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Gamification in Statistics: The Impact of Flashcard-Based Learning on Engagement and Comprehension

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Abstract

Digital education has transformed traditional learning approaches, offering innovative strategies to enhance student engagement and comprehension. Despite these advancements, students often struggle with basic concepts due to passive learning methods, limited retention, and low motivation. This study explores the effects of gamified flashcard-based learning on students' engagement, motivation, and perceived understanding of statistical concepts. Adopting a one-group pre- and post-survey design, the intervention was conducted for students enrolled in an introductory statistics course. Students participated in a flashcard activity designed to encourage peer interaction, rapid recall, and competitive learning in a one-hour session. Surveys administered before and after the activity captured changes in attitudes toward learning statistics, confidence, and motivation. Quantitative analysis revealed slight, but statistically non-significant differences across most items: confidence in understanding statistics (p = 0.058), motivation to participate (p = 0.414), and openness to interactive methods (p = 0.564). However, qualitative responses from open-ended questions revealed strong positive perceptions of the activity, with students highlighting its engaging, enjoyable, and collaborative nature. They reported benefits such as improved recall, greater interaction with peers, and increased enthusiasm for learning. These findings suggest that while short-term perceptual gains may not always translate into statistically significant changes, gamified flashcard activities can enrich the classroom experience and promote active engagement. The study shows the value of incorporating interactive, student centred strategies in teaching foundational statistics, offering practical implications for educators seeking to create dynamic learning environments.

Keywords: Flash Card, Gamification, Active Learning, Statistics

Introduction

Teaching statistics at the higher education level is constantly challenging as educators, especially when it comes to maintaining student interest, drive, and conceptual

comprehension. Many students approach statistical topics with anxiety or disinterest because they are considered to be difficult and complicated (Peiró-Signes et al., 2021). While being instructive, traditional lecture-based approaches usually promote passive learning, which decreases the likelihood for engagement, interaction, and deep cognitive processing (Klein et al., 2023). Educators are continually searching for innovative approaches to improve how quantitative subjects like statistics are taught as higher education keeps evolving in response to pedagogical and technological advancements (Ismail et al., 2022).

Educational methods have progressed significantly, with an increasing interest in active learning methodologies that involve students in the learning process. Active learning is a technique in which students actively participate in their learning rather than passively obtaining knowledge from teachers (Freeman et al., 2014). Based on research, methods of active learning such as peer teaching, problem solving, and the use of digital tools improve course comprehension and memory retention (Dogani, 2022).

Gamification learning, a teaching approach that introduces elements of game design, such as challenge, productivity, and instant feedback into the learning process, is one potential approach. It has long been acknowledged as flashcard-based learning, in particular, is an effective instrument for promoting active recall, repetition, and retrieval practice (Smiderle et al., 2020). By motivating peer collaboration, improving classroom excitement, and motivating students to engage more fully, gamified flashcard activities could enhance learning (Lin et al., 2018).

The objective of this study is to explore the way gamified using a digital flashcard as a based learning method to promote student engagement and perceived statistics understanding. It focuses on looking at the outcomes of the flashcard race type activity, which was implemented with foundation-level university students. The study used a one group pre- and post-survey design to assess changes in motivation, involvement, and attitudes towards interactive learning. Quantitative results show minor improvement in engagement and confidence, while qualitative feedback from open ended questions indicates the way students value the activity's interactive, collaborative, and entertaining components (Jutin e al., 2024).

By critically examining the impact of gamified flashcards, this study contributes to the growing body of literature on active learning and pedagogical innovation in teaching of mathematics and statistics in an effort to develop increasingly exciting and educational circumstances, this provides empirical reasons for implementing interactive methods that extend beyond standard education.

Literature Review

Gamification is the use of game elements in non-game settings. These elements can include points, badges, leaderboards, and storytelling. In education, gamification has gained attention as a way to make learning more interactive and engaging. It aims to move away from passive instruction and promote active student participation. Rooted in theories of motivation and cognitive development, gamification seeks to enhance both student engagement and learning outcomes by leveraging elements traditionally associated with play (Alsawaier, 2018). Through goal-directed activities, gamified environments can stimulate both intrinsic and extrinsic motivation by addressing learners' psychological needs for

competence, autonomy, and recognition. Popular educational platforms like Kahoot! and Khan Academy illustrate how gamification has been widely adopted, particularly in STEM education, to provide instant feedback, promote healthy competition, and support self-regulated learning.

Although gamification has become increasingly popular in educational settings, it is not without its challenges. Scholars have highlighted the issue of the novelty effect where initial enthusiasm for gamified activities may decline over time if these tools are not supported by well-designed and consistent pedagogical frameworks (Bayraktarlı & Selcuk, 2025). Furthermore, an overreliance on extrinsic rewards such as points and badges, can divert attention from meaningful learning processes and potentially undermine students' intrinsic motivation (Xiao & Hew, 2024).

To address these concerns, researchers have emphasized the importance of aligning gamified instructional design with robust theoretical frameworks, such as Self-Determination Theory (SDT). SDT underscores the significance of fulfilling learners' psychological needs for autonomy, competence, and relatedness. When these needs are effectively supported, gamified experiences can lead to sustained engagement and deeper learning; conversely, poorly implemented gamification may result in disengagement or cognitive overload (Zainuddin et al., 2024; Liang, 2024).

In addition to SDT, insights from behaviorist and constructivist theories provide a broader foundation for understanding gamification's effectiveness. Behaviorism highlights how reinforcement through rewards and feedback can condition desired behaviors, a mechanism often used in gamified systems. Meanwhile, constructivist learning theory emphasizes the role of active participation, problem-solving, and knowledge construction through experience which is core characteristics of well-designed gamified learning environments. The use of scaffolding, collaboration, and real-time feedback within such environments aligns with constructivist principles, enabling learners to incrementally build expertise through guided interaction (Ede, 2022; Eswaran, 2024).

The potential of gamification is particularly relevant in the context of statistics education, a domain where students frequently encounter cognitive and emotional barriers. Research has consistently shown that many students perceive statistics as overly abstract and mathematically dense, often resulting in anxiety, low motivation, and limited conceptual understanding especially among those with weaker backgrounds in mathematics (Dost, 2024; Tishkovskaya & Lancaster, 2012). Traditional approaches to teaching statistics have often focused more on procedural skills, like formula memorization and computation, rather than on interpretation, reasoning, and applying concepts to real-world situations. (Noor et al., 2024).

In response to these challenges, there is an increase in empirical research supporting the use of gamified learning to improve educational outcomes. A recent meta-analysis by Aguilar et al. (2023), synthesizing findings from 41 studies and over 5,000 learners, reported a significant positive effect of gamification on student learning. The study identified several moderating factors, such as the type of learner and duration of the intervention, noting that shorter, focused gamified activities tend to yield stronger results. Additional reviews have confirmed

that digital gamification tools, such as quiz platforms and virtual escape rooms, are effective in improving student independence, engagement, and academic performance in subjects like physics and computer science. (Jaramillo-Mediavilla, 2024)

While digital gamification tools have shown promising results, most research tends to focus on these high-tech methods, often neglecting low-tech alternatives that might offer similar benefits, particularly in settings with limited resources. One such overlooked approach is the use of card-based games for teaching. Card-based games, like flashcards, can leverage cognitive strategies such as active recall and spaced repetition to enhance long-term memory retention (Lazarevic, 2024; Solehah et al., 2024). When combined with game elements such as points or team-based competition, these tools can enhance student engagement, critical thinking, and collaboration. Given their affordability and ease of implementation, card-based games represent a practical and inclusive pedagogical strategy. However, limited research has investigated the effectiveness of low-tech gamified tools, such as flashcards, in university-level statistics courses, particularly within Malaysian contexts.

Methods

This study employed a one-group pre- and post-survey design, a form of descriptive and exploratory research. The descriptive component allowed for the systematic observation and measurement of students' engagement, motivation, and perceived understanding of statistical concepts. The exploratory aspect aimed to gain insights into the effectiveness of using a gamified flashcard activity in a university-level statistics classroom.

This design was selected due to practical limitations in creating a control group and the need to evaluate the effectiveness of a new teaching strategy within a real classroom setting. By comparing students' responses before and after the intervention, the study aimed to assess any perceptual shifts attributed to the learning activity.

The participants were foundation-level university students enrolled in an introductory statistics course. A total number of students enrolled in the course is 213, but the study focused on one class with 16 students where the gamified flashcard activity was implemented. Participants from this class were selected through convenience sampling, as they were readily accessible to the researcher. While this non-probability sampling approach limits generalizability, it is appropriate for exploratory classroom-based educational research. These students possess different levels of mathematical background, making it essential to explore innovative approaches to support their comprehension and interest in learning statistics. All participants were informed about the study’s purpose and gave consent to participate. Anonymity and confidentiality were maintained throughout the process

Research Design

This study employed a quantitative, descriptive one-group pre-test and post-test design to examine the impact of a gamified flashcard-based activity on students’ motivation, engagement, and perceived understanding of statistical concepts. The research design aligns with quasi-experimental methods, as it involved measurements taken before and after an instructional intervention without the inclusion of a control group.

A total of 16 foundation-level university students enrolled in an introductory statistics course participated in the study. The sampling method used was convenience sampling, as the participants were students from the researcher's own class. All participants provided informed consent, and confidentiality was maintained throughout the study.

Data were collected using structured questionnaires administered before and after the intervention. The survey instrument consisted of Likert-scale items measured on a 4-point scale (1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree) to assess three key constructs: students' motivation, confidence in understanding statistical content, and openness to interactive learning methods. Additionally, open-ended questions were included to gather qualitative insights into students' experiences during the activity.

The instructional intervention was a gamified activity known as the Flashcard Race, designed to reinforce students' understanding of statistics through active learning, rapid recall, and peer collaboration. Prior to the activity, students were given a 10-minute review period with a summary of the topic. They were then divided into teams of four. In each round, flashcard are displayed via Quizizz, featured questions involving statistical definitions, formulas, or problem-solving tasks. The team that responded correctly first received a point. If the response was incorrect, the opportunity was passed to the remaining teams. The team with the highest score at the end was declared the winner. This competitive structure encouraged active engagement, quick thinking, and collaboration among peers.

To evaluate the impact of the intervention, pre- and post-survey responses were compared using descriptive statistics and paired-sample t-tests. Prior to conducting the t-tests, the assumption of normality for the difference scores was tested using the Shapiro-Wilk test. Results indicated that the data violated the normality assumption for all three constructs: confidence in understanding Statistics ($p = .007$), motivation to participate ($p = .001$), and openness to interactive learning ($p < .001$). As a result, non-parametric tests were considered more appropriate for subsequent analysis.

Result and Discussion

This section presents the findings from both the pre- and post-survey aimed at evaluating the impact of flashcard-based interactive learning on students' confidence, motivation, and openness to interactive methods in a foundation-level statistics course. Quantitative analyses were complemented with qualitative responses to provide a comprehensive understanding of student experiences.

The pre-survey responses revealed a broad range of student learning preferences and initial attitudes toward gamified methods. When asked how they preferred to learn statistics, students most frequently selected problem-solving activities ($n = 12$), followed closely by traditional lectures and interactive games ($n = 11$). Fewer students preferred visual aids ($n = 7$), and only a small number preferred group discussion ($n = 3$). This distribution suggests a strong inclination toward active and applied learning, even among students who still value traditional instruction.

Regarding prior exposure, 62.5% of students ($n = 10$) reported having experience in using flashcards or interactive games, indicating a moderate level of familiarity with such tools.

Students' enthusiasm for interactive learning methods was generally high: 56.25% were either "excited" ($n = 9$) or "very excited" ($n = 5$) about using interactive strategies to learn statistics, while only 12.5% ($n = 2$) reported low excitement levels. No students expressed a complete lack of interest. These findings suggest that the learner demonstrates both openness and a strong inclination toward the adoption of gamified learning approaches.

To evaluate the impact of the Flashcard Race on students' confidence, motivation, and openness to interactive learning, the Wilcoxon Signed-Rank Test was conducted due to the violation of normality assumptions as indicated by the Shapiro-Wilk test and due to small sample size (Zimmerman, 1996). Table 1 shows the result analysis from Wilcoxon Signed-Rank test. The test compared pre- and post-survey scores for three constructs.

Table 1
Wilcoxon Signed-Rank Test result

Construct	**Z-value**	**p-Value (Two-Tail)**	**Significant? (p < .05)**
Confidence in understanding statistics	-1.897	0.058	Not statistically significant, approaching significance
Motivation to participate in class	-0.816	0.414	No significant difference
Openness to interactive methods	0.577	0.564	No significant difference

Based on Table 1, the results from the Wilcoxon Signed-Rank Test indicated no statistically significant changes in students' confidence, motivation, or openness to interactive learning following the Flashcard Race intervention. Although the change in confidence approached significance ($p = .058$), motivation ($p = .414$) and openness ($p = .564$) did not show meaningful statistical differences. These findings suggest that the short, single-session gamified intervention may not have been sufficient to produce measurable shifts in students' perceptions on its own, especially with a small sample size ($n = 16$).

Despite the absence of statistically significant outcomes, the Flashcard Race demonstrated practical significance in promoting student engagement and positive learning experiences. As mentioned by Latif et al. (2019) and Maricoto et al. (2016), educational interventions can still be considered pedagogically impactful even in the absence of statistically significant results, especially when supported by qualitative feedback. In this study, students consistently described the Flashcard Race as "*fun*", "*engaging*", and "*interactive*". These affective reactions align with student engagement theory, which posits that cognitive, emotional, and behavioral involvement are foundational to effective learning (Sugden et al., 2021). The positive sentiment expressed in the open-ended responses reinforces the value of the intervention. Students emphasized teamwork, peer discussion, and critical thinking, with comments such as "*It's fun to discuss and learn with your friends*", "*Discussing the correct answer*", and "*It allows critical thinking and faster solution making*". These observations reflect the core strengths of collaborative, gamified strategies and are consistent with Moreno's (2024) findings that real-time and interactive learning environments can enhance active participation and memory retention.

From cognitive perspective, the flashcard activity draws upon principles of retrieval practice and spaced repetition, known to improve long-term memory consolidation (Azzam et al., 2021). Although not directly measured, students' reflections such as "*Easy to recall on what I learned in previous classes*" and "*It encourages speed and accuracy*" suggest that the activity reinforced prior learning and promoted rapid cognitive processing. Additionally, the positive responses to whether the activity should be repeated in future classes indicate high levels of student endorsement. Statements such as "*YES. IT WAS THE MOST ENGAGING CLASS EVER. I'M SURE NO ONE WAS SLEEPING*" and "*Yes, because it allows more interactions and in-depth discussion with groupmates*" highlight the intervention's success in creating an enjoyable and participation learning environment which is highly valuable outcome in traditionally challenging subjects like statistics.

The contrast between the quantitative and qualitative findings highlights the importance of a mixed-methods approach in educational research. While Likert-scale data provides structured measurements, open-ended responses offer richer, contextual insights into students' live experiences. This divergence suggests that short-term interventions may influence students' perceptions and behaviors in meaningful ways not immediately captured through statistical testing.

Conclusion

This study investigated the effects of flashcard-based interactive learning on students' confidence, motivation, and openness to active learning strategies in a foundation-level statistics course. Although the quantitative results revealed no statistically significant improvements in all areas, students maintained high levels of confidence and motivation across both pre- and post-surveys. Importantly, qualitative feedback from students highlighted strong appreciation for the interactive, competitive, and collaborative aspects of the Flashcard race. The findings suggest that flashcard activities have the potential to support a more dynamic and interactive classroom environment, particularly in subjects where student engagement is traditionally low. Although the short-term measurable effects were modest, the positive student responses suggest that such interventions may contribute meaningfully to cognitive engagement and classroom participation over time. This study offers one of the few empirical insights into low-tech gamification approaches in Malaysian statistics education, providing practical implications for educators seeking accessible, scalable strategies to increase engagement. Limitations include small sample size and the absence of a control group, which restrict the generalizability of the findings. Future research should incorporate larger samples, control conditions, and objective learning outcome measures to more comprehensively evaluate the long-term effectiveness of gamified learning tools.

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