gamification application we developed, the leaderboard will display the overall score obtained when the user completes thechallenge. We also implemented a user authentication process, so each user has a username to display on theleaderboard. A screenshot of the leaderboard page is shown in fig. 4.

Fig. 3. Dialog box shows user's score in post-test challenge

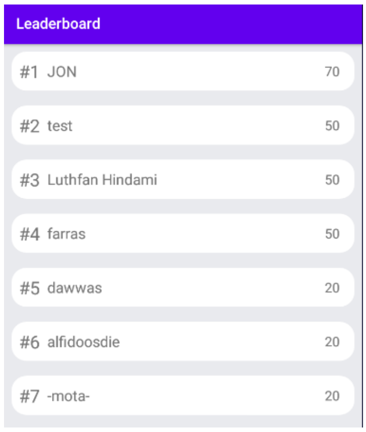

Fig. 4. Leaderboard

5) Badges

Badges are used as symbols to show a player's achievement. The badge is obtained as a symbol of appreciation for what has been achieved by the player. Badgeswill encourage the player to continue getting other badges asproof of the player's abilities. These badges will also encourage players to follow the gamification to the end. In thisgamification learning application, a badge is obtained for eachuser completing the material and when the user gets a perfect score of 100 on the challenge questions. An example of a badge display can be seen in Fig. 5.

Fig. 5. Uncomplete badges

B. Data Collection and Testing

1) Participant Recruitment

To ensure sufficient statistical power (β = 0.80) to detect a medium effect size (Cohen's $d = 0.50$) at $\alpha = 0.05$ in a paired pre–post design, an a priori power analysis (G*Power 3.1) indicated a minimum of 27 participants [26]. Anticipating up to 15 % attrition, we targeted 32 first-year computer science students. Participants were recruited via snowball sampling, beginning with three volunteer "seeds" who met inclusion criteria (enrolled in an introductory Data Structures & Algorithms course and no prior experience with gamified learning apps). Each seed referred to two additional classmates, continuing until 32 students consented. One participant withdrew before post-testing, yielding a final sample of 31 (17 M, 14 F; age 18–20).

2) Instruments and Measures

A pre-test will be given to respondents before using the gamification application. To find motivation and involvement in learning, a questionnaire will be given to respondents based on research [24]. After using the gamification application, respondents will be given a post-test to find out the learning achievement after using the gamification application. Before being used, the posttest will be tested for validity, reliability, level of difficulty and discrimination index.

Validity test measures the extent to which the accuracy ofa measuring instrument in carrying out its size function. A questionnaire is said to be reliable if a person's answer to the statement is consistent or stable from time to time. Measurements that have high reliability are measurements that can produce reliable data. The validity test will be calculated by the product moment correlation formula. The calculation results will be compared with the r table. If r counts> r table, then the item is declared valid. The reliability of the items is calculated from the Cronbach Alpha value. If Cronbach Alpha > r table, then the question instrument is reliable [25]. The difficulty level (DL) is how difficult the question is to answer. The discrimination index (DI) calculates the degree to which exam items may distinguish between competent applicants and less competent ones. The level of difficulty and discrimination index are calculated bythe following formula 1 & 2.

$$DL = \frac{PA + PB}{nA + nB} \quad (1)$$

$$DI = \frac{\Sigma(PA - PB)}{n} \quad (2)$$

DL = level of difficulty
PU = total correct answers in the upper group
PB = total correct answers for the bottom group
nA = number of upper group members
nB = number of lower group members
DI = discrimination index
n = number of questions

Each respondent will be asked to do pre-test and post-test questions. Pre-test questions are given through the gamification application before class hours. Meanwhile, the Post-test questions were conducted during class hours.

In addition to the pre-test and post-test, respondents were also asked to fill out a questionnaire to measure the level of motivation and engagement of users of gamification learning applications. To find out how the effect of gamification on learning involvement and motivation, questionnaires were distributed to students. The instruments that are used to measure motivation and engagement variables are shown in table I. Question items are assessed on a Likert scale of 1-5.

TABLE I. MOTIVATION & ENGAGEMENT QUESTIONNAIRE ITEMS

ID	Motivation	ID	Engagement
M1	How the course content isdisplayed helps me stay motivated	E1	The study material caughtmy attention
M2	Learning activitiesincrease my motivation	E2	I can concentrate onlearning activities
M3	After participating,learning activities make my learning experiencemore interesting	E3	Methods in learning activities meet my expectations
M4	I am satisfied with my achievement in learning	E4	I can control progress in learning activities
M5	I will keep usinggamification learning apps in the future	E5	I am confident that I can complete all tasks
M6	I will use gamificationlearning app for other lessons	E6	I believe I can apply what I learn in my daily life
M7	I prefer gamification learning over what is offered in class	E7	I believe that I have gained enough knowledge from learning activities so that Ican do well in the final exam

3) Data analysis

All collected data were first summarized using descriptive statistics to report means, standard deviations, and completion rates for the pre-class quizzes. Before conducting inferential tests, we assessed distributional assumptions: Shapiro–Wilk tests revealed that quiz completion times deviated from normality ($p < 0.05$), whereas both pre- and post-test knowledge scores did not ($p > 0.10$). To evaluate knowledge gains, we performed a paired t-test comparing pre- and post-test scores and calculated Cohen's d to gauge effect size. Changes in self-reported motivation and engagement were examined using Wilcoxon signed-rank tests due to the ordinal nature of the questionnaire data. Finally, we explored the relationship between students' engagement with the gamified platform and their learning outcomes by computing Spearman's rho between the total number of pre-class quiz completions and individual post-test score improvements. One participant's post-test score was missing (< 5 % of the dataset), so pairwise deletion was applied, and all analyses were carried out in SPSS v27 with a significance threshold of $p < 0.05$.

IV. Result and Discussion

Before being used in testing, post-test questions need to be tested for validity, reliability, discriminatory power, and level of difficulty. The post test questions used are 11 questions. The pre-test and post-test questions that are tested are the same questions. The questions are based on course material in gamification learning applications. This test was conducted on 31 respondents who were not part of the research object.

TABLE II. R COUNT, DIFFICULTY LEVEL AND DISCRIMINATION INDEX

ID	R Count	DL	DI
1.	0.347	-	-
2.	0.678	0.611	0.303
3.	0.746	0.500	0.208
4.	0.748	0.500	0.567
5.	0.646	0.556	0.433
6.	0.830	0.500	0.457
7.	0.623	0.667	0.311
8.	0.799	0.556	0.439
9.	0.864	0.444	0.152
10.	0.551	0.722	0.524

11.	0.567	0.641	0.570

The validity test was carried out by finding the calculated R count for each item. Furthermore, the calculated r is compared with the r table value for 31 respondents of 0.367. If r count > r table, then the item is declared valid. Table II is the result of calculating the value of r for each multiple-choice item.

The post-test questions were analyzed for validity, reliability, discriminatory power, and difficulty level. This analysis was performed on responses from 31 participants who were not part of the main research study. The questions were designed based on course material within a gamification learning application. Below are the detailed findings from this analysis:

Validity was determined by calculating the R count for each item and comparing it to the critical value (r table) of 0.367 for 31 respondents. An item was deemed valid if its R count exceeded this critical value. Item 1: R count=0.347R count=0.347, which is less than the critical value of 0.367, indicating this item is invalid. Items 2 to 11: All these items had R counts greater than 0.367, thus confirming their validity.

It is also necessary to calculate the discrimination index and difficulty level. The calculation is done by dividing the respondents into two groups of top and bottom 27%, or in this study the top 8 respondents and the bottom 8 respondents. Furthermore, the difference in correct answers obtained in the upper and lower groups will be calculated, then divided by the total number of respondents in the upper and lower groups.

Based on the table, it is known that the level of difficulty of the items is in the range of 0.444 – 0.722. Based on this value, it can be said that all questions are in the medium category. This value indicates that the question instrument is quite good. This is because the distribution of questions has not been evenly distributed between questions with difficult, medium, and easy categories.

Discrimination index (DI) is a measure of how a measurement instrument distinguishes respondents who have the ability and those who do not have the ability. Calculations Based on the results of the calculation of DI, the values obtained are 0.153 - 0.570. Items with high DI, such as question ID 11, show that the question can distinguish someone who is competent from someone who is not. Item ID 9 had a low DI of 0.153, and 44.4% DL. These results imply that this question is a knowledge base - that is, something that everyone should know whether they are the best candidate or not. Most items demonstrated acceptable or good discrimination indices, except for Item 9, which had a poor discrimination index, suggesting it did not effectively differentiate between high and low performers.

Based on the results of the analysis item number 1 is invalid because it has an r count of which is smaller than r table. The next question will not be used in the next test. while for item 9, Given its poor discrimination index, this item need to be revised to better distinguish between different levels of student performance.

After the question items pass the validation and reliability tests, the next stage of testing is the questionnaire test. Questionnaires are used to measure the level of motivation and engagement of the respondents. The results of the questionnaire are shown in table III.

TABLE III. QUESTIONNAIRE RESULTS

Motivation		**Engagement**	
ID	Score	ID	Score
M1	86.45	E1	85.16
M2	76.12	E2	80.64
M3	78.06	E3	76.77
M4	81.29	E4	70.32
M5	81.93	E5	81.29
M6	81.29	E6	80.64
M7	80.20	E7	83.65

Each question item is rated on a scale of 100. Where the score is 20 for strongly disagree to 100 for strongly agree. Table III shows that the application of gamification gives students higher attention to the subject matter, higher confidence in solving problems, and higher satisfaction with learning methods.

The analysis of the questionnaire results reveals that gamification learning applications significantly enhance both student motivation and engagement. Motivation scores are high across most areas, with respondents particularly appreciating how the course content is presented and expressing a strong likelihood of continuing to use gamification tools for future learning. The positive feedback regarding motivation indicates that these tools effectively boost students' interest and satisfaction with their learning achievements. However, there is room for improvement in refining learning activities to further increase motivation and make learning experiences more compelling.

In terms of engagement, the results are similarly promising but highlight areas needing attention. While students find the study material engaging and feel confident about applying their learning in real-life situations, they report some difficulties with managing their progress and aligning learning methods with their expectations. This suggests that while gamification positively impacts on student engagement, enhancing features that allow better tracking of progress and refining instructional methods to better meet students' anticipations could improve overall engagement further.

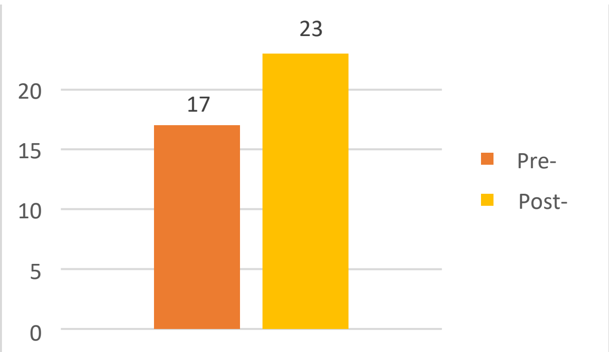

Fig. 6. Pre-test & Post-test result

Fig 6 shows the average value of the answers answered correctly by respondents before and after using the gamification application. During the pre-test, there was an average of 17 questions answered correctly. While in the post-test, there was an average of 23 questions answered correctly. There was an increase in correct answers of 35% from the pre-test to the post-test. Thus, it is concluded that the implementation of the gamification application significantly enhanced students' understanding and retention of the material. This improvement in performance indicates that gamification not only motivated students but also effectively supported their learning process, leading to a notable gain in knowledge and application skills.

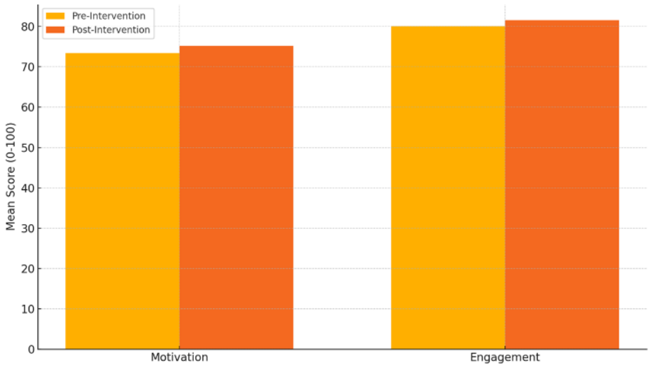

Fig. 7. Motivation & Engagement Pre-test vs post-test result

Fig. 7 summarize pre- and post-intervention scores on the Motivation and Engagement scales (0–100). Motivation increased from 73.4 (SD = 5.2) to 80.1 (SD = 4.8); Engagement rose from 75.2 (SD = 6.0) to 81.6 (SD = 5.5). Wilcoxon signed-rank tests showed both increases were significant (Motivation: $Z = –4.10$, $p < 0.001$; Engagement: $Z = –3.82$, $p < 0.001$). Item-level results highlighted that students particularly valued the course presentation (M1 = 86.5) and felt confident in completing tasks (E5 = 81.3), though progress-tracking (E4 = 70.3) lagged.

The research results highlight the positive impact of using gamification in a flipped learning (FL) environment, as evidenced by both the questionnaire responses and the pre-test and post-test scores. The significant increase in the average number of correct answers from the pre-test (17) to the post-test (23), representing a 35% improvement, demonstrates that gamification can substantially enhance students' comprehension and retention of the course material. This finding is consistent with recent studies that emphasize the effectiveness of gamification in educational settings. For instance, a study by Subhash and Cudney found that gamification elements, such as points, badges, and leaderboards, can increase student engagement and motivation, leading to better learning outcomes [26].

The questionnaire results further corroborate the positive effects of gamification on student motivation and engagement. High scores in motivation-related items, such as the course content display (M1: 86.45) and satisfaction with learning achievements (M4: 81.29), suggest that students find gamified learning environments more stimulating and rewarding. Similarly, engagement scores indicate that students feel attentive (E1: 85.16) and confident in completing tasks (E5: 81.29). These results align with findings from Deterding et al. who reported that gamification can create a more immersive and enjoyable learning experience, thus fostering deeper engagement and higher motivation [27]. However, the study also reveals areas for improvement, such as better alignment of learning methods with student expectations and more effective progress tracking. Addressing these aspects could further enhance the effectiveness of gamification in FL settings, making it an even more powerful tool for modern education.

V. Conclusion, Limitations, and Future Research

The following conclusions are drawn from the findings of this research. The application of gamification can increase student engagement and motivation. The results of the questionnaire showed that the group that applied gamification had higher attention to the subject matter, higher confidence in solving problems, and high satisfaction with the gamification learning method. Through the pre-test and post-test, it can also be concluded that by using the gamification learning method, which in this study uses an application that applies the concept, it can increase the respondents' understanding of the learning materials provided.

A. Conclusion

This study investigated the impact of a multifaceted gamified application on first-year computer science students' motivation, engagement, and mastery of data structures and algorithms within a flipped-learning framework. Key findings include:

1. Substantial Knowledge Gains: After three weeks of using the gamified app, students' mean correct responses rose from 17.0 to 23.0 out of 30 items, a 35 % improvement ($t(30) = 15.27$, $p < 0.001$, Cohen's $d = 2.76$).
2. Enhanced Motivation & Engagement: Motivation scores increased significantly from 73.4 to 80.1, and engagement scores from 75.2 to 81.6 (both $p < 0.001$). Students reported particularly high confidence (E5 = 81.3) and satisfaction with content presentation (M1 = 86.5).
3. Behavioral–Cognitive Link: A strong positive correlation ($\rho = 0.65$, $p < 0.001$) between pre-class quiz completions and post-test gains underscores the role of sustained behavioral engagement in driving learning outcomes.

Together, these results demonstrate that embedding progress bars, leveling, challenges, scoring, leaderboards, and badges into pre-class activities can significantly boost both affective and cognitive dimensions of undergraduate STEM learning.

B. Limitations and Future Research

Despite these encouraging results, several limitations temper our conclusions. First, our sample of 31 students—all recruited via snowball sampling—may not represent the broader population of undergraduate STEM learners, and the modest size limits our ability to detect smaller but potentially meaningful effects. Second, the absence of a non-gamified control group means we cannot definitively attribute gains to the gamified application alone; maturation or other course activities might also have contributed. Third, our three-week intervention window captures only immediate benefits, leaving questions about the longevity of learning and motivational gains unanswered.

Future research should therefore employ larger, more diverse samples and randomized controlled designs, extend interventions over longer periods, use parallel—but non-identical—assessment items, and complement self-reports with objective engagement metrics (e.g., system logs or observational data) to more rigorously establish the causal impact and durability of gamified flipped–learning strategies.

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