Fostering student engagement, learning communities and student performance through game-based learning

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Abstract

One way to encourage student engagement is through incentivisation. Rewarding students with marks, even for relatively low-tariff assessments, can encourage good study habits in students who were previously disengaged with learning materials. However, assessment-based incentivisation has inconclusive results on student learning. Therefore, this raises the question of whether alternative forms of incentivisation lead to better engagement and student learning. A more subtle form of incentivised engagement are active learning pedagogies such as game-based learning. The idea is that through fun and appealing learning activities, students are more likely to be actively engaged, and assimilate knowledge faster because there is an element of friendly competition with peers. In theory, gamification works by drawing student's attention to goals, nudging students in the right direction, giving students immediate feedback, rewarding good performance and breaking down learning into manageable tasks.

In this study, students on statistics modules at an Australian and a UK university are incentivised through participation in games, and the effect is considered in terms of student performance, engagement, and the student experience. At the Australian university, incentivisation seemed to help academically weaker students to achieve higher marks, but no effect was observed for academically stronger students. At the UK university, incentivisation seemed to increase good student behaviour (attendance and homework completion) for around a third of students but this did not lead to better exam performance. At both universities, qualitative feedback from students was positive in terms of their enjoyment, providing extra motivation and assisting their learning.

Keywords: Kahoot, game-based learning, gamification, engagement, learning communities, competition, mathematics education

Introduction

Student engagement can be defined to mean the time and effort that students spend on activities which result in successful student outcomes, and the associated actions by universities that encourage students to participate in such activities (Wolf-Wendel et al., 2009). One way to encourage student engagement is through incentivisation. Summative assessment, where marks directly determine student outcomes, is the most obvious and widespread form of incentivisation and we might describe many students as "assessment-driven" (Holmes, 2018). Rewarding students with marks, even for relatively low-tariff assessments, can encourage good study habits in students who were previously disengaged with learning materials (Shaker et al,, 2023).

However, using continuous assessment to drive engagement has inconclusive results on student learning. For example, Freeman et al. (2007) showed that for students at risk of failing, artificially incentivising engagement through assessment can lead to better outcomes, whereas for students performing above average, it can be detrimental. Students with high levels of intrinsic, autonomous motivation will learn more when external, controlling incentives are not present (Vansteenkiste et al. 2009). Therefore, this raises the question of whether alternative forms of incentivisation lead to better engagement and student learning.

Compulsory attendance policies are a form of incentivised engagement which reportedly boost engagement and achievement (Coates and McCormick, 2014) but are criticised for promoting a surveillance culture and infantilisation of higher education where students simply meet a threshold for easy-to-measure behaviours rather than rewarded for learning (Macfarlane and Tomlinson, 2017). A more subtle form of incentivised engagement are active learning pedagogies, where student engagement is increased through actively constructing knowledge (Coates, 2009).

Game-based learning is a strategy used by instructors that includes an element of game play within the learning activities (Plass et al., 2015). Game-based learning can be viewed as an overarching term that includes both educational games, and gamification. Educational games are a form of active learning where learning activities include recognised game formats such as quizzes or voting. The idea is that through fun and appealing learning activities, students are more likely to be actively engaged,

and assimilate knowledge faster because there is an element of friendly competition with peers. The danger is that the extrinsic motivation skews student behaviour to meet the instant gratification of the game which distracts from deeper forms of learning. On the other hand, gamification involves gaming-type rewards, such as avatars, points, levels/stages, badges, leaderboards, prizes, content unlocking and progress bars, familiar to gamers (Nah et al., 2014). These rewards are normally acquired for activities within the learning context that are not game-based (Hamari, 2017).

The theoretical framework for gamification is still being formulated in the literature but the broad consensus is that gamification works by drawing students' attention to goals, nudging students in the right direction, giving students immediate feedback, rewarding good performance and breaking down learning into manageable tasks (Krath et al., 2021). Gamification has been shown to produce beneficial outcomes in terms of student behaviour, motivation and learning, particularly when combined with collaborative learning, but the variety of game-based features and contexts in the literature makes it harder to draw conclusions (Sailer and Homner, 2020). Gamification often relies on educational digital and smart technology, itself a tool for promoting student engagement (Bond et al., 2020), and combined they can provide feedback from students to educators (Kalogiannakis et al., 2021). However, not all studies demonstrate a positive impact on student learning and some have suggested gamification needs to be combined with other pedagogies. For example, gamification could provide the motivation for the pre-class and post-class stages of flipped learning (Zainuddin et al., 2020).

For mathematical subjects, game-based learning and gamification research is most prevalent in primary education with various physical games and online platforms supplementing traditional teaching, but less research has been done in higher education (Zeybek & Saygi 2023). Two studies have shown positive impact on engagement and attainment in teaching calculus (Goehle, 2013, and Rincon-Flores et al., 2018) but specific examples for other branches of advanced mathematics are hard to find in the literature. In the broader sphere of computer science related subjects, gamification has been shown to have positive impact on student performance, attendance and attitudes but more research is needed on which game elements are most successful and to discount potential confounding factors (Ortiz Rojas, 2016).

Bolland et al. (2023) found that introducing extrinsic motivation, i.e. mandatory labs, had the effect of improved student performance and was perceived positively by students. Game-based learning has also been identified as one way to foster learning communities (Herro, 2016). Within statistics education at university level, game-based learning has been linked to lowered anxiety and increased confidence in students studying statistics (Shaker et al., 2020). However, further studies looking at gamification within statistics education at university level are needed.

In this study, we consider the use of educational games in the context of two statistics modules; one at an Australian university and another at a UK university. In both modules, the educational game incorporated the accumulation of points throughout the semester, with leaderboards shown to students at regular intervals and prizes awarded to winners at the end of the semester. The effect of implementing this style of educational game is considered in terms of student engagement, student performance, and the student experience.

Methods

Participants

Australian University – third year module

The participants of this study at the Australian university were students enrolled in the final (third) year module *Analyses of Linear Models* (STA3LM) between 2018-2022. This module is offered over a 12-week semester, in the second half of each calendar year. In total, there were 46 students enrolled in the module over the 5-year period, as detailed in Table 1.

Table 1. Students enrolled in STA3LM from 2018-2022

Year	Students
2018	14
2019	12
2020	8
2021	8

2022	4
Total	46

UK University – fourth year module

Financial Mathematics is a Masters level module taught to final year undergraduate Masters students and students on a one-year MSc Financial and Computational Mathematics programme. There were 22 students enrolled in this module which ran during the first semester of 2023/24, of whom 14 provided consent to participate in the study.

Course background

Australian University

The class activities of STA3LM include weekly 2-hour lectures, and weekly 2-hour computer lab / practice classes. Starting from Week 1, two short Kahoot quizzes are included during the lecture: the first approximately after the first hour, and the second at the end of the lecture. The Kahoot quizzes normally contained 4-5 questions that related to the lecture content that had just been covered, and took 5 minutes or less to play. Each year, at Week 2, students were able to choose whether or not the class would have a "running leaderboard" that year, whereby their Kahoot points starting at Week 2 onwards would contribute to the leaderboard. The leaderboard was shown to students at regular intervals throughout each semester, and prizes were awarded to winners at the end of each semester. In four out of the five years, the student consensus was to have the running leaderboard. In 2020, students elected not to include the running leaderboard, partly due to the presence of PeerWise (https://peerwise.cs.auckland.ac.nz/) that year, which was another way students obtained weekly points. PeerWise and its use in STA3LM is further discussed in Ketnor et al., (2022). For the entire period (2018-2022), the use of Kahoot and accumulation of Kahoot points did not contribute to student marks or assessment.

UK University

Financial Mathematics is taught using a 'flipped' approach, with students watching pre-recorded videos outside of class and formative questions being solved in class. There are formative homework tasks to complete each week and an online discussion forum (called Piazza) for students to post questions/answers. The module is assessed by a single 3 hour written exam at the end of the module. An informal "Investment Game" is run throughout the semester, with students collecting points from attending class, completing the weekly online homework and posting questions/answers on the discussion forum. In addition, each student chooses a FTSE100 company each week and gains additional points depending on how much the company's share price rises or falls in the following week. The leaderboard is shown to the students each week and the student with the highest points total wins a voucher at the end of the semester. A student's mark for the module is determined by an end-of-semester 3-hour closed-book written exam.

Data Collection

At the Australian university, quantitative data includes student performance data, as well as Kahoot points obtained during the two weekly Kahoot quizzes from Week 2 onwards. Qualitative data includes student responses from an evaluation of teaching regarding Kahoot (see Appendix) which was carried out in 2018, and student comments from the yearly institutional student feedback surveys from 2018-2022.

At the UK university, attendance data was collected via students scanning a QR code that was displayed at the beginning and end of each class. Homeworks were conducted using an online webpage and consisted of 2 or 3 questions. The webpage automatically marked student attempts and issued each student with a unique code when they had correctly answered the questions. The code, which proved they had completed the homework, and the student's chosen FTSE100 company, were submitted via an online form prior to the weekly deadline. Submitting a valid code gained them homework points and their investment points were determined by the share performance of their chosen company over the following week. These points, along with the attendance points, contributed to the Investment Game points each week. Engagement with the virtual learning environment (VLE) was measured through

number of clicks during the semester and reported as a decile relative to other students. In terms of qualitative data, a survey (see Appendix) was distributed to students, who were given 10 minutes to complete a survey during one of the teaching sessions. Students who did not attend that particular session were sent the survey via email. In total, 14 out of 22 students completed the survey.

Ethical approval for this research was obtained from both the Australian and the UK university, RN HEC21427 and F1476 respectively.

Data Analysis

Data from both universities were analysed using both quantitative and qualitative methods. Characteristics of the student cohort are presented using descriptive statistics and plots. At the Australian university, a quantile regression model was used to determine whether a relationship exists between Kahoot points (and therefore participation) and student performance. At the UK university, Mann-Whitney tests were used to compare VLE engagement and exam performance between students who engaged with the investment game and those who did not.

Thematic analysis was used to analyse student comments from both universities. A systematic, data-led, inductive approach was used, whereby comments were assigned to codes that emerged from the data. The coding was done iteratively, whereby one coder identified codes and assigned comments to codes initially, followed by a second coder assigning comments to established codes, and adding new codes where appropriate. Where there were discrepancies, codes were fine-tuned via discussion and consensus, until both coders reached 100% agreement.

Results

Quantitative results

Australian University

To inform the analysis carried out in this section, and to control for differing student abilities, students were placed into one of four groups based on their Weighted Average Mark (WAM), which includes their marks across all subjects completed in

their degree at the university. The boundaries of the four groups were based on WAM quartiles as detailed in Table 2.

Table 2. STA3LM groups based on Weighted Average Mark (WAM)

Group	WAM Range	Students
Group 1	(77.9 – 100]	12
Group 2	(73 – 77.9]	11
Group 3	(65.9 – 73]	11
Group 4	[0 – 65.9]	12
Total		46

Figure 1 shows the total Kahoot points across the semester, separated by WAM group. The figure shows that while there is considerable overlap between the four groups, the number of Kahoot points generally decreases as WAM decreases.

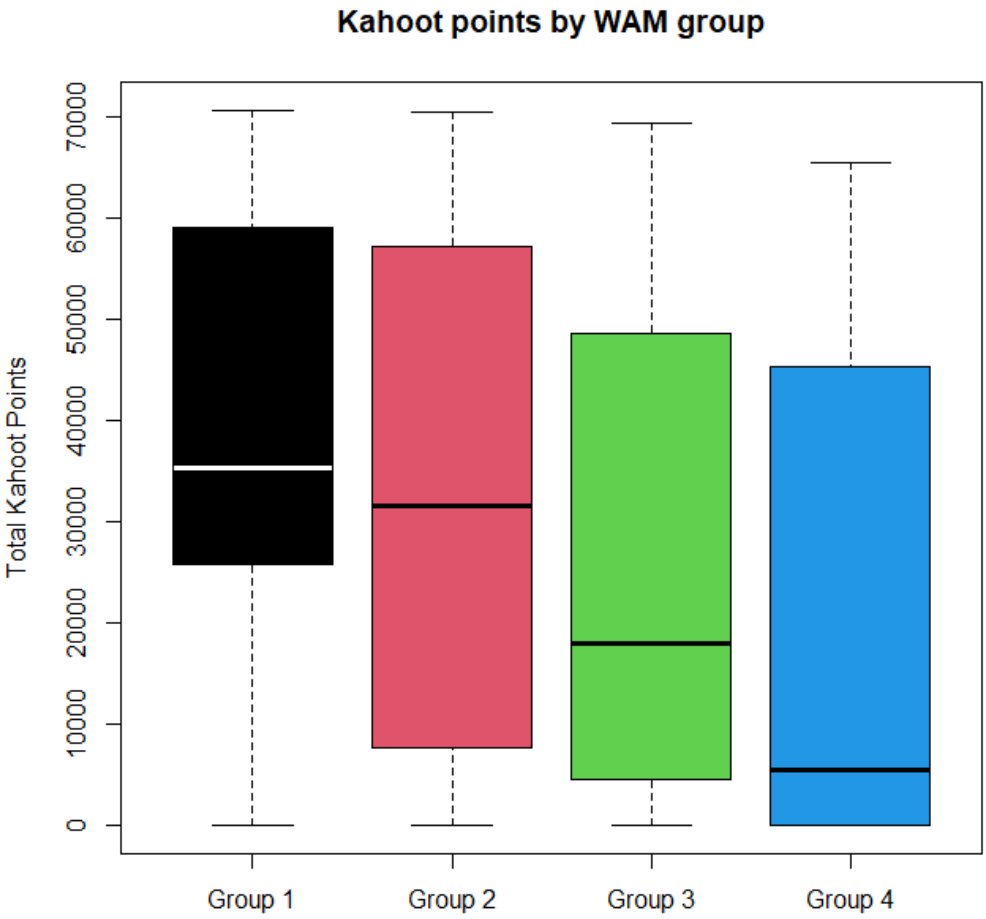

Figure 1. Total Kahoot points for each WAM group (Australian university students).

To determine whether a relationship exists between Kahoot points (and therefore participation) and student performance, a quantile regression model has been estimated with Final Mark as the response variable. The explanatory variables included in the model are Kahoot points, WAM group, and the interaction between Kahoot points and WAM group. This allows us to determine whether the relationship between Kahoot points and student performance differs between WAM groups. The results of this analysis are presented in Table 3, with the model presented visually in Figure 2.

Table 3. STA3LM groups based on Weighted Average Mark (WAM)

	Median Estimate (SE)	*t*-value	*p*-value
Intercept (Group 1)	89.38 (8.19)	10.92	< 0.001
Kahoot Points	-0.0001 (0.0002)	-0.55	0.589
Group 2	-14.02 (9.42)	-1.49	0.145
Group 3	-27.28 (10.88)	-2.51	0.017
Group 4	-60.25 (17.28)	-3.49	0.001
Interaction (Group 2)	0.0002 (0.0002)	0.81	0.423
Interaction (Group 3)	0.0002 (0.0003)	0.91	0.371
Interaction (Group 4)	0.008 (0.0004)	2.05	0.047

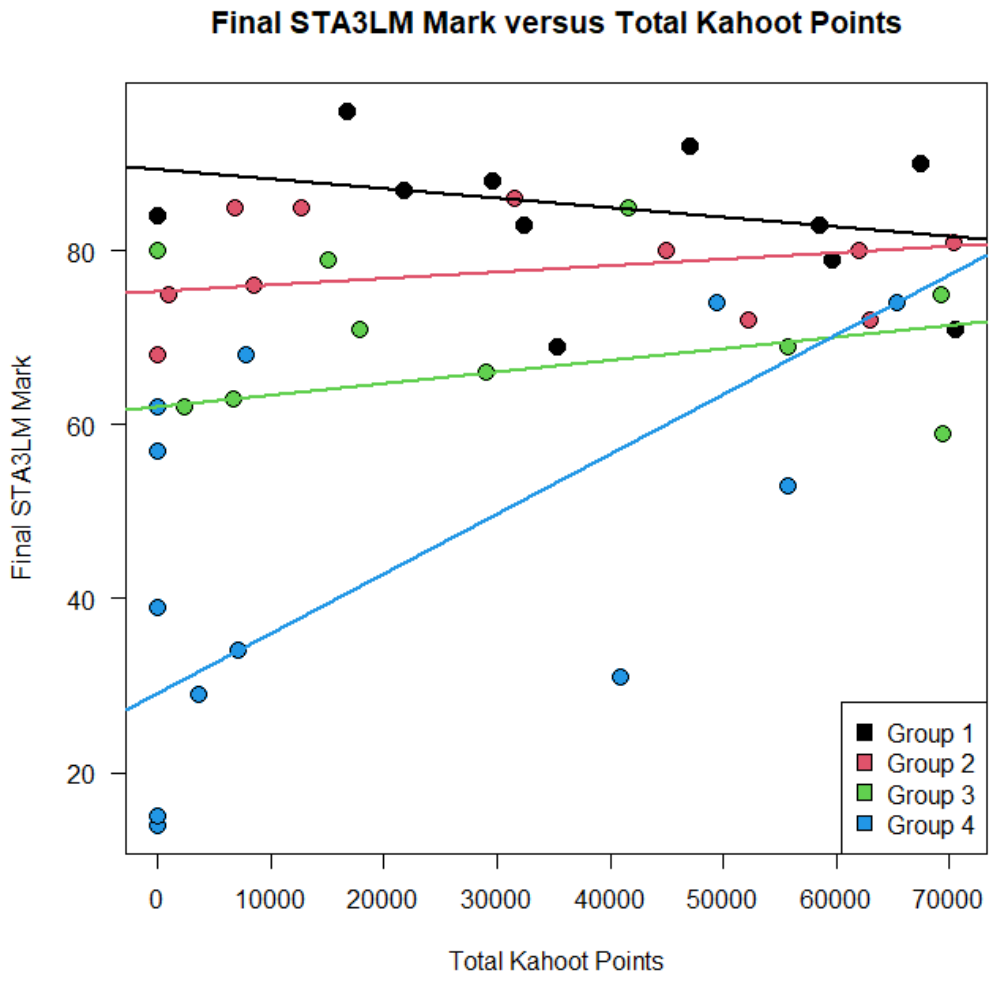

Figure 2. Scatter plot of Final STA3LM Mark versus Total Kahoot Points, with regression lines estimated by the quantile regression analysis included.

The reference category in the quantile regression model is Group 1, meaning that the estimated slope for Group 1 is -0.0001, however the association is not significant. The slopes for Group 2 and Group 3 are not significantly different from Group 1. However, the slope for Group 4, estimated as 0.0079 (-0.0001 + 0.008), is significantly different from Group 1. More specifically, we estimate that for each 1 point increase in Kahoot points, median Final Mark increases by 0.0079 (p = 0.047). Therefore, while Kahoot participation is not significantly associated with student performance for Groups 1-3, there is a significant association with student performance for Group 4.

UK University

For the postgraduate students, this was their first module at the university so no prior attainment data were available. Of those that consented to take part in the study, six

were UK undergraduate students, three were UK postgraduate students and five were international postgraduate students.

Students received a maximum of 44 points for Attendance (4 points per week) and a maximum of 40 points for completing the weekly Homeworks (4 or 2 points per week depending on the homework). The distribution of engagement, for those who consented to take part in the study, is shown in Figure 3. We observe that there is a skew in the Attendance distribution, with over half of students attending the majority of sessions. For Homeworks, around a third of the students regularly submitted homeworks. (Other students may have completed the homeworks online but not submitted the outcome to the Investment Game.)

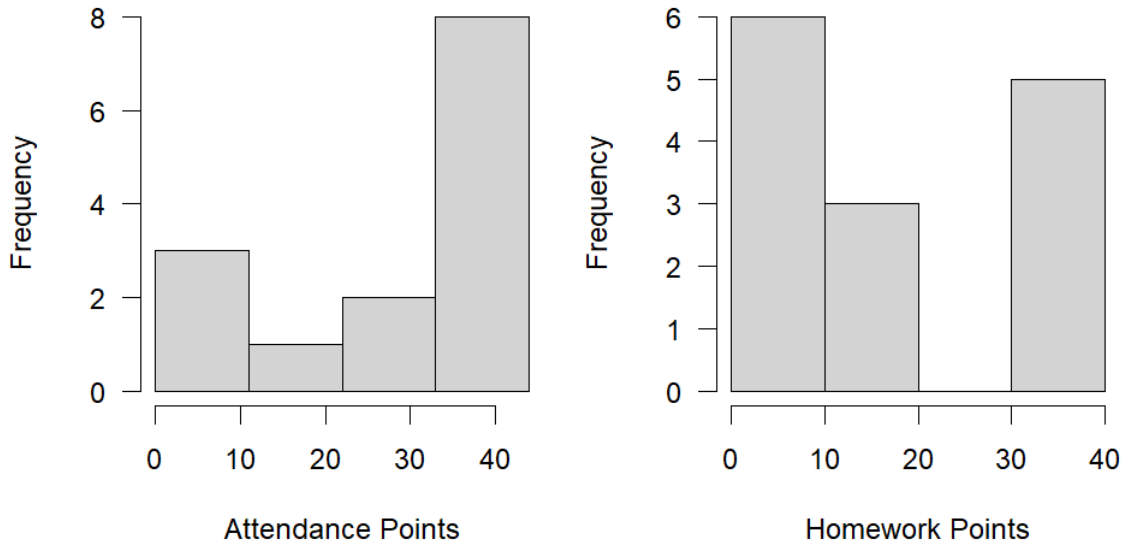

Figure 3. Histograms of Attendance Points (left) and Homework Points (right) for students playing the Financial Mathematics investment game.

Given Attendance and Homeworks were both incentivised as part of the Investment Game, we identified 4 students who had high point scores in both (Attendance score above 40 and Homework score above 30). Initially it is unclear whether the high engagement from these individuals is the result of incentivisation or students being naturally diligent in their study habits. Interestingly, the level of engagement with the VLE (a behaviour which was not incentivised) of the high-point-score students is no different to other students (see Figure 4, left panel) suggesting the high level of engagement with just the Attendance and Homeworks may be a consequence of the

incentivisation. The median VLE engagement decile for the high-point-score group is 5.5, compared to 6 for the other students, which is insignificant (p = 0.8152).

Similarly, their performance in the final exam is no different (see Figure 4, right panel), suggesting that while incentivisation encouraged good behaviour for these high-point-score students with respect to Attendance and Homeworks, the incentivisation did not result in improved learning. The median exam score for the high-point-score group is 54.5, compared to 53 for the other students, which is insignificant (p = 0.9999).

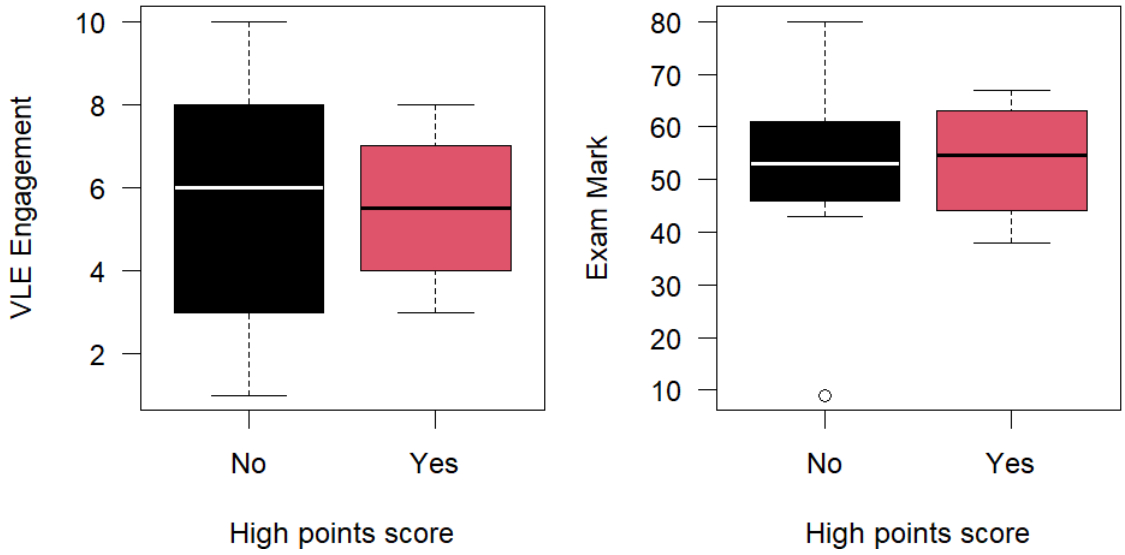

Figure 4. Boxplots of VLE Engagement (left) and Exam Mark (right) by whether they achieved high point scores (Attendance score above 40 and Homework score above 30) while playing the Financial Mathematics investment game.

Qualitative results

Australian University

To evaluate students' perceptions about using Kahoot throughout the semester, we refer to feedback provided by students in an evaluation of teaching about Kahoot carried out in 2018, as well as yearly data from 2018-2022 from the institutional student feedback survey which is carried out at the end of each semester.

Seven students responded to the evaluation of teaching questionnaire, which comprised of two statements with an agreement scale from 1 (strongly disagree) to 5 (strongly agree), followed by open-ended questions. The two statements, and their mean agreement scores are provided in Table 3. The results indicate that students

perceived Kahoot to be useful generally in the subject, and also that it worked well in helping them learn.

Table 3. Agreement scores resulting from the evaluation of teaching on students' perceptions of Kahoot in STA3LM.

Statement	Mean Agreement Score (out of 5)
Classroom polling is useful in STA3LM	4.7
Kahoot! worked well in helping me learn	4.9

Table 4 shows the five most prominent themes arising from the open-ended questions in the evaluation of teaching. The most prominent theme to arise is "Increased enjoyment / engagement", with 12 individual comments, followed by "Learning community" and "Learning", with 7 comments. Students also indicated they found Kahoot useful for revision, and that its presence meant they were more likely attend class, with 4 comments relating to both themes respectively.

Table 4. Themes arising from open-ended questions in the evaluation of teaching on students' perceptions of Kahoot in STA3LM.

Theme	Number of comments
Increased enjoyment / engagement	12
Learning community	7
Learning	7
Revision	4
More likely to attend class	4

From the institutional surveys from 2018-2022, a total of 54 comments have been analysed. Of these comments, 14 directly mentioned Kahoot, and a further 11 comments can reasonably be attributed to the use of Kahoot in the class, for a total of 25 individual Kahoot-related comments. Table 5 shows the five most prominent themes to arise from the Kahoot-related comments. Nine comments indicated that students thought Kahoot was the best aspect of the subject, but no further elaboration was provided. Nine comments also related to the learning community that was created as a result of students enjoying Kahoot. Engagement, learning encouraged by

engagement, and class attendance were the three other prominent themes, represented by 8, 7, and 7 comments respectively.

Table 5. Themes arising from Kahoot-related comments made in institutional feedback surveys between 2018-2022.

Theme	Number of comments
Fun / learning community	9
Best part of the subject (nothing else mentioned)	9
Engagement	8
Learning encouraged by engagement	7
Class / attendance	7

Overall, the analysis highlights that the use of Kahoot in STA3LM facilitated the following:

- Development of a learning community. For example, *"A great tool that has allowed the class to bond and create friendships".*
- Learning. For example, *"Provides opportunities to continue learning and immediate feedback".*
- Motivation to attend and engage in class. For example, *"Kahoot because it made the lectures more interesting and provided a reason to attend face–to–face rather than listening to it on echo.".*

UK University

At the UK university, over 60% of students reported they were more likely or much more likely to attend classes, submit homeworks and learn the module content because of the Investment Game (see Figure 5). The effect on the use of the Piazza discussion forum was less clear. No students reported they were less likely to participate in the different activities because of the investment game. Half the students reported greater engagement with the module overall as a result of the Investment Game, with 6 out of 14 students reporting they engaged with this module more than their other modules.

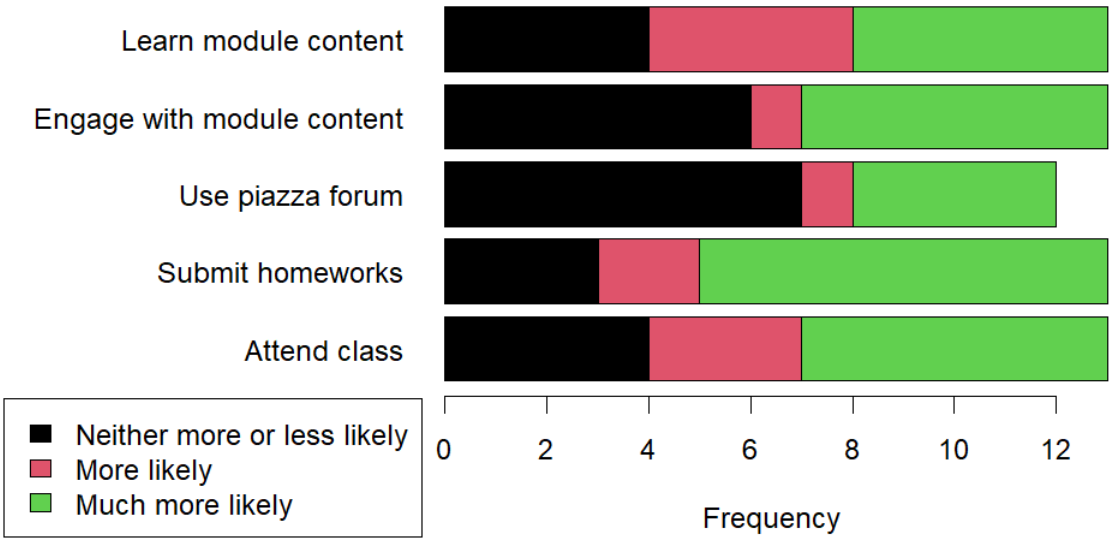

Figure 5. Financial Mathematics student responses to "Because of the investment game, I am more or less likely to...". No students responded 'Less likely' or 'Much less likely'.

When asked to explain what they like or disliked about the game, five students mentioned that it introduced an element "fun" to the module, while four students also mentioned they liked the competitive aspect. Importantly, they appreciated that the fun aspect "relates to [the content of] the module" and the competition was "healthy" because "the outcome is partly chance rather than 100% your effort". Even though it was designed to only be a fun addition to the module, four students found it informative and seven students like the real-world relevance of monitoring the stock prices. Students reported that it "made me check the financial times more", "let me know the basic facts of stock investment" and included "more real-world application than anywhere else in the course".

When asked why students had participated in the Investment Game, six students made comments related to it encouraging engagement such as "provides extra motivation to complete homeworks", "help me to engage in classes more often", "made me love learning even more", "motivates me to learn more about this module" and "makes me more interested". For those that didn't actively participate a variety of reasons were given such as they'd have engaged with classes and homeworks anyway, they preferred to study individually, and they'd got behind with studying the content and therefore didn't want to attend.

Results of the thematic analysis are summarised in Table 6.

Table 6. Themes arising from open-ended questions in the survey carried out at the UK institution

Theme	Number of comments
No effect	9
Real world / relevance	7
Motivation	6
Fun	5
Informative	4
Competition	4

A notable feature of this particular semester-long game design, which may have contributed to the theme of *no effect*, was that when students fell behind over the course of the semester (perhaps due to high workload in other modules or family commitments) they then couldn't catch up and the incentivisation became less effective. Only 4 out of the 14 students who participated in the study were responding to the incentive by the end of the semester. An alternative incentivisation that rewarded students more regularly or that took, say, their best 8 scores from the 11 weeks, may have encouraged more students to stay active in the game for longer.

Discussion and Conclusions

Following the thematic analyses, there are a number of parallels that can be drawn between the two institutions in terms of how students responded to the inclusion of a game-based initiative that facilitated accumulation of points throughout a semester. At both institutions, *learning, motivation, attendance, engagement* and *fun* emerged as prominent themes, indicating that including these or similar game-based initiatives is highly likely to lead to an improved student experience. *Learning community* was a prominent theme at the Australian university, but not at the UK university. One explanation for this is that the activities required to gain points at the UK university were individual in nature (e.g. submitting homeworks, attending class, choosing a FTSE100 company), whereas at the Australian university, Kahoot points were achieved by students participating together in a classroom activity. Another difference

was that *real word / relevance* emerged as a prominent theme at the UK university, but not the Australian university, and this was because the Investment Game provided incentive for students to become more familiar with the stock market.

No association was found at the UK institution between participation in the game and student performance. There are a number of possible explanations for this result, such as the open-book nature of the online homeworks compared to the timed closed-book exam format. The exam also contains a variety of question formats to test higher-level skills (e.g. proof) compared with the purely numerical responses in the online homeworks. Although incentivisation encouraged students to engage with the module content (through attending classes and completing homeworks) this did not directly result in better learning, and incentivising study skills which do lead to better learning but are not so easily measured externally is much harder to do. This reinforces the point that intrinsic motivation is better than artificially induced motivation and that the induced behaviours need to be more closely aligned to the desired output (e.g. increased exam score).

However, an association between participation in the game and student performance was observed at the Australian university, but only amongst students in the lower performing WAM group. This finding is similar to the findings of Shaker et al., (2023) where incentivisation led to improved performance in students whose performance was below average before incentivisation. This study again indicates that further research is required to understand the link between different motivational styles, response to incentivisation, and links to performance.

In conclusion, our findings indicate that the inclusion of game-based activities that facilitate accumulation of points throughout a semester can lead to an improved student experience for most students. However, induced improvements in student performance are mainly restricted to otherwise lower-performing students.

Appendix

Australian University: Evaluation of teaching (Kahoot) questions

1. Classroom polling is useful in STA3LM (5-point agreement scale)
2. Kahoot! worked well in helping me learn (5-point agreement scale)

3. Please explain your choices for the previous questions.
4. How should classroom polling be used to maximize your learning?
5. What did you like and/or dislike the most about using Kahoot! in STA3LM?

UK university survey

1. Overall my engagement with this module is (higher than my other modules, about the same, less than my other modules).
2. Because of the investment game I am (much more likely, more likely, neither more or less likely, less likely, much less likely, don't know) to
    a. Attend class
    b. Submit homeworks
    c. Use Piazza forum
    d. Engage with the module
    e. Learn the module content
3. What did you like/dislike the most about the investment game? Please explain. (free text response).
4. Please explain why you have or haven't engaged with the investment game. (free text respose)
5. Any other comments on the module?

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