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Leveling Up Learning: Assessing the Impact of Gamification on Student Performance and Perception in an Electrical Engineering Linear Circuits Course

Dr. Ahmed Dallal, University of Pittsburgh

Dr. Ahmed Dallal is an Associate Professor in the Department of Electrical and Computer Engineering at the University of Pittsburgh, where he has been a faculty member since 2017. His scholarly work spans two interconnected areas: engineering education research and biomedical signal and image processing. In education, Dr. Dallal investigates pedagogical innovations, including blended learning, active learning, and gamification, with a focus on improving student performance and engagement in ECE courses. In his technical research, his interests include biomedical signal processing, neural data analysis, machine learning, computer vision, and networked control systems. Dr. Dallal is an active member of ASEE, where he has served in multiple leadership roles in the New Engineering Educators Division, including Division Chair.

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Abstract

This study investigates the effectiveness of gamification, specifically Nearpod's "Time to Climb" quiz feature, as a pedagogical tool in an undergraduate Linear Circuits and Systems course. Using a quasi-experimental design, student performance was compared between an experimental section (Fall 2025, n=58) incorporating gamified review activities and a control section (Spring 2025, n=34) using traditional lecture-based review methods. Quantitative analysis revealed that students in the gamified section achieved significantly higher mean scores on both comprehensive exams and conceptual tests. Survey data from 47 students in the experimental section indicated positive perceptions, with high ratings for engagement, learning effectiveness, and classroom dynamics on 5-point Likert scales. Thematic analysis of open-ended responses revealed that students valued the immediate feedback, interactive nature, and competitive elements, though some expressed concerns about time pressure and question difficulty alignment with exams. These findings suggest that gamified formative assessment tools can enhance both learning outcomes and student engagement in foundational engineering courses.

Keywords: gamification, engineering education, active learning, Nearpod, student engagement, electrical circuits, formative assessment.

1. Introduction

The landscape of higher education continues to evolve, with educators increasingly seeking innovative pedagogical strategies to enhance student engagement, motivation, and learning outcomes. Among these strategies, gamification—the application of game-design elements in non-game contexts [1]—has emerged as a promising approach to transform passive learning environments into dynamic, interactive experiences. Within engineering education, where students must master complex, abstract concepts, gamification offers a potential pathway to mitigate common challenges such as low engagement, conceptual difficulties, and passive learning behaviors.

Foundational electrical engineering courses, such as Linear Circuits and Systems, present unique pedagogical challenges. Students must develop both procedural skills for circuit analysis and deep conceptual understanding of electrical phenomena that are inherently abstract and invisible. Traditional lecture-based instruction, while effective for content delivery, often fails to adequately engage students or provide the immediate feedback necessary for conceptual development. These challenges are compounded by large class sizes, diverse student backgrounds, and the cumulative nature of electrical engineering knowledge.

Game-based student response systems (GSRSs) such as Nearpod, Kahoot!, and Quizizz have gained considerable traction in educational settings as tools for implementing gamification principles. These platforms incorporate elements such as points, leaderboards, time pressure, and immediate feedback to create engaging learning experiences while simultaneously providing formative assessment data. The "Time to Climb" feature in Nearpod specifically gamifies quiz activities by presenting multiple-choice questions in a competitive format where students race to answer correctly, with visual progress indicators and leaderboard displays enhancing the game-like experience.

Despite growing interest in gamification within STEM education, empirical evidence regarding its effectiveness in undergraduate engineering courses remains limited. While numerous studies have demonstrated positive effects of gamification on student motivation and engagement, findings regarding academic performance are more variable, with some studies showing significant improvements while others report minimal or no effect. Furthermore, much existing research has been conducted in K-12 settings or disciplines outside engineering, limiting the generalizability of findings to undergraduate electrical engineering education.

This study addresses this gap by investigating the impact of Nearpod's Time to Climb activities on student learning outcomes and perceptions in a sophomore-level Linear Circuits and Systems course. Specifically, this research examines: (1) whether students in gamified sections demonstrate improved performance on comprehensive exams and conceptual assessments compared to students in traditional lecture-based sections, and (2) how students perceive the gamified activities in terms of engagement, learning effectiveness, and classroom dynamics.

2. Background and Literature Review

2.1 Theoretical Foundations of Gamification in Education

Gamification in educational contexts is grounded in several theoretical frameworks. Landers' Theory of Gamified Learning provides a comprehensive model explaining how game elements can be strategically used to improve educational experiences by influencing learner behaviors and attitudes that, in turn, affect learning outcomes [2]. This theory bridges the gap between serious games and gamification, offering a unified approach to leveraging game elements in education. The framework suggests that game attributes (such as points, leaderboards, and badges) can influence learning through two pathways: by directly affecting learning behaviors and by moderating the relationship between instructional content and learning outcomes.

From a motivational perspective, Self-Determination Theory posits that intrinsic motivation is fostered when three basic psychological needs are met: autonomy, competence, and relatedness. Gamification elements can address these needs by providing choices in learning activities (autonomy), offering immediate feedback on performance (competence), and creating opportunities for social interaction through competition and collaboration (relatedness). Additionally, Flow Theory suggests that optimal engagement occurs when challenge levels are appropriately matched to skill levels, a balance that well-designed gamified activities can achieve.

2.2 Empirical Evidence on Gamification Effectiveness

A substantial body of research has examined the effects of gamification on learning outcomes across various educational settings. Meta-analyses examining gamification effectiveness have found significant positive effect sizes for gamification on student learning outcomes, suggesting that gamification can be a powerful tool for enhancing academic achievement [3], [4]. Research has further revealed that offline learning environments and higher education settings show particularly strong effects, supporting the potential of gamification in university classrooms.

Research specifically examining game-based student response systems has yielded consistently positive findings. A systematic literature review analyzing 93 studies on Kahoot!, a platform similar to Nearpod's Time to Climb feature, concluded that such tools can have positive effects on learning performance, classroom dynamics, student attitudes, and anxiety reduction [5], [6]. The review noted that the competitive elements, immediate feedback, and game-like atmosphere contributed to enhanced engagement and improved learning outcomes in most cases.

However, literature also reveals important nuances and limitations. Some studies have reported mixed results, with gamification benefits appearing to diminish over time due to novelty effects [7]. Research has emphasized that the effectiveness of gamification varies based on student characteristics, including personality traits and prior gaming experience [8]. Furthermore, challenges such as time pressure, fear of public failure, and technical difficulties have been identified as potential barriers to the effectiveness of gamified learning experiences [9].

2.3 Gamification in Engineering Education

Within engineering education specifically, gamification has been explored as a strategy to address persistent challenges including low student engagement, high failure rates in foundational courses, and difficulty in developing conceptual understanding. Research in electrical engineering education has demonstrated that active learning approaches, including gamified activities, can significantly improve both student engagement and learning outcomes compared to traditional lecture-based instruction [10]–[12].

A study examining the use of Nearpod for reviewing lessons in engineering courses found that 98% of students preferred Nearpod to traditional review methods, with 91% reporting increased motivation [13]. Importantly, students in gamified sections demonstrated higher passing rates and average scores compared to non-gamified sections. Similarly, research on leaderboard-based gamification in STEM higher education found significant improvements in learning performance for students in gamified conditions.

2.4 Nearpod and Time to Climb

Nearpod is a cloud-based interactive learning platform that enables instructors to create and deliver engaging presentations with embedded interactive elements including polls, open-ended questions, collaborative boards, and gamified quizzes [14]. The Time to Climb feature specifically transforms quiz activities into competitive games where students answer multiple-choice questions while racing against a timer. Students select avatars that visually climb as they answer questions correctly, with a real-time leaderboard displaying anonymous rankings.

Research examining Nearpod's effectiveness has shown positive outcomes across various educational contexts [15]. Studies have found that the platform's interactive features, including Time to Climb, promote student engagement, enhance interactivity, and improve learning outcomes. The combination of immediate feedback, competitive elements, and visual progress indicators aligns with gamification principles that have been shown to enhance motivation and learning in educational settings.

3. Methods

3.1 Research Design

This study employed a quasi-experimental design comparing student performance and perceptions between an experimental section incorporating gamified review activities and a control section using traditional lecture-based instruction. The comparative design utilized consecutive semester offerings of the same course: the control section was offered in Spring 2025, and the experimental section was offered in Fall 2025. Both sections covered identical curriculum content, used the same textbook and problem sets, and were taught by the same instructor, minimizing confounding variables related to instructional differences. In addition, same exams were administered in both sections, and students had no access to the exams outside the classroom.

3.2 Participants and Context

Participants were undergraduate students enrolled in Linear Circuits and Systems, a sophomore-level required course for electrical and computer engineering majors at the University of Pittsburgh. The control section (Spring 2025) included 34 students, while the experimental section (Fall 2025) included 58 students. The course covers fundamental topics in DC and AC circuit analysis, including Kirchhoff's laws, mesh and nodal analysis, Thevenin and Norton equivalents, transient response, phasor analysis, and frequency response.

3.3 Intervention

In the experimental section, Nearpod's Time to Climb activities were incorporated as a regular component of selected lectures to reinforce key concepts and prepare students for assessments. Prior to each checkpoint (midterm) and final exam, students participated in Time to Climb sessions consisting of 8-12 multiple-choice questions covering recently taught material. The questions were designed to assess conceptual understanding of circuit principles rather than complex numerical calculations.

During Time to Climb sessions, students used their personal devices to access the activity through a session code. Each question was displayed for a set time period (typically 30-60 seconds depending on complexity), and students received immediate feedback on their responses. A leaderboard displayed anonymous rankings based on accuracy and speed. Following each session, the instructor reviewed commonly missed questions and addressed misconceptions identified through the aggregate response data.

In the control section, the same time allocation was devoted to review activities, but these consisted of traditional instructor-led review sessions. During these sessions, the instructor presented practice problems on the board, worked through solutions, and answered student questions. While students could ask questions and participate in discussion, the format was primarily teacher-centered without the gamified elements, immediate individual feedback, or competitive aspects present in the experimental condition. However, active learning was used throughout the semester with the same frequency in both sections.

3.4 Data Collection

Data collection included both quantitative performance measures and qualitative perception data. Quantitative measures consisted of two primary assessments:

Comprehensive Exam: Students in both sections completed three free-form exams throughout the semester requiring them to show their problem-solving procedures and derive circuit responses. The total possible score across all three exams was 217 points. These exams assessed both procedural skills and conceptual understanding through multi-step circuit analysis problems.

Conceptual Test: A 25-point multiple-choice conceptual test was administered to both sections, measuring understanding of fundamental DC and AC circuit concepts without requiring extensive calculations. This test was designed to assess conceptual gains independent of procedural calculation skills.

Qualitative data was collected through an anonymous post-semester survey administered to students in the experimental section. The survey instrument included 13 Likert-scale items (5-point scale: 1=Strongly Disagree, 5=Strongly Agree) organized into three categories: (1) engagement and enjoyment (4 items), (2) learning effectiveness (5 items), and (3) classroom dynamics (4 items). Additionally, the survey included two overall effectiveness questions and four open-ended questions. A total of 47 students completed the survey, representing an 81% response rate.

3.5 Data Analysis

Quantitative performance data were analyzed using independent samples t-tests to compare mean scores between the experimental and control groups on both the comprehensive exams and the conceptual test. Effect sizes were calculated using Cohen's d to assess the practical significance of any observed differences. Pass rates (defined as achieving ≥60% of the maximum possible score) were compared between groups to assess differential impacts on student success.

Survey data were analyzed descriptively, with means and standard deviations calculated for each Likert-scale item. Category means were computed for the three thematic areas (engagement, learning effectiveness, classroom dynamics). Open-ended responses were analyzed using thematic analysis to identify recurring patterns in student perceptions.

4. Results

4.1 Quantitative Performance

Analysis of student performance in the two types of class tests revealed statistically significant differences between the experimental and control groups on both assessment measures. Table 1 presents the descriptive statistics and inferential test results for exam and conceptual test scores.

Table 1. Comparison of Performance in Exams

Measure	Control (n=34)	Exp. (n=58)	t-value	p-value	Cohen's d	Effect
Exam Score (/217)	130.34 (51.93)	160.71 (33.23)	3.42	<0.001**	0.74	Medium
Conceptual Test (/25)	17.06 (5.16)	18.89 (3.41)	2.04	0.045*	0.44	Small-Med

*Note: Values represent Mean (SD). *p<0.05, **p<0.01*

For comprehensive exam scores, students in the experimental section (M=160.71, SD=33.23) significantly outperformed students in the control section (M=130.34, SD=51.93), t=3.42, p<0.001. The effect size (Cohen's d=0.74) indicates a medium-to-large practical effect. Notably, the experimental group also demonstrated lower variability in scores, suggesting more consistent performance across students.

For the conceptual test, students in the experimental section (M=18.89, SD=3.41) also significantly outperformed students in the control section (M=17.06, SD=5.16), t=2.04, p=0.045. The effect size (Cohen's d=0.44) indicates a small-to-medium practical effect.

Analysis of pass rates revealed substantial differences between groups. Using a threshold of 60% of the maximum possible score, the experimental section achieved an 86.2% pass rate on exams compared to 58.8% for the control section, a difference of 27.4 percentage points. For the conceptual test, the pass rate was 89.7% in the experimental section compared to 72.7% in the control section. Figure 1 compares the score distribution between the two sections.

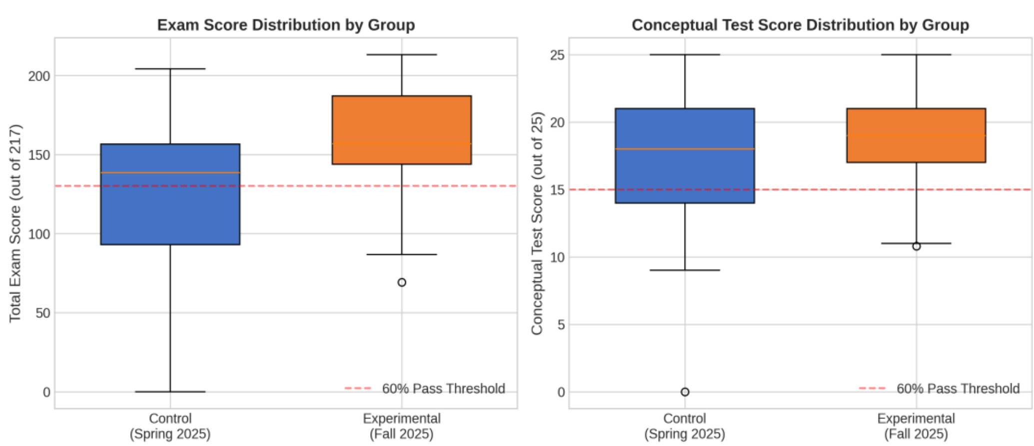

Figure 1. Score Distribution Comparison Between The Control and Experiment Sections

4.2 Qualitative Analysis: Likert Scale Items

Survey responses from 47 students in the experimental section revealed generally positive perceptions of the Time to Climb activities. Table 2 presents the mean ratings and standard deviations for each survey item, organized by category.

Table 2. Student Perceptions of Time to Climb Activities (n=47)

Survey Item	Mean	SD
Engagement & Enjoyment		
Made lectures more engaging	4.02	0.97
Looked forward to classes with T2C	3.87	1.06
Competitive aspect increased participation	3.62	1.26
Made learning more enjoyable	4.06	0.99
Category Mean: 3.89 (SD=1.08)		
Learning Effectiveness		
Helped understand key concepts	3.72	1.14
Immediate feedback was valuable	4.04	1.00
Effective review of material	3.91	0.95
Highlighted areas needing study	3.83	1.14
Contributed to exam performance	3.26	1.19
Category Mean: 3.75 (SD=1.11)		
Classroom Dynamics		
Increased attentiveness during class	3.98	1.13
Created interactive environment	4.11	1.01
Motivated to come prepared	3.60	1.25
Encouraged peer discussion	3.55	1.23
Category Mean: 3.81 (SD=1.17)		

Note: Scale: 1=Strongly Disagree, 5=Strongly Agree. T2C = Time to Climb.

Across all categories, mean ratings exceeded the neutral point (3.0), indicating generally positive perceptions. The highest-rated items were "Created interactive environment" (M=4.11), "Made learning more enjoyable" (M=4.06), "Immediate feedback was valuable" (M=4.04), and "Made lectures more engaging" (M=4.02). The lowest-rated item was "Contributed to exam performance" (M=3.26).

Regarding the overall effectiveness, 42.6% of students rated Time to Climb as "Very effective" or "Extremely effective," while 31.9% rated it as "Moderately effective." When compared to traditional review methods, 40.4% found Time to Climb to be "Somewhat more effective" or "Much more effective," 38.3% found it "About the same," and 21.3% found it less effective.

4.3 Qualitative Analysis: Open-Ended Responses

Thematic analysis of open-ended responses revealed several recurring patterns. When asked what they liked most, students frequently mentioned: (1) Immediate feedback and self-assessment - "It allowed me to see what I need to study more"; (2) Engagement and fun - "They were fun and engaging"; (3) Interactive classroom environment - "It pulled the entire class together and the room felt more alive"; and (4) Competition as motivation - "The competitive nature was fun and made me strive for the correct answer."

When asked what they liked least, concerns included: (1) Competitive pressure - some students felt uncomfortable being compared to peers; (2) Question difficulty alignment - multiple students noted a disconnect between Time to Climb questions and exam questions; (3) Time pressure - the time-limited nature was challenging for some; and (4) Time efficiency - a few students felt activities consumed time that could be used for other review methods.

Approximately 70% of respondents supported using Time to Climb in other engineering courses, often with qualifications about its suitability for conceptual versus problem-solving content.

5. Discussion

This study investigated the impact of Nearpod's Time to Climb gamified activities on student performance and perceptions in an undergraduate Linear Circuits course. The results provide evidence supporting the effectiveness of gamification as a pedagogical strategy in engineering education, while also revealing important considerations for implementation.

The quantitative findings demonstrate statistically significant and practically meaningful improvements in student performance associated with the gamified intervention. Students in the experimental section achieved mean exam scores approximately 23% higher than the control group, with a medium-to-large effect size (Cohen's d=0.74). These findings align with prior research demonstrating positive effects of gamification on academic performance in STEM education [3], [16]. Particularly noteworthy is the substantial improvement in pass rates observed in the experimental section. The 27.4 percentage point increase in exam pass rates suggests that gamification may be especially beneficial for students who might otherwise struggle. This finding has important implications for student retention in gateway engineering courses.

Survey results indicate that students generally perceived Time to Climb activities positively. The highest ratings were associated with creating an interactive environment, making learning enjoyable, and providing valuable immediate feedback. These findings are consistent with research indicating that gamification enhances student engagement [17]. Interestingly, the lowest-rated item concerned the perceived contribution to exam performance (M=3.26), despite the quantitative evidence showing significant improvements. This discrepancy may reflect students' difficulty in accurately assessing factors contributing to their learning.

The qualitative data revealed challenges that merit attention. Concerns about competitive pressure highlight the importance of considering individual differences. The perceived disconnect between Time to Climb questions and exam content represents a design challenge inherent to the platform's format constraints.

Finally, the study limitations should be considered. The survey was administered only to the experimental section and the study was conducted in a single course at one institution. Future work will consider multiple sections and courses to assess the effectiveness of gamification in different contexts and student bodies. Finally, the absence of a delayed post-test prevented conclusions about long-term retention. The authors plan to assess long-term retention in follow-up classes that requires having Linear Circuits and Systems as a prerequisite.

6. Conclusion

This study provides empirical evidence supporting the effectiveness of Nearpod's Time to Climb as a gamification tool for enhancing student performance and engagement in an undergraduate electrical engineering course. Students in the gamified section demonstrated significantly higher exam and conceptual test scores compared to students receiving traditional instruction. Survey data indicated positive student perceptions, though students also identified challenges related to competitive pressure and question-exam alignment.

These findings contribute to the growing body of research on gamification in STEM higher education and offer practical implications for engineering educators. Time to Climb and similar gamified tools appear to be effective low-stakes strategies for promoting active learning. However, implementation should consider individual student differences and position gamified activities as complements to traditional instructional methods.

Future research should examine effects across different engineering disciplines, investigate the influence of student characteristics on gamification effectiveness, and assess long-term retention of learning gains.

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