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Effects of Game-Based Learning on Engagement and Academic Performance for Undergraduate Science and Engineering Students*

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In recent years, the adoption of flipped learning as an educational approach has gained significant momentum. This pedagogical method involves the delivery of direct instruction outside of the classroom, utilising videos, quizzes and lecture slides to facilitate active learning during class time. To address the challenge of student motivation and enhance overall engagement, the incorporation of game-based learning within the flipped learning approach has emerged as a promising solution. This research aims to explore the potential of gaming in promoting active learning and fostering a deeper understanding of course material. The findings highlight the positive impact of gamification on student engagement and academic performance within an undergraduate Engineering module. Through the integration of game elements, such as Kahoot and a leader board system, students exhibited increased motivation and active participation throughout the course. The implementation of game-based strategies effectively captured students' attention and facilitated a dynamic learning environment. The results demonstrated a positive correlation between engagement levels and academic performance, affirming the efficacy of gamification in promoting enhanced learning outcomes. Furthermore, this study highlighted the importance of recognising and celebrating student achievements through public displays of accomplishment. The public acknowledgement of high achievers not only instilled a sense of pride and motivation in these students but also inspired their peers to strive for excellence. The collective applause and recognition from the entire class served as a powerful reinforcement of the value and significance of active engagement in the module. These findings emphasise the potential of integrating flipped learning and game-based strategies as a comprehensive educational framework that caters to diverse student needs and maximises learning outcomes. Future research will focus on scaling up the study to encompass a wider range of undergraduate Engineering modules, involving a larger cohort of students from various disciplines. By expanding the investigation, a more comprehensive understanding of the effects of gamification on different student populations can be attained. Overall, this study contributes to the growing body of literature on gamification in education, underscores its potential to transform traditional instructional practices and promotes effective teaching and learning experiences.

Keywords: student engagement; student experience; gamification; Kahoot; flipped learning; active learning

1. Introduction

Prior to the onset of the COVID-19 pandemic, engagement was a well-known challenge in higher education, and its impact has been exacerbated by the effects of the lockdown and associated restrictions on the delivery of education. University students are becoming increasingly autonomous and can decide how much engagement they are willing to invest in their academic pursuits. Nevertheless, making ill-judged decisions, such as lacking in engagement, can be detrimental to students' higher education achievements [1, 2]. While flipped learning offers numerous advantages, its effectiveness greatly hinges on students completing out-of-class activities. Successful flipped classroom implementation assumes students possess the intrinsic motivation necessary to engage with these materials [3]. However, studies have indicated that students may perceive video lectures as less captivating and struggle to sustain their focus, making the flipped learning model beneficial primarily for motivated students who are willing to undertake the additional workload [4–6]. In addition, social media and other forms of easily accessible digital information have become the norm, making it difficult to capture students' attention and motivate them to engage with academic content [7]. As a result, this issue has garnered attention from educational institutions worldwide.

One approach that has been found to help overcome this challenge is gamification which is a technique incorporating game-like elements into educational contexts. Several studies have indicated that incorporating gamification elements, such as points, badges and leader boards can increase student motivation and engagement in online learning environments [8–10]. For instance, a study published in the International Journal of Educational Technology in Higher Education found that incorporating gamification elements into an online course increased student engagement and motiva-

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tion [11]. Similarly, another study revealed that competition and recognition can increase intrinsic motivation, which is self-driven motivation rather than from external rewards [12, 13]. Gamification that requires active engagement and includes competitive elements seem to be particularly effective in influencing students' psychology and transforming behaviours [14, 15]. Incorporating competition into the gamification process provides a clear goal for students and a means of measuring progress, leading to increased motivation and effort put into enhancing academic performance [16].

This study attempts to develop further the gamification concept by introducing individual point collection, scores, podiums and awards into the learning process. Existing standard formative quizzes are perceived as routine learning and not engaging, instead, gaming elements incorporating unlocking phases that require students to complete a certain level to progress to the next were introduced. Point collection, which allows students to accumulate points by participating in online activities and answering interactive quizzes, provided them with a sense of progress and accomplishment. Kahoot, an interactive learning platform, was used to create online quizzes and surveys accessible from students' own devices. This platform provides real-time feedback on their responses, allowing them to evaluate their performance and compare it to their peers. To further enhance student engagement, the element of competition was added. The students competed against each other on a weekly basis and, depending on the number of points collected (based on the levels unlocked and the Kahoot participation), they could win a gold, silver or bronze virtual medal, which is then advertised and celebrated in the classroom [17].

2. Methodology

This study was tested in a large engineering second year module ''Designing for sustainable manufacturing'' that suffered from a lack of engagement after it went into mixed-mode education (MME, where some activities were online and others in-person), with many students choosing not to attend in person sessions intended to complement remote learning. The approach used in this study employs a novel and comprehensive methodology, grounded in the tenets of gamification. Specifically, three distinct gamification elements were introduced into the module, each designed to enhance student engagement, foster a sense of progression and facilitate a rewarding learning experience. Given that engagement for this study refers to in-class attendance as well as completion of synchronous (in-class) and asynchronous (out of class) activities, the following changes to the module were implemented:

Integration of Kahoot Quizzes: To leverage the asynchronous content provided on the virtual learning environment (VLE) platform, interactive Kahoot quizzes were introduced as a means of encouraging students' comprehension and retention of the material. These quizzes, accessible on various devices, provided real-time feedback and fostered healthy competition among students. It is anticipated that this method will not only promote active participation but also facilitate self-assessment, allowing students to evaluate their performance and compare it to their peers [18, 19].

Running of Weekly Formative Quizzes: A series of formative quizzes, aligned with the asynchronous activities, were introduced on a weekly basis. The completion of each quiz served as a prerequisite for unlocking subsequent quizzes, creating a progressive learning experience akin to advancing through different levels in a game. By setting grade or point thresholds for each quiz, students were motivated to actively engage with the module content, ensuring a solid foundation of knowledge before progressing further. This is open for students to attempt multiple times in order to progress to the next level.

Adoption of the Activity Completion Feature: To enable students to track their progress and gauge their engagement, an Activity Completion Feature was incorporated into the module's VLE. This feature provided a visual representation of students' involvement and progress, allowing them to monitor their completion status for various activities, like watching videos, taking quizzes, reading documents, submitting work, etc.

Establishment of a Leader board (Kahoot): As a means of recognizing and celebrating student achievements, a weekly leader board was generated and prominently displayed on the QM+ platform. The leader board incorporated data from Kahoot quizzes, formative quizzes and activity completion, showcasing the top performers.

3. Results and Discussion

Fig. 1 shows the engagement results from 2021–2022 and 2022–2023 academic years, it provides valuable insight into the impact of incorporating Kahoot as a gaming element in the module. Because 2021–2022 academic year was still affected by Covid-19 restrictions, the following analysis only takes into account asynchronous activities. The analysis highlights a compelling contrast between the current year's engagement levels, influenced by the introduction of gaming elements and changes in delivery, and the previous year's engagement patterns. In the current year, the observed pattern of

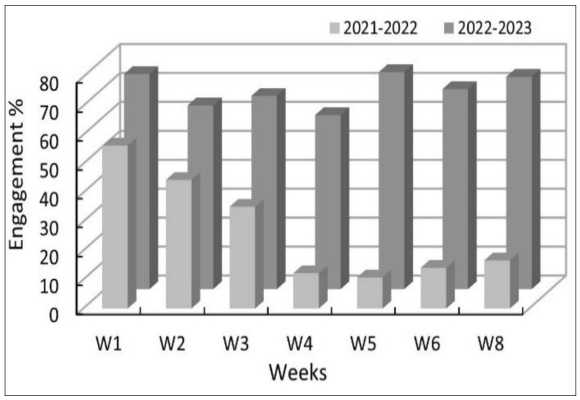

Fig. 1. Weekly comparison of student engagement for two subsequent years.

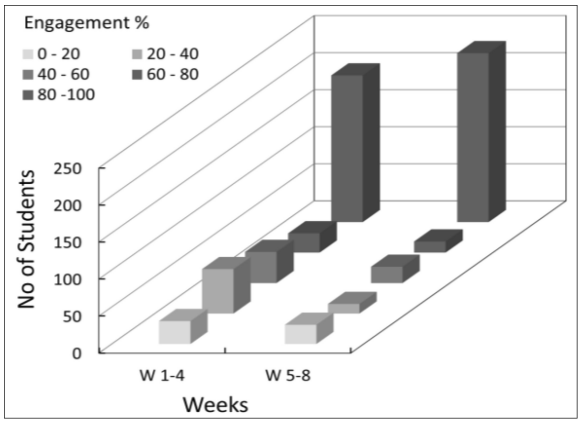

Fig. 2. Effect of gaming element on students' engagement.

engagement demonstrates noteworthy fluctuations, indicating a dynamic response to the introduction and integration of Kahoot into the module structure. Initially, during Week 1, a high level of engagement was observed, signifying students' initial enthusiasm and eagerness to participate in the module. However, as the weeks progressed, a gradual decline in engagement became apparent, suggesting a potential decline in student motivation or interest in the course material. This decline resonates with the challenges identified in the existing literature concerning the sustainability of student engagement in conventional instructional methods. Of particular interest is the notable increase in engagement observed during Week 3, which coincided with the introduction of Kahoot as a pilot. This temporary surge in engagement can be attributed to the novelty and excitement associated with the gaming element, captivating students' attention and fostering their active involvement. This finding aligns seamlessly with previous discussions on the potential benefits of gaming in fostering student engagement and interest. However, engagement levels experienced a subsequent decline, underscoring the need for a more sustained and integrated implementation of Kahoot to maintain students' active participation. The subsequent incorporation of Kahoot as a regular component of the lectures in Week 5 appears to have effectively addressed this challenge. From this moment onwards, a consistent and stable level of high engagement was observed throughout the remaining weeks of the term.

Comparatively, when considering the engagement data from the previous year, a contrasting narrative emerges. The chart reveals that the highest level of engagement occurred during Week 1 but failed to regain momentum and instead experienced a continuous decline throughout the term. This stark contrast highlights the significance of the gaming elements and the changes in delivery implemented in the current year, which have evidently contributed to the sustained and elevated levels of engagement observed.

Fig. 2 depicts the effect of gaming elements on the students' engagement. Students are categorised based on their level of engagement into the following groups (bands): Band A is 80–100%, Band B 60–80%, Band C 40–60%, Band D 20–40% and Band E 0–20%, during weeks 1–4 and weeks 5–8 of the semester. It offers valuable insights into the impact of incorporating gaming methods, such as the leader board and Kahoot, on student participation and engagement. It can be seen that notable shifts in student distribution across the engagement groups become apparent when comparing the weeks sets, where the comprehensive gaming elements were fully integrated into the module.

It can be observed that there was a decrease in the number of students belonging to the lower engagement groups, specifically the 0–20% to 60–80% categories when comparing weeks 1–4 to weeks 5–8. This decline indicates a reduction in disengaged students within the module. Conversely, the 80–100% engagement group exhibited an increase in student representation during Weeks 5–8. This supports the notion that the integration of gaming methods positively influenced student engagement and active participation. It suggests that the gaming interventions effectively motivated and sustained the involvement of students who were already highly engaged, further enhancing their overall learning experience.

Looking further into the data, Fig. 3 shows an initial decline in student engagement with the passage of weeks. However, the implementation of Kahoot, introduced in week 4, appears to have effectively reversed this disengagement trend. Notably, a polynomial best-fit curve underscores this positive shift, with engagement levels exhibiting an upward trajectory from week 4 onwards. Interestingly, the observed patterns in student performance

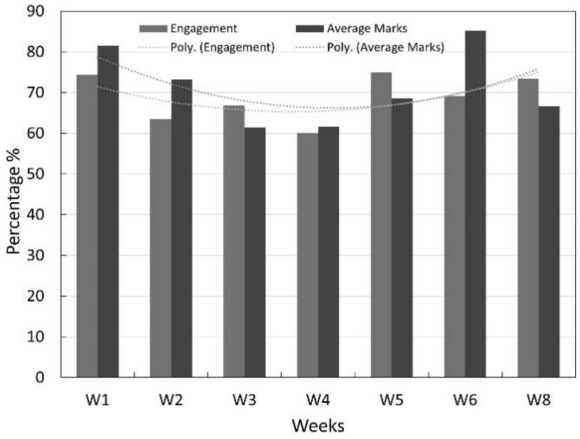

Fig. 3. Weekly comparison of engagement and average marks of cohort.

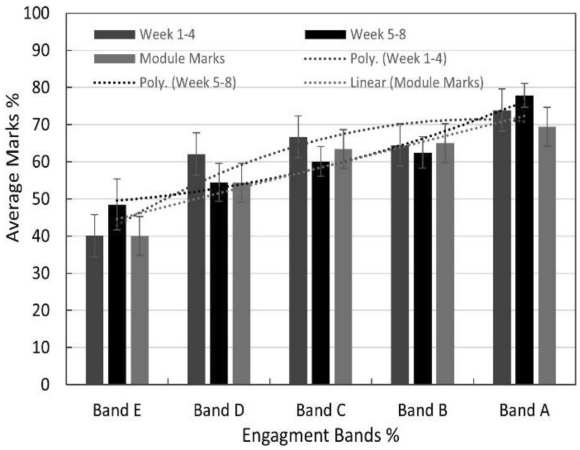

Fig. 4. Average marks across different levels of student engagement before and after the introduction of gaming element (weeks 1–4 and weeks 5–8).

closely mirror those in engagement, suggesting a potential interplay between engagement and academic achievement. However, it is essential to acknowledge that while this alignment strongly suggests a relationship, this study does not account for all possible variables. Consequently, the observed increase in average marks could be influenced by factors beyond the scope of this investigation. Future research should address potential variables to strengthen the validity of these findings and explain the nuanced dynamics between engagement and academic success. For example, week 8 displays a lower average mark compared to the previous one, even though engagement kept increasing. A possible explanation is the reduction in student focus due to more commitments in other modules, typically multiple coursework submissions around that time of the semester.

Fig. 4 shows that there is a positive association between student engagement and academic performance. It can be observed that the students in the higher levels of engagement bands (Band A is 80–100%, Band B 60–80%, Band C 40–60%, Band D 20–40% and Band E 0–20%) clearly achieve superior grades compared to their counterparts in lower engagement bands.

Furthermore, for weeks 1 to 4, as noted above, average marks increase as students' engagement level increases, however, the rate of increase clearly weakens between the second and last engagement bands as underlined by the polynomial best-fit curve. This could suggest a potential saturation in the influence of engagement on academic outcomes.

Similarly, for week 5–8, average marks increase as students' engagement increase. It also shows that students in higher engagement bands score higher grades compared to those in lower engagement bands. However, this time, the increase is consistent across all bands with the polynomial best-fit curve showing a clear continuous upward trend, potentially due to the introduction of gaming elements to the delivery of the module.

It is also worth noting that, even though average marks consistently increase with higher engagement in all bands, the average mark achieved by students with mid-engagement levels (bands D–B) has slightly decreased between the first 4 weeks and the last 4 weeks (i.e., first and second halves of the semester). This decline can be attributed to several factors, with one prominent consideration being the increasing complexity of module content as the weeks progress. This may have posed a challenge for students who initially displayed average engagement, exacerbating their ability to catch up with the evolving curriculum. In contrast, the lowest and highest engagement bands (E and A) saw an increase in average marks, which might suggest that the introduction of gamification had a stronger effect on these students. In order to find out if these differences are significant, a T-statistics analysis is conducted. Table 1 shows the statistical analysis with paired sample T-test between the average marks and student engagement during weeks 1–4 activities and weeks 5–8 activities (i.e. before and after the introduction of gaming element).

Table 1 suggests that that there is a significant difference in means of grades and engagement [20].

Table 1. T-test analysis results

Variable	Type of Test	P Value	P < 0.05
Weeks 1–4 Grades vs Week 5–8 Grades	T-test: Paired Two Sample for Means	0.01553	Significant
Weeks 1–4 Engagement vs Week 5–8 Engagement		0.00049	Significant

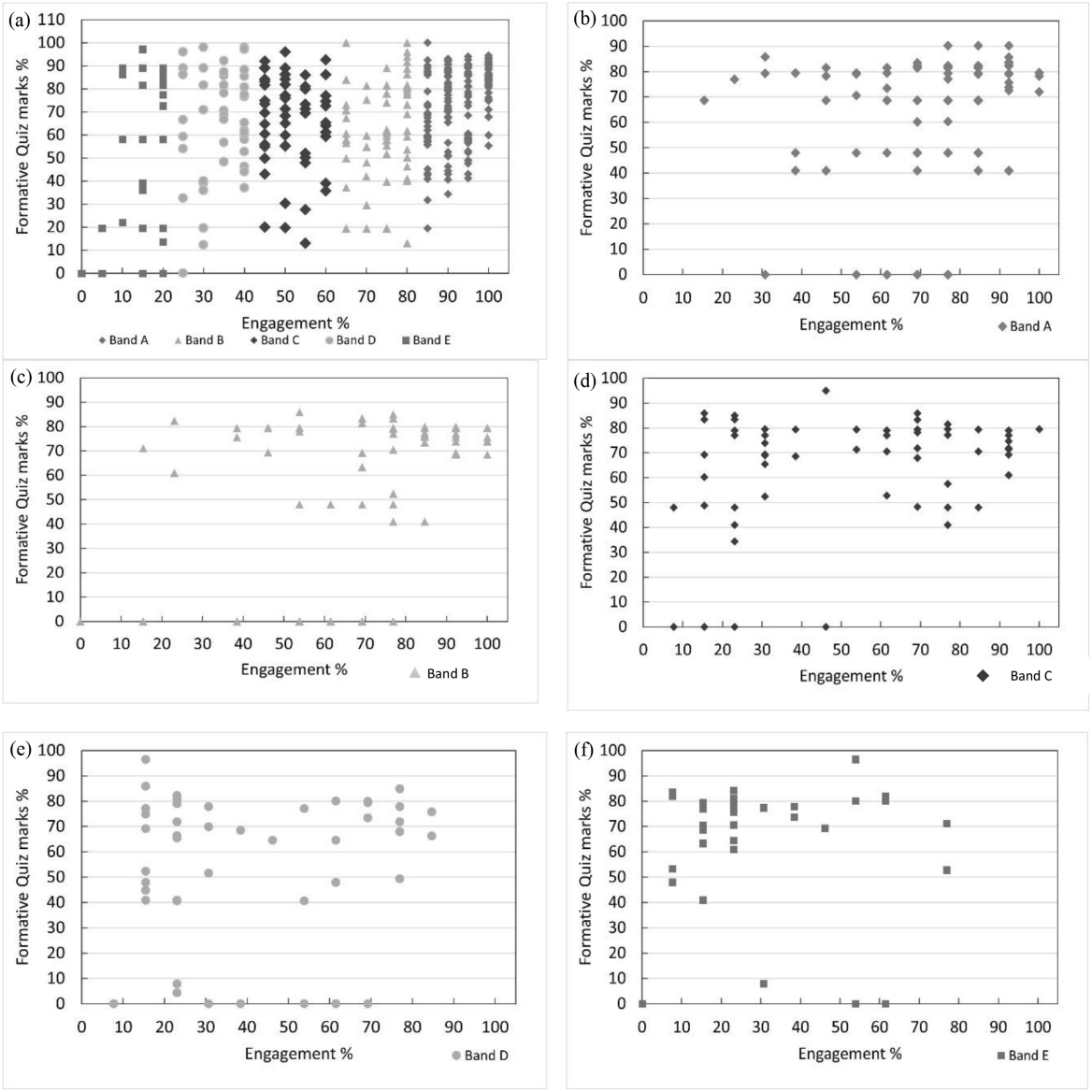

Fig. 5. Tracking student engagement and their academic performance in summative assessments. (a) distribution showing different levels of student engagement in weeks 1–4; (b) Engagement of Band A students in weeks 5–8; (c) Engagement of Band B students in weeks 5–8; (d) Engagement of Band C students in weeks 5–8; (e) Engagement of Band D students in weeks 5–8; (f) Engagement of Band E students in weeks 5–8.

It is then likely that, in general for the whole cohort, engagement and grades before and after the intervention (integration of gaming elements) have been positively affected.

Fig. 5 provides a comprehensive visualisation of student engagement patterns, illustrating bands A to E, where E corresponds to the lowest engagement level (0–20%) and A the highest (80–100%). Fig. 5a shows the student engagement band and their average grades in weeks 1–4 whereas Figs. 5b–5f shows their shift in engagement band and their corresponding grades in weeks 5–8. Interestingly, around half the students within the highest engagement band A (Fig. 5a) experienced a shift towards lower engagement (Fig. 5b). Nevertheless, their academic scores remained above average, implying a firm grasp of the course material, and potentially reflecting their academic ability. It seems that these students may have deliberately reduced their engagement levels in later weeks possibly due to a sense of mastery over the module content or a need to allocate more time to other modules. Notably, the graph demonstrates that their marks remained consistently high, indicating a sustained level of academic achievement despite the decrease in engagement.

Examining the performance of the middle bands it was observed that bands B, C and D (Figs. 5c, 5d, 5e respectively), exhibited a propensity to move in both lower and higher engagement bands. However, this did not prevent them from consistently

achieving scores above the passing threshold of 40% for quizzes.

The most concerning band, E, (Fig. 5a) characterised by minimal engagement in weeks 1–4, exhibited approximately half the number of students transitioning to higher engagement (Fig. 5f). The other half of students, with higher average grades, exhibited stagnant engagement levels. It is plausible to argue that these individuals possess inherent aptitude or self-motivation, enabling them to achieve high marks without the need for extensive engagement. This suggests that there may be a subgroup of academically talented students who naturally excel, irrespective of their engagement levels. Importantly, despite the initial low engagement, most students in this band managed to attain average or above academic scores in later weeks.

Overall, in weeks 1–4, there were 107 students scoring below 50% in engagement, but with subsequent shifts, 34 students (31.8%) transitioned to higher engagement levels in weeks 5–8. Similarly, among the group of students scoring above 50% in engagement (245 students), 51 students (20.8%) experienced a shift towards even higher engagement. Conversely, 35 students (14.3%) experienced a shift towards lower engagement. Furthermore, it is noteworthy to observe that there was a substantial decrease in the number of students (only 4 students) scoring below 40 marks in weeks 5–8 compared to earlier weeks (42 students). This suggests a positive impact resulting in better engagement, as fewer students struggled to meet the minimum academic threshold. This trend supports the notion that students with initially low engagement showed an upward trajectory, moving towards higher engagement levels and subsequently achieving improved academic performance.

It is worth noting that a small proportion of students (~6%) did not participated in the quizzes for unknown reasons even though they were still engaged with the module. These are the students with zero marks in Figs. 5b–5f. These students represent exceptional circumstances that deviate from the typical engagement and performance patterns observed within the dataset.

4. Conclusion

In conclusion, the findings of this study provide good evidence supporting the positive impact of incorporating gaming elements, such as Kahoot, in a flipped learning environment within an undergraduate Engineering module. The analysis of various data sets consistently demonstrated a significant increase in student engagement and its implication on academic performance. The results revealed a positive relationship between the level of engagement and academic performance across different measures of engagement, confirming the efficacy of gamification in fostering increased student involvement and active participation. The introduction of gaming elements was successful in enhancing student motivation and interest in the course material.

Moreover, the analysis of engagement levels over the duration of the module showcased the initial decline in engagement and subsequent fluctuations, highlighting the need for a sustained and integrated approach to maintain students' active participation. The steady and high levels of engagement observed following the full incorporation of Kahoot and leader board into the module delivery indicate their effectiveness in cultivating a consistent and stable level of student engagement throughout the course. These positive findings are indicative of the potential benefits of gamification in enhancing student engagement and learning outcomes in Engineering education. By leveraging gamification strategies, educators can create dynamic and interactive learning experiences that cater to students' diverse needs and preferences. The motivational aspect of gamification proved to be instrumental in improving students' performance, as evidenced by the notable increase in academic scores among students with healthy engagement levels.

Building upon these promising results, future research will aim to scale up the current study by targeting a wider range of undergraduate Engineering modules within the department and involving a larger cohort of students. This expansion will enable the exploration of the effects of gamification across various Engineering disciplines, allowing for a more comprehensive understanding of its impact. Additionally, incorporating qualitative research methods, such as interviews or surveys, can provide deeper insights into students' experiences and perceptions regarding the integration of gaming elements in their learning journey.

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References

1. Y. Hao, Exploring undergraduates' perspectives and flipped learning readiness in their flipped classrooms, *Computers in Human Behavior*, **59**, pp. 82–92, 2016.

2. G. D. Kuh, The National Survey of Student Engagement: Conceptual framework and overview of psychometric properties, *Indiana University Center for Postsecondary Research*, 2001.
3. M. Wolff, M. J. Wagner, S. Poznanski, J. Schiller and S. Santen, Not another boring lecture: Engaging learners with active learning techniques, *The Journal of Emergency Medicine*, **48**(1), pp. 85–93, 2015.
4. S. Freeman, S. L. Eddy, M. McDonough, M. K. Smith, N. Okoroafor, H. Jordt and M. P. Wenderoth, Active learning increases student performance in science, engineering, and mathematics, *Proceedings of the National Academy of Sciences*, **111**(23), pp. 8410–8415, 2014.
5. R. Fisher, Á. Perényi and N. Birdthistle, The positive relationship between flipped and blended learning and student engagement, performance, and satisfaction, *Active Learning in Higher Education*, **22**(2), pp. 97–113, 2018.
6. M. B. Gilboy, S. Heinerichs and G. Pazzaglia, Enhancing student engagement using the flipped classroom, *Journal of Nutrition Education and Behavior*, **47**(1), pp. 109–114, 2015.
7. R. Junco, The relationship between frequency of Facebook use, participation in Facebook activities, and student engagement, *Computers & Education*, **58**(1), pp. 162–171, 2012.
8. W. H. Huang, W. Y. Huang and J. Tschopp, Sustaining iterative game playing processes in DGBL: The relationship between motivational processing and outcome measures, *British Journal of Educational Technology*, **41**(6), pp. 1017–1032, 2010.
9. C. Cheong, J. Filippou and F. Cheong, Engaging students in higher education through gamification: A case study, *Journal of Information Systems Education*, **25**(3), pp. 233–244, 2014.
10. R. N. Landers and A. K. Landers, An empirical test of the theory of gamified learning: The effect of leaderboards on time-on-task and academic performance, *Simulation & Gaming*, **45**(6), pp. 769–785, 2014.
11. W. H. Huang, W. Y. Huang and J. Tschopp, Sustaining iterative game playing processes in DGBL: The relationship between motivational processing and outcome measures, *British Journal of Educational Technology*, **41**(6), pp. 1017–1032, 2010.
12. D. I. Cordova and M. R. Lepper, Intrinsic motivation and the process of learning: Beneficial effects of contextualization, personalization, and choice, *Journal of Educational Psychology*, **88**(4), pp. 715–730, 1996.
13. T. W. Malone and M. R. Lepper, Making learning fun: A taxonomy of intrinsic motivations for learning, in R. E. Snow and M. J. Farr (eds.), *Aptitude, learning, and instruction: Conative and affective process analyses*, **3**, Routledge, pp. 223–253, 1987.
14. A. M. Grant and F. Gino, A Little Thanks Goes a Long Way: Explaining Why Gratitude Expressions Motivate Prosocial Behaviour, *Journal of Personality and Social Psychology*, **98**(6), pp. 946–955, 2010.
15. J. Cameron, K. M Banko and W. D. Pierce, Pervasive negative effects of rewards on intrinsic motivation: The myth continues, *The Behavior Analyst*, **24**(1), pp. 1–44, 2001.
16. J. Hamari, J. Koivisto and H. Sarsa, Does gamification work? A literature review of empirical studies on gamification, *49th Hawaii International Conference on System Sciences*, pp. 3025–3034, 2014.
17. M. Ekici, A systematic review of the use of gamification in flipped learning, *Education and Information Technologies*, **26**(3), pp. 3327–3346, 2021.
18. A. I. Wang and R. Tahir, The effect of using Kahoot! For learning – A literature review, *Computers & Education*, **149**, 2020.
19. S. A. Licorish, H. E. Owen H. E, B. Daniel and J. L. George, Students' perception of Kahoot!'s influence on teaching and learning, *Research and Practice in Technology Enhanced Learning*, **13**(9), 2018.
20. A. Field, *Discovering statistics using SPSS*, 3rd edn, Sage, London, 2009.

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