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GAME-BASED STUDENT RESPONSE SYSTEM: THE EFFECTIVENESS OF KAHOOT! ON JUNIOR AND SENIOR INFORMATION SCIENCE STUDENTS' LEARNING

Helen E. Owen*	University of Otago, Dunedin, New Zealand	helen.owen@otago.ac.nz
Sherlock A. Licorish	University of Otago, Dunedin, New Zealand	sherlock.licorish@otago.ac.nz

Corresponding author*

ABSTRACT

Aim/Purpose	We aimed to investigate the circumstances under which Kahoot! (a Game-based Student Response System (GSRS)) increases junior and senior Information Science university students' learning and knowledge retention beyond that of traditional teaching methods. We also explored whether the positive learning impacts of Kahoot! vary as a function of student subject-knowledge (i.e., junior vs senior students).
Background	The effectiveness of game-based student response systems (GSRSs) as learning tools in the classroom remains unclear, given inconsistent findings across educational research. Kahoot! enhances secondary and tertiary students' attention and motivation during class, but its effectiveness on learning and retention of course knowledge may vary depending on situational and individual factors. In New Zealand universities, students spend three years studying towards a Bachelor's degree, majoring in subject(s) of their choice. By the end of their third year of study, students are eligible to graduate with a sound knowledge of their chosen major. Thus, first-year students (referred to as "junior students") and third-year students ("senior students") may differ in terms of their learning styles and their ability and willingness to integrate Kahoot! use into their course work and revision. It is hypothesised that differences in subject knowledge between junior versus senior students will influence the perceived effectiveness of Kahoot!.
Methodology	Thirteen first-year (*junior*) and fourteen third-year (*senior*) Information Science students (total n = 27), who used Kahoot! in seven lectures (for 30 minutes per lecture) were interviewed about their perception of Kahoot!'s effectiveness. We

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	conducted a mixed-methods case study of students' interview transcripts, demographic records and student scores, where thematic (content) analysis was used to analyse interview responses. Then, we quantified themes for a one-way ANCOVA, with student subject knowledge predicting Kahoot!'s effectiveness, when controlling for students' duration of tertiary study and study habits (i.e., hours dedicated to course work per week) as potential confounders.
Contribution	This study addresses the conflict in existing literature around whether GSRSs improve student learning beyond traditional teaching methods. To our knowledge, this is the first study that shows GSRSs (namely Kahoot!) use improves, or at least, supplements tertiary students' learning and knowledge retention of lecture content. This study also reveals how student characteristics (i.e., accumulated tertiary experience) and their subject knowledge influence the effectiveness of Kahoot! as a learning tool.
Findings	Kahoot!'s use increased students' learning and knowledge retention, among other positive impacts (e.g., attention and engagement). However, the perceived learning impact of Kahoot! was greater for senior students. Senior students found Kahoot! more useful for learning new knowledge and revising previously acquired knowledge. On the other hand, while junior students also experienced positive learning impacts using Kahoot!, they reported concerns regarding limited and shallow content coverage, and the time-consuming and distracting nature of the platform.
Recommendations for Practitioners	Educators should take care to ensure GSRSs are appropriately implemented to support rather than replace traditional teaching methods (e.g., "chalk and talk" style presentations, PowerPoint use). In addition, lecturers using GSRSs should clearly inform students about the examinable content and their expectations for performance in formal assessments.
Recommendations for Researchers	The positive impact of Kahoot! use on students' learning and knowledge retention may be due to stronger interactions and engagement during class. Researchers should more closely explore how student-lecturer interactions and in-depth discussions following GSRS use influence learning. Thus, there is a need to re-evaluate Malone's (1980) intrinsic motivation theory in relation to the "interactive" or "enjoyability" components experienced during Kahoot! use.
Impact on Society	The positive impacts of Kahoot! use on student learning vary for junior and senior students. However, our findings indicate that both cohorts of students benefit from 15-minute Kahoot! sessions at the end of a lecture or course unit, allowing them to test their knowledge and revise* previously taught material. Kahoot! provides a comfortable platform that allows students to ask and answer questions without embarrassment. More experienced students can also evaluate their learning by creating their own Kahoot! quizzes and providing feedback to the lecturers. Overall, Kahoot! use could have a positive impact on teaching and learning globally.
Future Research	Beyond the recommendation for researchers above, future research should explore how differences in lecturers' teaching styles and students' self-regulation of learning impact Kahoot!'s effectiveness as a learning tool.
Keywords	game-based student response systems, Kahoot!, classroom dynamics, engagement, motivation, junior and senior information science students

[*Publisher's note: in British English, *revise* can have the same meaning as *review*.]

INTRODUCTION

Interactive technologies are becoming increasingly more common in lectures in view of enhancing students' motivation and engagement during class, both of which are held to be critical for academic success (e.g., Brandford-Networks, 2015; Martin, 2008; Pintrich & Schrauben, 1992). Across science, humanities and commerce courses, learning technologies (e.g., response cards, e-learning programmes, problem-based learning, and student response systems) are often blended with traditional "talk and chalk" teaching methods to encourage student autonomy and proactivity in their learning (Poon, 2013; Yen & Lee, 2011).

Student-response systems (SRSs) are frequently used to display multiple-choice questions to offer opportunities for students to problem-solve together, which fosters teamwork, peer interaction, and assesses students' abilities simultaneously (Sellar, 2011). These technologies not only improve classroom dynamics, but increase student attendance, focus and engagement (Caldwell, 2007; Heaslip et al., 2013; Kay & LeSage, 2009). At the more advanced level of learning technologies, gamification elements have been incorporated into SRSs to create more contemporary game-based student response systems (GSRSs) such as Kahoot! and Socrative systems (Plump & LaRosa, 2017; A. I. Wang, 2015). Unlike SRSs, which are predominantly used to teach students facts in an interactive environment, learning with GSRSs also occur through processes of analytic reasoning and creative problem solving (Prensky, 2001). Students can efficiently and easily operate GSRSs from their mobile devices, i-pads and laptops (Brandford-Networks, 2015), which not only personalizes students' learning experiences, but reduces time and set-up costs, and requires no additional training for teachers (Kay & LeSage, 2009; Plump & LaRosa, 2017). This allows teachers to predominantly focus on multiple-choice quiz creation. The gamification elements and real-time feedback of GSRSs further enhance students' in-class engagement, enjoyment, and fun, beyond that of SRSs learning experiences (Plump & LaRosa, 2017; A. I. Wang, 2015).

One such GSRS, Kahoot!, is an open game-based learning platform designed to foster student engagement and motivation using the three components of Malone's theory (1980) of intrinsic motivation instruction: *challenge* (answering questions to compete with other students), *fantasy* (absorbed and engaged through "game-play"), and *curiosity* (sensory and cognitive stimulation; see also A. I. Wang, 2015). In the context of early educational computer games, Malone (1980) proposed that these components were necessary cognitive "heuristics" (or shortcuts) to student absorption and enjoyment in their learning environment, without the need for an external reward. Over the past decade, these intrinsic motivation components have been integrated into SRSs (Kay & LeSage, 2009), gamified e-learning platforms (Domínguez et al., 2013), and now GSRSs (A. I. Wang, 2015) to maximise student engagement and improve learning. Firstly, students must have a clear goal or challenge that is set at an appropriate difficulty level so attainment is uncertain but possible with effective problem-solving, or even through trial and error responding (e.g., Koster, 2005). The integration of "meta-goals", such as solving a problem within a short timeframe or obtaining a higher score for performance, further increases motivation and engagement beyond solving the problem itself. Consistent with earlier computer games and SRSs, Kahoot! intends to challenge students. The teacher projects quiz questions on a screen for students to answer using web browsers on their digital devices. Students are awarded points for answering questions correctly and efficiently, within a given timeframe. Kahoot! promotes "friendly competition" as students' scores are displayed on the screen after each quiz, allowing for a relative comparison of performance, which motivates students to progress up the scoreboard.

Secondly, Malone (1980) proposes that a fantasy component (e.g., an imaginary setting or social scene) is necessary for player engagement and is more likely to be motivating if the "fantasy" experiences are both the cause and effect of performance (see also Watson et al., 2011). Unlike SRSs, the Kahoot! platform creates a fantasy "game-show" environment in which the students become players and the teacher acts as the host by controlling the pace of play. Surface-level gamification features (e.g., suspenseful music and colour displays) are incorporated on a multi-player platform to facilitate

problem-solving but also vary depending on students' success. These fantasy cues increase absorption, concentration and, in turn, intrinsic motivation to learn, similar to the effects of flow in game-based learning (Csikszentmihalyi, 1991).

Finally, a game environment is more likely to be intrinsically motivating if it stimulates players' sensory and cognitive curiosity. Suspenseful music and colour displays are also integrated into games to reward performance and enhance the salience of the goal or challenge (i.e., stimulating sensory curiosity; Malone, 1980). These features increase attention, focus and immediacy of learning (e.g., Connolly et al., 2012; Gagné & Driscoll, 1988). More importantly, the presentation of complex but incomplete information provides an optimal learning environment that stimulates cognitive curiosity through constructive, real-time feedback, information on demand, self-regulated learning, or team collaboration (Wouters et al., 2013). This environment allows the player to extend their problem-solving and leads to the formation of complete knowledge structures. Kahoot! increases students' cognitive curiosity as it monitors students' problem-solving time and reports their score and relative performance after they have participated.

Teachers use Kahoot! to create quizzes or surveys on particular course content, allowing them to tailor the content of their lectures to meet the students' needs and knowledge gaps. Teachers may later lead an in-depth post-quiz discussion that teaches students to distinguish between the correct and incorrect answers and refine their problem-solving strategies to avoid making the same errors in the future (A. I. Wang, 2015). Not only does this provide lecturers with a deeper understanding of what students know and need to work on, discussions may also stimulate students' cognitive curiosity.

Kahoot! should also be an effective learning tool, according to the Situated Learning Theory (Lave, 1988), because students develop problem-solving skills through observation (i.e., listening to the lecturer) and exploratory behaviour (i.e., testing their knowledge in the quizzes). Given that Kahoot! adopts all of Malone's (1980) components for intrinsic motivation instruction, Kahoot! is both a game-based learning platform and an SRS with the addition of gamification elements (see Deterding et al., 2011, for a distinction on the two concepts). Kahoot! promotes a comfortable, non-judgmental environment in which students can contribute answers anonymously, thus increasing participation (A. I. Wang, 2015). Kahoot! is also a multi-media platform, allowing for images and videos to be added to quiz questions, and is integrated in social media so students can share their quiz results online.

Despite consistent findings that GSRSs, like Kahoot!, increase motivation, attention, and attendance in class (Plump & LaRosa, 2017; A. I. Wang, 2015), there is conflicting evidence as to whether they improve students' enjoyment and engagement during class (Barrio et al., 2016; A. I. Wang & Lieberoth, 2016). This void in understanding around GSRS effectiveness also extends to concerns about the benefits they provide beyond traditional teaching methods, in terms of enhancing learning and knowledge retention, and improving students' academic performance (A. I. Wang, 2015). Previous research has generalized findings from successful implementations of game-based learning tools and other computer mediated learning platforms (e.g., Aleven & Koedinger, 2002; Domínguez et al., 2013; Papastergiou, 2009). However, such works have largely used quantitative measurements rather than adopting a mixed-methods approach to explore the impact of GSRSs on learning. In addition, recent studies that *have* explored the effects of GSRS use on learning have failed to control for between cohort-differences (e.g., subject knowledge between junior and senior students) and within-cohort differences (e.g., gender, duration of study, study habits, and learning styles). Such insights are necessary to pinpoint the specific circumstances under which GSRSs are useful for teaching.

This research sheds light on the conflicting evidence as to whether GSRSs, namely Kahoot!, improve student learning and knowledge retention beyond traditional teaching methods. The paper also expands on the existing GSRS literature, which only broadly explored their effectiveness in secondary rather than tertiary education settings. We adopted a mixed-methods approach to understanding stu-

dents' experiences about how and when (i.e., in what learning contexts or situations) Kahoot! use improves or, at least, facilitates learning and knowledge retention, and identified the contexts in which traditional teaching methods should be prioritized over Kahoot! in lectures. Students' engagement, motivation and learning are quantified from the prevalence of themes extracted through semi-structured interviews. Secondly, through content analysis and ANCOVA, we conduct a comparative analysis to explore whether differences in student subject knowledge influence preference for and perceived usefulness of Kahoot!, while controlling for within-cohort differences. This research may help inform tertiary educators about the best practices for integrating GSRSs into their lectures. Also, from a theoretical perspective, this research highlights the importance of peer and student-lecturer interactions (an interactive "teamwork" component) for Kahoot!'s effectiveness as a learning tool. Moreover, a re-evaluation of Malone's (1980) theory for intrinsic motivation instruction may be required.

LITERATURE REVIEW

To justify our investigation, we firstly discuss the conflict in existing literature about whether the use of educational video and computer games and with GSRSs improve student learning. Secondly, we consider individual-level differences (i.e., gender, study habits and learning styles) and cohort-level differences (i.e., student subject knowledge) that may influence Kahoot!'s perceived impact on learning and knowledge retention. Finally, this review leads to the development of our research questions.

THE IMPACT OF GSRSS ON STUDENT LEARNING

Research exploring the learning impacts of Kahoot! and similar GSRSs is limited; however, the potential effectiveness of GSRSs as learning tools has been supported by an extensive body of successful educational video and computer game adaptions. Indeed, games have increased students' knowledge acquisition that is comparable with and, in some cases, even greater than knowledge gained through traditional teaching methods. For instance, Gagné and Driscoll (1988) claimed that by informing students' about the necessary learning outcomes and providing them with an opportunity to test themselves, learning through educational games strengthens students' short-term memory and meta-cognition. Ebner and Holzinger (2007) found that even at the minimal level of impact, civil engineering students who played the game "Internal Force Master" were able to draw as many technical designs for structural concrete after two months of study in the course comparable to students who learnt through traditional methods only. All students, regardless of teaching method used, showed increases in knowledge and drawing skill between the pre-test versus post-teaching test. Furthermore, computer games improved high school computer science students' knowledge of computer memory systems to a greater extent than other computer-mediated learning tools, namely, educational websites (Papastergiou, 2009). Students also reported that the games were more appealing and valuable than traditional learning resources. Similarly, elementary school students who participated in games designed to increase nutrition knowledge and attitudes showed greater post-intervention nutrition knowledge and improved healthy eating habits compared to students who studied the same objectives via Powerpoint presentations (Jui-Mei et al., 2011).

However, these studies explore the effectiveness of video and computer games rather than GSRS as a learning tool, so the findings may not be generalizable. In fact, contrary to the consistent positive impacts of games as learning tools (Ebner & Holzinger, 2007; Jui-Mei et al., 2011; Papastergiou, 2009), the extent to which GSRS implementation in classrooms is successful varies (Licorish et al., 2018). That said, GSRSs, including Kahoot!, encourage students to reflect on their understanding of existing concepts while helping them broaden their knowledge (Plump & LaRosa, 2017) and facilitate their ability to argue their viewpoints on topics (Méndez, & Slisko, 2013). In addition, GSRSs are often thought of as a dialogue game in which a desired and ongoing teacher-student conversation, involving critical discussion and reasoning, exploratory talk, and creative thinking, leads to effective

conceptual change and promotes knowledge acquisition (Ravenscroft, 2007; A. I. Wang & Tahir, 2020).

As noted in the previous section, GSRSs are founded on the mechanism of gamification or game principles in web-based technology that support learning (A. I. Wang, 2015). Properties including real-time feedback, points rewarded for quick responses, leader board displays, suspenseful music, colourful displays, images, and video shows make GSRSs particularly attractive to students. These aspects are combined with standard quizzes and survey games in a web-based setting, where students become players and the teacher acts as the host by controlling the pace of play (Ranieri et al., 2018). Quiz or survey questions are asked sequentially, where students respond via their personal devices (e.g., mobile devices and laptops) and a summary of correct and incorrect answers are visualised (Limniou & Mansfield, 2019). Students are awarded points for answering questions correctly and efficiently within a given timeframe, and the scores of top students are shown on a leader board. These features promote excitement among students and a positive classroom environment (Plump & LaRosa, 2017; A. I. Wang, 2015).

To examine the extent of its positive learning effects, Kahoot! has been integrated into third-year information science university courses to compliment traditional teaching methods (Licorish et al., 2018). Adopting a phenomenological (qualitative) approach, students discussed their perceptions of Kahoot! as a learning tool in semi-structured interviews. Kahoot! was found to have positive effects on attention and focus, interaction and engagement, fun and enjoyment, and learning and knowledge retention. In particular, students' reports of enhanced learning and knowledge retention revealed themes of Kahoot!'s usefulness for evaluating knowledge during class, revising, and the lecturer's competence in facilitating discussions. Although most (at least 86%) students agreed that Kahoot! exceeded traditional teaching methods for the first three broad categories, there was considerable variability in personal preferences of how and when Kahoot! is most useful (e.g., learning content in class versus revising old content). Similar variance in students' responses was seen for whether or not Kahoot! yields similar or better improvements in learning and knowledge retention compared to traditional teaching methods (Licorish et al., 2018). Additional research is needed to further examine these differences and to also determine whether perceived learning and knowledge retention is associated with real improvements in academic performance.

In fact, despite the evidence of positive learning impacts of e-learning platforms, educational computer and video games, there is limited research indicating positive impacts of GSRSs, and, in particular, of Kahoot! use on knowledge retention. However, a few studies reveal some negative impacts on learning. GSRS researchers speculate that students' perceptions of positive learning impacts of Kahoot! (e.g., enhancement of the understanding of concepts) may be confounded with or overshadowed by students greater motivation for learning (Ke, 2009; Licorish et al., 2018; Plump & LaRosa, 2017). For instance, when Kahoot! was administered to students in teams, students reported preparing their material and planning their strategy so as to not let their team down (Plump & LaRosa, 2017). Similarly, students attributed greater learning and retention to their revision and Kahoot! quiz preparation efforts, rather than the implementation of Kahoot! itself (Licorish et al., 2018). Bergin and Reilly (2005) reported that learning naturally increases when students are more motivated, and game-based learning does indeed enhance students' interest and motivation. Thus, students may be performing better due to their own efforts rather than the new learning platform. This is consistent with findings that game-based learning increases learning *motivation* but does not enhance achievement, problem-solving and meta-cognitive awareness (e.g., Ke, 2009; Papadakis & Kalogiannakis, 2018). For instance, high school students' report greater engagement during class and more positive attitudes towards their computer programming course when using a gamified learning platform (i.e., the game "ClassCraft") than traditional learning methods (Papadakis & Kalogiannakis, 2018). However, although the cohorts were matched for age, gender, and pre-existing knowledge and were taught by the same instructor, there were no post-course differences in performance between students who learnt using the gamified platform versus traditional methods. Furthermore, as noted

above, lecturers may be more aware and invested in students' learning needs; however this does not necessarily lead to increases in academic achievement. In other words, it remains unclear whether motivation (i.e., concept development) translates into learning, knowledge retention, and academic achievement, or simply increases students' motivation to learn.

More concerning, previous research reveals negative criticisms of GSRSs on student learning. Students reported that Socrative, a similarly designed GSRS to Kahoot!, improved classroom dynamics and knowledge awareness, but they disagreed that Socratives enhanced ability, concept understanding and test practice procedures (Méndez & Slisko, 2013). Students also implied that Socrative was not suitable for learning difficult material, potentially because it does not allow for open-ended questions, short statements as responses, or discussions of relevant theory in sufficient depth due to time constraints. However, the associations between these negative aspects of Socrative and consequences for student learning remained unclear as previous negative reports were only collected through open-ended response questions rather than semi-structured interviews, where there is scope to probe such issues further.

Although no explorations of GSRS effectiveness have yielded negative learning impacts per se, there is evidence of a reduction in classroom dynamics with repeated use of gamification tools and, which may also reduce positive learning impacts. In a mixed-methods study, Domínguez et al. (2013) found that students who completed basic ICT modules using a gamified e-learning platform (i.e., received "awards" for units completed, and comparative feedback via leader boards) reported high motivation and enjoyment using the tool. These students also initially engaged more with the e-learning platform than both students who learnt using non-gamified platforms and students who used traditional course material only (e.g., pdf print-outs; control group). They also had higher final scores in the course. However, they participated less on class activities and performed worse in written assignments. Of more relevance, A. I. Wang (2015) found that regular use of Kahoot! (one session per lecture for a whole semester) resulted in a small "wear-off" effect of positive classroom dynamics for software engineering students. Only 52% of students agreed that Kahoot! increased positive, topic-relevant communication with classmates compared to 67% of first-time users. Although both groups of students were similarly engaged and motivated, the "wear-off" effect of classroom dynamics has previously increased students' state of boredom, which once manifested, is persistent across learning environments, and consequently decreases students' learning ability while increasing problem behaviours (Baker et al., 2010; Squire, 2005).

Although A. I. Wang (2015) did not measure within-cohort changes in perceived learning, there were no differences in perceived learning between the software engineering students and first-time users, which is somewhat concerning given that the stakes were higher for the former group of students to learn and retain content for formal examinations. However, the validity of this measure was questionable as students noted in their unstructured open-ended responses that they focused more on the lecture content that they deemed to be relevant to their final examinations, rather than what they specifically learnt from Kahoot!. This implies that how and when GSRSs are implemented and integrated into traditional teaching methods is vital to determine their effectiveness as learning tools. It also remains unclear whether such a "wear-off" effect even exists given that, as noted earlier, no change in classroom dynamics for the software engineering students was measured between the start and end of the semester.

The Roles of Individual Differences and Cohort Differences Impacting Student Learning

The conflicting findings about the effectiveness of GSRSs as learning tools may be due to different analytical approaches (i.e., quantitative rather than qualitative), differences in how Kahoot! is implemented, and differences in students' subject knowledge, study habits, and overall duration of tertiary

study. Contextual factors (e.g., subject matter or lecturer) may also be responsible for the contradictory findings. To our knowledge, no research has explored how domain experience influences perceptions of the effectiveness of GSRS use, resulting from differences in learning styles. We have thus drawn from research on other non-traditional learning approaches in developing our proposition below.

Firstly, although Kahoot! encourages all students to discuss and self-explain their problem-solving strategies, students' preferred learning styles and their abilities to regulate their own learning (i.e., self-reflective assessments of performance and goal evluation) vary between individuals within-classrooms (Ellis & Zimmerman, 2001) and as a function of students' subject knowledge. For instance, pre-existing subject knowledge was associated with both greater self-reflection/goal evaluation, and later learning gains as a result of game-based instruction (Sabourin et al., 2013). Surprisingly, Senior students (who better regulate their learning) are more likely to seek assistance with their learning (Zimmerman & Martinez-Pons, 1990), access alternative curriculum resources beyond those aquired through lectures (e.g., after-school classes and use of tutorials; Barron, 2004), and engage in more self-study, such as note-taking (Sabourin et al., 2013). Although the difference in subject expertise between senior and junior students has, to our knowledge, not yet been manipulated in game-based learning research, previous research suggests that students with greater subject knowledge and more advanced self-regulation strategies are more likely to experience greater learning gains through flexible and autonomous learning instructional methods (Zimmerman, 2002). Further research is required to explore whether students are more likely to engage in self-study and monitor and regulate their academic outcomes because of accumulated learning experiences over time or greater subject knowledge. It also remains unclear whether effective use of Kahoot! would differ between Junior vs Senior students (levels of student subject knowledge), even after accounting for duration of tertiary study.

Considering within-cohort differences, previous research suggests that the effectiveness of GSRSs as learning tools are not likely to differ between males and females, despite gender differences in learning style. Zimmerman and Martinez-Pons (1990) found that female high-school students demonstrated more goal-setting and planning strategies, kept records of their learning, and more frequently monitored their progress compared to male students. They also favour rehearsal-based information processing strategies and adopt a non-competitive approach to learning (Bonnano & Kommers, 2008; Casey, 1996). In contrast, males typically favour a manipulation-oriented information processing approach and are cognitively stimulated by competition. To some extent these information processing strategies translated into perceived ease of use with learning technologies. Males reported that games allowed them to relax and increased their alertness while learning, whereas females reported lower confidence and greater hesitancy when using games as learning tools and reported such learning tools as being less useful (Bonnano & Kommers, 2008). However, despite these differences, male and female students found game-based learning similarly enjoyable (Bonnano & Kommers, 2008) and motivating (Papastergiou, 2009), and considered playfulness similarly important in determining their intention to use e-learning tools (Y. S. Wang et al., 2009), which may buffer perceptions of low self-efficacy with technology. In fact, self-management for mobile learning is a greater predictor of user intention for females than males.

Not surprising, motivation and enjoyment predicted similar learning outcomes for males and females. Papastergiou (2009) even found that male and female computer science students showed comparable increases in post-intervention knowledge acquisition after playing an educational computer game, even though males displayed initially greater knowledge than females and showed greater involvement with and liking for games. Similarly, Jui-Mei et al. (2011) found no gender differences in nutrition knowledge, nutrition attitudes, or healthy eating habits after the implementation of game-based learning. Given that Kahoot! targets elements of "challenge" and "curiosity" (Malone, 1980), male and female students should find Kahoot! similarly enjoyable and cognitively stimulating, and, thus, we may not find significant differences in their learning and knowledge retention using Kahoot!.

Finally, students' study habits (e.g., hours dedicated to study per week) and ability to tackle difficult and extensive course content also vary within cohorts and may impact the effectiveness of non-traditional learning approaches, such as GSRSs use. Integrating blended learning strategies (i.e., problem-based learning) with traditional teaching methods can be resource- and time-consuming, and increases the students' overall workload beyond recommendations in the curriculum (Ruiz-Gallardo et al., 2011). Problem-based learning (PBL) shares some similarities with GSRS use in that it allows students to learn through collaborative complex problem-solving under the guidance of the lecturer (e.g., Hmelo-Silver, 2004; Ketelhut & Schifter, 2011), thus increasing student responsibility, critical thinking, social interaction, and communication beyond traditional teaching methods. Despite the heavier workload, introducing problem-based learning in biology, geography, and science teachers' college courses increased the proportion of higher achieving students compared to previous assessments with traditional learning methods alone (Ruiz-Gallardo et al., 2011). The authors found that, as long as students did not perceive the workload to be excessive, increased effort towards study resulted in improved academic achievement. In particular, students were less likely to feel over-burdened with a high workload if they found the subject matter enjoyable rather than difficult, established a positive student-teacher relationship, and were actively engaged in their learning (see also Kember & Leung, 2006). Therefore, it would be interesting to extend these findings from problem-based learning to explore whether the impacts of GSRSs (i.e., Kahoot!) on learning vary as a function of student subject knowledge, controlling for study habits (hours dedicated to course work) and duration of tertiary study. We are testing for an independent effect of *subject* specific knowledge on student engagement, motivation and learning, over and above that of their overall tertiary experience.

Research Questions

Given outcomes explored in previous work above, we anticipate that students with higher academic self-efficacy and awareness of their own capabilities (Zimmerman & Martinez-Pons, 1990) would be better able to use Kahoot! to their advantage. This increased awareness is likely to come about through greater-subject knowledge (e.g., Sabourin et al., 2013; Zimmerman, 2002). Senior students (with greater subject knowledge) may also demonstrate higher motivation, engagement, and knowledge retention when using Kahoot!. Subject knowledge may also influence students' preference for use (e.g., in class versus externally for revision). On the other hand, there is also evidence suggesting that the longer students spend at university, the more capable they would be at devising learning strategies for academic success using Kahoot!, and monitoring and regulating their academic outcomes (e.g., Sabourin et al., 2013). It therefore remains unclear whether student subject knowledge would impact Kahoot! use after controlling for students' accumulated tertiary experience.

Furthermore, the literature has reported mixed evidence around the effects of the use of games in teaching in relation to gender (Bonnano & Kommers, 2008), and, thus, gender differences may not be associated with Kahoot!'s influence on classroom dynamics and the way games enhance students' engagement, motivation, and learning.

In fact, as with similar GSRSs, such as Socrative, for which some students reported restrictions in the way the tool presents difficult course material (Méndez, & Slisko, 2013), it still remains unclear whether motivation in the classroom through the use of Kahoot! translates into improvements in academic performance (Ke, 2009), particularly given the variability in perceived usefulness of Kahoot! as a tool for revision versus learning new material.

Given these gaps in knowledge, we thus outline the following research questions to lead our enquiries.

RQ1. What are students' perceptions of Kahoot!'s use on classroom dynamics, their engagement, motivation, and learning when completing a first-year university course?

RQ2. What are students' perceptions of Kahoot!'s use on classroom dynamics, their engagement, motivation, and learning when completing a third-year university course?

RQ3. Are there differences in the perceptions of Kahoot!'s use for these two cohorts that may be associated with students' subject knowledge?

RQ4. Which individual difference factors (e.g., gender, duration of tertiary study, study habits) are associated with students' perceptions of Kahoot!'s use, and do they influence the effect of student subject knowledge on perceptions of Kahoot! use?

RQ5. Are there associations between students' perceptions of Kahoot!'s use and their academic performance?

METHOD

We employed a combination of qualitative and quantitative approaches to address the stated research questions. We believe that a qualitative research approach is relevant to utilise in this study because the phenomenon being studied is not easily distinguished from the context in which it is observed (Yin, 2013). Using an explorative case study, we intend to unravel complex perceptions and issues relating to the use of Kahoot! in the context of students' engagement, motivation, and learning. Quantitative measures are then used to analyse meta-themes and relationships among themes discovered through qualitative observations (Barcellini et al., 2008). These approaches are combined to enrich the insights gained and provide deep levels of interpretation for the phenomenon under consideration. Additionally, qualitative aspects of the work help to explain statistically significant findings revealed through the quantitative data analyses, thus providing triangulation for the techniques that are used (Leech & Onwuegbuzie, 2009). We provide details around the design of Kahoot!, our sampling and participants and measures, data processing and analysis in the following three subsections.

KAHOOT! DESIGN

The game-based student response system (Kahoot!) was used as a part of two Information Science courses at University of Otago in 2016 and 2017, a first year course (Information and Communications Technology – INFO111 (also referred to as COMP111), first semester of 2017) and a third year course (Information Systems Strategy and Governance – INFO322, second semester of 2016). We considered the first year students to be "Junior" and third year students to be "Senior" in terms of their subject knowledge, although four students (n = 4) in the first year course had been studying at the university for as long as the average third year INFO322 student (M = 3.4 years). Only two second-year university students (n = 2) were studying in the third year course. This tool was used in four (4) different ways during seven (7) different lectures for the third year course, with a duration of about 30 minutes on average (students could also play Kahoot! outside of the classroom). For the first year course, the tool was used in four (4) different ways in seven (7) different lectures, with the same duration.

Kahoot! was used:

1) to quiz students on various topics to understand their competence before tailoring lesson plans (both first and third years)

2) for exploring students' knowledge of topics after they were delivered in lectures (both first and third years)

3) to help students to validate their comprehension and understanding of topics by having them design their own Kahoot! assessments which were then collectively played (for both first and third years)

4) to help with class introduction, including the students, lecturers, and topics (first years only)

5) for fun where the focus was on topics unrelated to the course (e.g., sports) (third years only).

Having studied together for numerous courses as part of their major subject, the third year (senior) students had already built rapport as a class, so it was not necessary to use Kahoot! for a 'class introduction.' In contrast, we implemented Kahoot! as an ice-breaker for first year (junior) students, to allow newcomers to communicate through fun exercises without pressure. In addition, senior students found their course more demanding in terms of workload than junior students did, and thus Kahoot!s that focused on 'fun topics' were introduced to reduce anxiety in the class, which was not observed among junior students. These differences were considered when interpreting our results. The Kahoot! game environment was designed with many interactive features (including suspenseful music), where students used mobile devices (smartphones, tablets and laptops) to join the games and answer questions, and responses to their choices were visualised (illustrated in Figure 1).

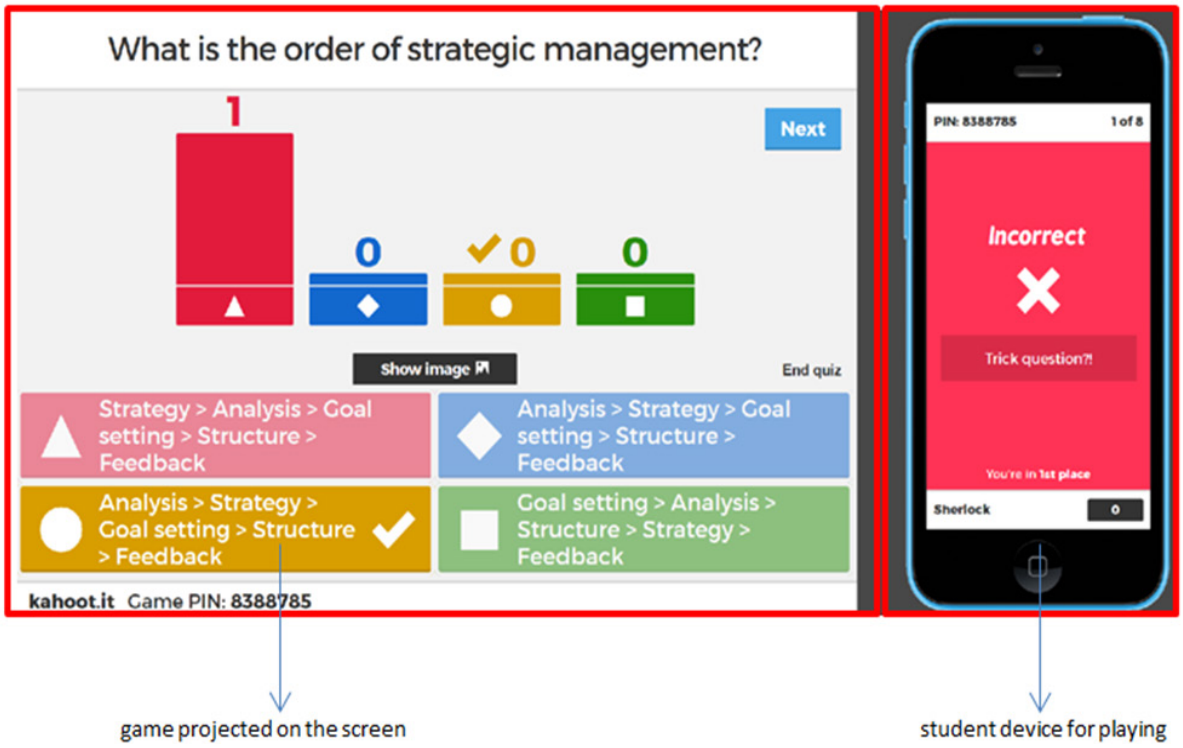

Figure 1. Game show interface projected on screen and on mobile device.

Data Collection and Sampling of Participants

Interviews

At the end of the courses in November 2016 (for INFO322) and May 2017 (for COMP111) students were interviewed using a semi-structured approach (our main instrument of data collection), where purposive non-probability sampling was used to recruit students enrolled in the courses. The study was announced and its purpose explained during the final lecture of each course, having received human and behavioural ethics approval from the university in which the study was conducted.

For the first year course (Information and Communications Technology), 13 student agreed to participate (5 male, 8 female), while 14 third year students (10 male, 4 female) from the Information Systems Strategy and Governance course agreed to participate in the study. Of the first-year participants, 11 were domestic students and two were international students; while 10 third year participants were domestic students and four were international students. The sample size is deemed adequate for the chosen (purposive) sampling method as the possible pool of participants is already restricted and yet

data saturation was achieved (Marshall, 1996). We also conducted a post-hoc power analysis using G*power to determine whether our sample size ($N = 27$) was adequate to achieve sufficient power to conduct an analysis of covariance. To have achieved a mean difference in perceived learning and retention between first-year and third-year Information Science students (2 independent groups), with Cohen's $f = 1.06$, $a = 0.05$ and one covariate (duration of study), we should have $1 - \beta = 0.99$ power in our study.

The 27 students agreed to participate in a 15-20 minute semi-structured interview during which they were asked questions relating to the use of Kahoot! during the course. The questions were focused on understanding students' experiences using Kahoot!, and the tool's influence on classroom dynamics, their engagement, motivation, and learning. Students were also asked to give suggestions for alternative uses of Kahoot! and describe their general experience with the tool. Sample questions included: "How do you feel about the changes in the [course] classroom dynamics brought about by Kahoot!?" and "Do you feel that Kahoot! increased/decreased your engagement during the [course], and how did it increase/decrease?". Students who gave short answers in response to questions (e.g., "Yes, it increased it [engagement]") were asked to elaborate on their answer (e.g., "How and to what extent does Kahoot! increase your engagement?"). *We are not allowed to share the students' data as indicated in the requirements of University of Otago ethical guidelines and approval number D16/318.*

Demographic records and student scores

As part of the interview process students' demographic information was recorded including age, gender, overall duration of tertiary study, course of study, hours dedicated to course work per week and hours dedicated to course overall per week. Students' internal course work and final examination scores were recorded at the time of the interview. These data were used to complement those from the interviews in supporting our analysis and interpretation of the outcomes.

Measures, Data Processing, and Analysis

Student subject knowledge is a dichotomous variable, determined by their course level in Information Science (COMP111 vs INFO322). We distinguish this from students' overall duration of tertiary study (accumulated student experience). Students' perceptions were extracted from their *interview* responses. Classroom dynamics is operationalized as the interaction between students and lecturers. Student engagement pertains to the level of attention, curiosity, focus, and interest that students show during the course. Motivation refers to the extent to which students are consistently engaged with the course work and interact in the classroom. Learning is defined as the knowledge and skills that students attain that are directly attributed to their involvement and participation in the course. Taken from the *demographic records and student scores*, gender is identified by a dichotomous code (Male = 0, Female = 1). Study habits are measured by the total number of hours of study dedicated to their course per week. Academic performance (achievement) is the students' average score across their internal assessment and final examination mark.

Students' responses to the interviews were transcribed by a research assistant, i.e., verbatim. These transcripts were then verified by the second author. The transcripts were identified by author ID, interview time, questions, and responses, and students were treated as the units of analysis. Thereafter, our analyses of the content were performed.

We adopted an inductive (bottom-up) approach to content analysis to test whether clear themes (of *perceptions*) relating to classroom dynamics, engagement, motivation, and learning appeared in the interview data (Patton, 1990). The procedure involved open coding where the interviews were read and re-read for familiarisation and initial codes were identified based on explicit, surface-level semantics in the data, rather than implicit responses and preconceptions (see Braun & Clarke, 2006). Through axial coding, codes were recombined and connections were formed between ideas. Then, we used NVivo software to conduct thematic mapping to restructure specific codes into broader themes. Fi-

nally, following Braun and Clarke's (2006) selective coding procedure, the resulting themes were refined and organised into a coherent, internally consistent account, and a narrative ("story") was developed to accompany each theme. Themes were extracted from answers provided in response to interview questions, which targeted *perceptions* around *classroom dynamics*, *students' attention, engagement, motivation*, and *learning*.

To quantify the above themes for descriptive statistics (Tables 1-4), the correlational analysis (Table 7), and the analysis of covariance (Table 8), we calculated the number of words representing a theme as a percentage of the total number of words in the interview dialogue. Breaking down text into smaller units of analyses allows for inductive coding at a finer level of detail and better captures differences in prevalence and strength of themes (e.g., Daniel & Harland, 2017; Thang & Koh, 2017). Thang and Koh (2017) recommend using a "counting and coding" strategy to accurately calculate the frequency of themes, particularly when analysing shorter textual data that varies in length and detail. We adhered to this strategy; however, we calculated theme occurrence (i.e., number of words comprising the theme) as a percentage of total words in participants' response to better capture the detail and intensity with which participants talked about a theme. For instance, in the present study, two students may mention the *learning and retention* theme, but one student may discuss this theme in more detail, over multiple sentences, covering multiple smaller "codes". This approach is consistent with content analyses of shorter texts in social psychology literature (e.g., Tausczik, & Pennebaker, 2010).

Prior to performing our deeper analyses, we also used descriptive statistics to summarise students' *demographic records and scores* (Tables 1-4), including the independent variable (*student subject knowledge*), control variables (*overall duration of tertiary study*, *gender*, *hours dedicated to course work per week* (study habits)) and *academic performance* (an additional dependent variable). As noted above, academic performance was measured based on coursework (e.g., essays and test for first year, case study and class project for third year) and final exam grades (both first and third years), where students tended to perform better in the former assessment. Then, we identify relationships among themes discovered through qualitative observations and other quantitative data collected.

Across both courses, there is a slight disparity in the number of observations for males and females (15 versus 12 respectively), so this difference is taken into consideration when examining statistical significance between these two groups.

RESULTS

FIRST-YEAR (JUNIOR) STUDENTS' PERCEPTIONS (RQ1)

The content analysis revealed six major themes for first-year (junior) students' experience using Kahoot! during their course: (1) attention and focus, (2) interaction and engagement, (3) learning and retention of knowledge, (4) fun and enjoyment, (5) negative reactions, and (6) improvements and suggestions. Learning and retention of knowledge and improvements and suggestions themes were prevalent in the responses of all 13 participants. Attention and focus and interaction and engagement were reported by 12 participants. Finally, fun and enjoyment and negative reactions themes were the least prevalent and were reported by 11 participants. In some instances, multiple themes were provided per student for the sub-themes and are presented below.

Attention and focus

We observed that 12 of the 13 participants reported that Kahoot! use positively influenced their attention and focus during class. All 12 of these participants reported specific reasons for and consequences of their increased attention and focus, with one participant also making a general reference to their heightened interest in lectures using the tool. Attention and focus increased during lectures due to a *point of difference* between Kahoot! and the PowerPoint lecture slides and when Kahoot! was used as a *break from the lecture*. Furthermore, paying more attention during Kahoot! sessions further enhanced students learning.

Table 1. Demographic Information for First-Year Information Science Students' (Junior Students)

Participant (Student)	Age	Gender	Duration (years) of Study	Hours dedicated to course overall (weekly)
1	20	Female	3	1.5
2	19	Female	2	2
3	24	Female	2.5	1
4	23	Male	5.5	3.25
5	19	Male	2	1
6	20	Female	2.5	2
7	19	Female	2	1.5
8	22	Male	2	5
9	20	Male	2	1.5
10	22	Female	4.5	4
11	19	Female	4	2
12	19	Male	1	0.5
13	20	Female	2	0.66

Table 2. Descriptive Statistics for First-Year Information Science Students' Demographics (Junior Students)

Gender	Statistic	Age	Duration (years) of study	Hours of study each week	Performance (%)	
					Coursework	Exam
Overall	Mean	20.5	2.7	2.0	80.5	60.5
	Median	20.0	2.0	1.5	84.0	61.0
	Std. Dev.	1.7	1.3	1.3	15.6	11.2
Male	Mean	20.6	2.5	2.3	82.6	63.0
	Median	20.0	2.0	1.5	87.0	66.0
	Std. Dev.	1.8	1.7	1.9	17.6	12.7
Female	Mean	20.4	2.8	1.8	79.3	58.9
	Median	20.0	2.5	1.8	77.5	58.5
	Std. Dev.	1.8	.96	1.00	15.4	10.7

Point of difference. Eight students felt they were more attentive and focused because they felt Kahoot! was very different to their regular lecture classes. Firstly, surface characteristics of the Kahoot!

learning environment, such as engaging music, bright visuals, and the use of their mobile phones immediately increased students' alertness, which meant they paid more attention to the questions presented. Students reported feelings of excitement and interest when Kahoot! was used in class.

"….Even from where you can make your name and you go through everything. It's quite different from just sitting there and listening and just looking at some slides as well. It's quite visually… lots of colours and everything, so it's not boring…" (Student 10)

Of the students who appreciated the point of difference, six students perceived Kahoot! as a more innovative approach to learning and reported that they preferred this to traditional methods, i.e., where students typically learn content by passively listening to lecturers' PowerPoint presentations. Students appreciated the lecturer's efforts to make the classes more engaging and fun. This positive perception of the lecturer's involvement in the students' learning further enhanced their attention and focus.

"Only, I think, that students appreciate it when lecturers try new things from the old model of just standing up and talking…. I think students can appreciate that lecturers are trying to be more engaging and that, in turn, it helps people's perception of the class regardless of how effective the "Kahoot!" works…" (Student 5)

The two remaining students did not report that Kahoot! improved their attention and focus beyond the traditional teaching model. However, these students believed that switching learning strategies from following lecture slides to participating in Kahoot! quizzes and vice versa enhanced their attention and kept them engaged during class. Students felt that, in contrast with the regular lectures, Kahoot! allowed them to more actively participate in the lecture, engage with the course content, and interact with each other.

A break from the lecture. Seven students responded positively to the idea of using Kahoot! as a break. Some students indicated that concentrating for the entire duration of the lecture can be difficult. Having a mid-lecture break with a quiz was refreshing for students and helped rejuvenate them for the second half of the lecture. Having the break also allowed students to engage and have fun, thus boosting the classroom dynamics.

"Oh yeah, maybe like a mid-lecture break for two minutes, have a few random questions. Because it's kind of interesting to see what other people in the class select as well, It's a bit fun, it wakes you up a bit." (Student 2)

Learning and attention. Similar to "point of difference", six students felt Kahoot! allowed them to more actively engage with the lecture content and listen more carefully during class. In this way, attention and focus positively influenced their learning of difficult concepts in the lectures. Because Kahoot! asked students open-ended questions, students were able to review specific material in more depth. Given the interactive nature of Kahoot! quizzes, students reported focussing more and thinking more carefully about how to answer each question to avoid feelings of embarrassment if they made mistakes in front of the lecturer and their peers.

"So being engaged in a more engaging and active learning environment rather than just typing down notes as quickly as I humanly could actually made me engage with that and understand it, for instance, a lot more." (Student 4)

Interaction and engagement

As stated above, 12 out of 13 participants reported that Kahoot! had a positive impact on their interaction and engagement. Extending beyond broad reports of this theme, seven students reported that Kahoot! use enhanced *classroom dynamics* and two students indicated that they were more likely to discuss and compare answers with their classmates.

Classroom dynamics. Rather than reporting individual impacts, students felt that Kahoot! improved the overall classroom dynamics by encouraging more students to contribute in class, feel more involved, and be more engaged. Students provided specific reasons as to why Kahoot! increased classroom dynamics. Firstly, three students reported that, compared to normal lectures, Kahoot! prompted a two-way communication system between the lecturer and the students. In a typical

lesson, when the lecturer asks a question, students are often reluctant to publically volunteer an answer. However, because Kahoot! creates a comfortable environment in which students feel their input is valid, students are more inclined to share and discuss their answers with the lecturer.

"*I think it's good because it's a two way relationship, we're really interacting and the whole class is getting involved."* (Student 7)

Secondly, Kahoot! increases classroom dynamics because it provides a more natural, comfortable setting in which students can communicate with one another. With the traditional teaching method, lecturers' attempts to encourage peer discussions often feel forced. In contrast, Kahoot! made students' social interactions more purposeful and allowed them to discuss and compare answers.

"I feel like I've already said this, but what I liked about it was that it got everyone talking and connected and to your neighbour you were like, 'What did you put?" (Student 6)

Learning and knowledge retention

All 13 of the participants reported that Kahoot! had a positive impact on their learning and knowledge retention. The results revealed four distinct subthemes: *discussion and comparison* of students' responses post-quiz, *evaluating knowledge*, *remembering*, and *revision*.

Discussion and comparison. Seven participants reported that Kahoot! allowed them to discuss and compare their answers. Five of the seven students discussed their problem-solving strategy (i.e., why they chose one option over another), providing a platform in which the lecturer is able to elaborate on why a particular answer is correct.

"And then when he would explain how, he would go through and be like, 'this is wrong because..', and I thought that was really helpful. And then you could add that to your notes." (Student 1)

In addition, students also reported that after using Kahoot!, they were able to compare their answers and performance to their classmates, which prompted positive social interaction through discussion and boosted individual students' confidence as the scoreboard revealed the percentage of students who gave the same responses for particular questions and scored similarly overall.

"…it was actually quite useful because when you were answering your questions and you were unsure of them, you could see how much of the class thought the same way as you." (Student 4)

Evaluating knowledge. Seven students reported that using Kahoot! allowed them to evaluate their knowledge and correct their mistakes for future tests. The Kahoot! post-quiz feedback helped students to more clearly distinguish between the content they knew well and the content they needed to work on, which, in turn, helped students use their revision time wisely. Furthermore, students often added the lecturer's explanation of Kahoot! answers to their lecture slides. This evaluation process was a "wake-up call" for some students who were surprised by the extent of their lack of knowledge, but rather than reducing their confidence, this increased their motivation to work harder and improve their performance for later tests.

"You're going to get asked questions on your test, so it's a good way of having an exam question, and you have a go at answering it. Then you go, 'Oh wow, I actually don't understand as much as I can, or, 'I can't quite answer that question,' so you spend a bit more time on it… You have the lecture so you have the bulk of the information that you want to get across, and then you also have "Kahoot!" to test on that, so you get to find out the gaps in your knowledge." (Student 8)

Revision. Nine participants reported that they felt Kahoot was useful for revising and preparing for exams and an additional two students reported that the tool helped with reviewing course content after lectures. Although some students felt that Kahoot! was not necessarily the most appropriate platform to learn new content, they reported that Kahoot! worked best as a revision tool. The multichoice structure of Kahoot! quizzes prepared students for what to expect in an INFO111 test or

exam. Consistent with the knowledge evaluation process, students were able to learn from their incorrect responses in Kahoot! quizzes by revising the relevant content until they had grasped the concepts. Because Kahoot! quiz questions were uploaded to Blackboard (an online system providing students' access to course information at the University of Otago), some students use Kahoot! to study course content externally when they missed a lecture.

"*Well, I think that is a good idea, but I think it would be better as a revision. Then you actually know that you should know this, but you don't. So you need to go over it. Or, 'Ok, I do know this' rather than knowing you already don't know it and are still getting it wrong."* (Student 11)

Two students implied the lecture slides and Kahoot! quizzes were equally useful as revision tools. They felt that Kahoot! should not be used instead of but rather complementary to the lecture slides. They believed the content in the slides should be used to create the Kahoot! quizzes, and students' performance on specific questions would indicate which lecture topics need to be reviewed in more detail.

"I reckon slides are good. The way I'd use "Kahoot!" is I'd have slides and then maybe have a 'Kahoot!' in between or at the end and use the information from the slides in the 'Kahoot!'. That way you're getting the slides so people can either write the slides or do whatever they want to do with them, and then the 'Kahoot!' is a good way to reinforce it or put it into a question." (Student 8)

Remembering. Five students reported that Kahoot! improved their memory of course content. Some students attributed this to the short duration and time of day of Kahoot! quizzes; students were usually tested with Kahoot! quizzes at the end of the lecture, allowing the lecturer to elaborate on the correct answer and engage in discussions before the lecture ends. Students also found the association between bright colours and question presentation supported learning. According to four of the five students, Kahoot! prompted a more in-depth exploration of course content. For instance, answering a multi-choice question allowed students to not only learn the correct answer but the relevance of the "incorrect" answers. Furthermore, the Kahoot! questions were more specific than the content of the lecture slides which allowed students to expand their knowledge in more detail.

"It was good because you could get specific answers for your questions whereas in the slides they're a bit more broad and it's like "this, this, this" but it's ("Kahoot!") like "What is this?" and it would give you the answer. I really found that useful because then I knew exactly what the answer was for these questions." (Student 7)

Fun and enjoyment

Nine students reported themes of fun, enjoyment, excitement, and positive experiences using Kahoot! The novelty features of Kahoot! including mobile phone use, the energising music, and bright colours all contributed to students' increased enjoyment and positivity using Kahoot! compared to a typical lecture. Students reported an immediate "lift in the mood" and a reaction of excitement throughout the class when a Kahoot! quiz was about to begin. Kahoot! created a light-hearted atmosphere in which students felt interested in the course content. In other words, students considered Kahoot! to be a more appealing learning method compared to traditional methods. In addition, Kahoot! use encouraged social interaction between students.

"I think it really lifts the whole class. Like you said, that's a one way relationship and it makes it a two way relationship because he's talking and we're responding. With 'Kahoot!', I found it really fun; when he said we're doing 'Kahoot!'. I really enjoyed that. I feel with lots of people it lifted them and got them more involved in the class as well; people might be tired and then they were like, "Oh, we're playing a game!" So it lifts the whole class up." (Student 7)

Getting to know others. Five of the nine participants enjoyed using Kahoot! as an ice-breaker to get to know and connect with their classmates. At the beginning of the course, students took part in a recreational Kahoot! quiz and answered questions about themselves and their academic background. The frequency distribution of responses provided students with information about how they were similar to other students, which prompted social discussion.

Negative reactions

Eleven students reported a variety of different negative reactions about the role of Kahoot! in class as well as features of Kahoot! that reduced its effectiveness as a learning tool. These themes included Kahoot! as a *distraction*, a *poor revision tool* and the perception that Kahoot! *restricted* the amount of content covered in a lecture.

Distraction. Five students reported that Kahoot! had the potential to distract students from their learning of lecture content. Most of these students felt that the process of choosing and entering a name into the Kahoot! system led to disruptive, unproductive behaviour as people would choose inappropriate and occasionally offensive names. Students also expressed concerns about the extent to which the information presented in Kahoot! was relevant and important to grasp. Due to time constraints, two students even went as far as reporting that they felt Kahoot! was not useful as a break from lecture content.

"Yeah, sometimes I felt that the information you'd be learning off of it, you weren't sure if it was actually important, or if they were just using it to get you more engaged…. What I didn't like was that sometimes I felt that it did waste a bit of time." (Student 6)

Restricts content coverage. Consistent with the distraction theme, five students felt that Kahoot! restricts the amount of course content that can be covered in class. Despite its positive impact on student engagement, because Kahoot! encourages student-lecturer interactions, the extent to which the lecturer can efficiently present all the relevant course content is reduced when playing Kahoot!.

"I think towards its detriment, to a small extent, it did mean that I don't think you cover quite as much material, because obviously it's that down time between the exchange of 'I'm giving a question' and 'You're giving an answer." (Student 4)

Furthermore, students reported that Kahoot! was not a useful platform for introducing new information to the class. They tend to score lower on quizzes containing unfamiliar information or content they were yet to learn and were therefore less likely to engage with or use rehearsal strategies to remember the answers or the related material in future. Kahoot! quizzes were more useful when they tested the students on course content from the most recent lecture.

Not a useful revision tool. Four students reported negative reactions of Kahoot! as a useful revision tool. These students believed that revision time should be used to focus in more depth on the lecture slides as they are more structured than the Kahoot! quizzes. This perception is partly due to uncertainty over whether students need to know specific information in the future. Students felt that, Kahoot! should be used as a short-term tactic to increase engagement in class.

"When I go away and do my own personal study, it's very much, 'I am reading now, I am taking in everything as much as possible'. Trying to make it fun externally or trying to put a focus on a little bit more light material at that point in time would probably sway my thinking or other students' thinking away from wanting to go in depth in the material or might miss something that would be crucial for examination learning." (Student 4)

Improvements and suggestions

Each student discussed an aspect of Kahoot! that they believe could be improved to further enhance engagement, motivation, and learning. Suggested changes were made regarding *frequency* of Kahoot! use, *time allowed* for Kahoot! sessions, *content of questions* (course material tested) and *technical issues* (bandwidth).

Frequency of Kahoot! and time of day. Ten students provided opinions on the frequency with which Kahoot! should be used. Firstly, the results regarding frequency of use revealed a mix-response that reflected individual differences in learning styles and preferences. Four students believed Kahoot! should be used more often, for instance, in at least five lectures per course set. It was also recommended that Kahoot! be incorporated into the curriculums of other courses (e.g., Economics). In

contrast, three students believed Kahoot! should be used less often than it currently is, with one student recommending a maximum of two Kahoot!s for the entire course. Secondly, the results revealed that Kahoot! would be most suitable to test recently acquired knowledge at either the end of the lecture and/or course. However, other students responded positively to Kahoot! quizzes occurring at the beginning of the lecture or at both the beginning and end to monitor learning progress.

"I guess time is a factor, but it would be more beneficial for me personally if it was at the end of a lecture, so then you can go over what you've just learned. Then, at the end of the semester as revisions for exams." (Student 11)

Content of Kahoot!. Three students believed that the difficulty and detail of content in the Kahoot! questions and answers could be further developed. Students recommended having a quiz that contained a mixture of examinable questions at the end of the semester. They felt that the lecturer could further elaborate on each answer and explain why it is correct before continuing on with the next question. They also felt that Kahoot!s could begin with simple questions but gradually become more difficult and technical as students expand their knowledge.

Technical issues. One student reported technical issues regarding the use of Kahoot!. One student reported difficulty using their mobile phones compared to their computers. However, technical issues were not frequent.

Time allowed and length of Kahoot!. Six students reported issues relating to the time allowed for Kahoot! during the lecture and the length of Kahoot!. Consistent with the frequency of use themes, students felt that a one-hour lecture was not long enough to discuss all the different possible responses to questions. Students also believed the Kahoot! sessions were too long. The lecturer's elaboration of answers, pauses between questions, and the collection of students' Kahoot! responses increased the length of Kahoot! sessions, and as a result, reduced student engagement. It was recommended that Kahoots! only last 5-6 minutes and act as a course review.

Third-year (Senior) Students' Perceptions (RQ2)

As with the analyses above, findings from the analysis revealed the same six major themes related to students' experience in the use of Kahoot! in the classroom: (1) attention and focus, (2) interaction and engagement, (3) learning and retention of knowledge, (4) fun and enjoyment, (5) negative reactions, and (6) improvements and suggestions. Three of the themes extracted from the data (i.e., attention and focus, interaction and engagement, and learning and retention of knowledge) were prevalent in the responses of all the 14 participants. Moreover, the themes of fun and enjoyment, negative reactions, improvements and suggestions were identified in the responses of 12 of the 14 participants.

Attention and focus

Attention. While the use of Kahoot! itself was an enjoyable activity, students said that Kahoot!s motivated them to pay attention during the lecture. The deployment of Kahoot! also motivated students to closely examine lecture material in order to prepare for the Kahoot! and answer questions correctly.

"I guess it keeps you more aware in a way but you've got to listen throughout the lecture to know what the answer is in Kahoot! which is also a good thing. So you're always focused if you want to do well in Kahoot!" (Student 7)

Having a break. A major barrier to staying focused in class was the length of the lecture as well as the time of day in which the lecture took place. Our analysis revealed that 9/14 participants highlighted the importance of having a break during lectures in order to balance and sustain a desirable level of attention during lectures. They reported that Kahoot! facilitated breaks in positive ways. Ten of the 14 respondents described staying focused in a 2-hour lecture as challenging, with some describing the experience as tedious or boring. Taking a break to engage in a fun activity allowed students to feel refreshed, providing timely relief at the halfway mark of the lecture and re-energizing students for the second hour. In addition to facilitating breaks during lecture, the use of Kahoot! also

created richer variation in lecture delivery, enabling a moment of fun while continuing to engage with lecture content, only in a more light-hearted way.

A point of difference. Participants referred to Kahoot! as a unique lecture experience that is enjoyable and stimulating to learning. Compared to engagement in other lectures, students mentioned that learning with Kahoot! was a rewarding lecture experience that is captivating and desirable.

"What's been good is that it was different… it allowed people to sort of sit back and go well this isn't how lectures usually run. So it did capture everyone's attention straight away." (Student 1)

Table 3. Detailed Demographic Information for Third-Year Information Science Students' (Senior Students)

Participant (Student)	Age	Gender	Duration (years) of Study	Hours dedicated to course overall (weekly)
1	22	male	4	6
2	22	male	4	6
3	21	female	4	5
4	21	male	4	3
5	23	male	4	2
6	22	female	4	5
7	20	male	3	8
8	20	female	3	4
9	22	male	4	11
10	20	male	3	6
11	19	male	2	3
12	22	male	3	10
13	21	male	4	8
14	24	female	2	9

Table 4. Descriptive Statistics for Third-Year Information Science Students' Demographics (Senior Students)

Gender	Statistic	Age	Duration (years) of study	Hours of study each week	Performance (%)	
					Coursework (/100)	Exam (/100)
Overall	Mean	21.4	3.4	6.1	81.7	73.4

	Std. Dev.	1.3	0.8	2.7	8.8	15.2
Male	Mean	21.2	3.5	6.3	81.5	73.8
	Std. Dev.	1.2	0.7	3.0	10.0	15.1
Female	Mean	21.8	3.3	5.8	82.1	72.4
	Std Dev.	1.7	1.0	2.2	5.8	17.9

Interaction and engagement

Our analysis suggests that Kahoot! gave students more opportunities to interact and engage with the lecturer, peers, and lecture content by providing a fun platform on which to engage. All 14 participants reported that Kahoot! positively impacted engagement in the class, and 13 of the 14 participants reported that Kahoot! increased their interaction in the lectures. Key points that emerged from the data were the importance of discussions, competition, and anonymity.

Interaction and discussion. Participants reported that the use of Kahoot! fostered interactivity and engagement during lectures, through answering questions, participating in quizzes, and discussions triggered by Kahoot!. The use of Kahoot! encouraged wider participation in class as opposed to conventional classrooms where discussions are often dominated by a few extraverted students. The wider student participation in the class also fostered deeper engagement in the learning environment.

"…Kahoot! gives me a platform that I can express what I think … even though it's silent … I still give ideas…" (Student 5).

Kahoot! fostered wider and active student participation and yet provided students with the opportunity to retain their most desirable personal choice of participation. Participants reported that when engaging with Kahoot! they interacted more with peers around them and with the lecturer during and after lectures than they normally would in any other lecture. Participants pointed out that with Kahoot! in the classroom, they could decide on the level of interaction that they felt comfortable with, either participating anonymously or overtly with friends, other classmates, the lecturer or with the whole class.

"Yes it made it more interactive. I supposed I don't talk in any other class … [I talked] with my classmates more than the teacher. I probably wouldn't have volunteered any information to the teacher. But I definitely did have more discussions in terms of the actual content with people around me than I did in other classes" (Student 6)

Competition. Nine participants discussed the competitive element of Kahoot! in relation to their interaction and engagement. Many respondents liked the competitive aspect of Kahoot!, seeing it as a motivating factor to participate, encouraging them to think critically, increasing their participating energy levels, and creating a lively classroom dynamic. Competition was viewed as a strong motivator, with one respondent describing how students like to 'perform' and another expressing their motivation to reach the top of the scoreboard and be the best in the class. Having a desire to win encouraged many students to prepare beforehand and engage with the material. It also seems to have been an icebreaker for many students, encouraging them to interact with their peers.

"…it was almost a sense of, not just competition, I want to be the best, but also comradery, hey do you think it's also the square, oh I hit the wrong one what did you go for?" (Student 9)

Anonymity. While viewed as a negative aspect of participation in technology mediated learning environments, allowing anonymity can foster deep and enriched participation. Providing anonymous participation in a learning environment can encourage wider participation as it inculcates a sense of safety and privacy (White & Dorman, 2001). The way Kahoot! was used in the course allowed students to enter a name of choice into the system each time they participated. Students could decide if

they wished to remain anonymous or identify themselves. Anonymity allowed students to feel safer when responding to questions. It also allowed students to focus on comparing the content of Kahoot! and differences of opinion, rather than comparing students' aptitudes. This encouraged participation, as students were able to take part without feeling that they were being judged for answering correctly or incorrectly. Several respondents described funny names within the Kahoot! adding positively to the element of fun and social learning in game-based environments (Squire, 2011).

"…so because it's anonymous it never creates conflict … so if the system is anonymous that's good for students." (Student 5)

Learning and knowledge retention

Nine out of the 14 participants stated that Kahoot! was a useful learning tool and all 14 described Kahoot! as having a positive influence on their learning experience. Throughout the interviews participants made positive references to how Kahoot! supported their learning. They stated that engaging with Kahoot! during lectures helped them not only to remember previously covered material but to understand new perspectives. They also reported that Kahoot! increased their knowledge. Knowing that there would be a Kahoot! in class also motivated several students to prepare and review material in order to do well in the Kahoot!. In particular, students enjoyed Kahoot!s that were relevant to the course, explored complex concepts and offered insight into applications of theory. Key benefits that participants discussed were how Kahoot!s aided revision, generated discussion and helped them to retain knowledge.

"When you get a question it does help you, you've got to think about the answer, you've got to look at lectures to prepare for it… so that's part of revision as well" (Student 3)

Revision. Participants felt strongly that Kahoot! could be used for revision, with 12 participants seeing Kahoot! as a useful revision tool. In fact, three participants had used Kahoot! as a revision tool for exam preparation. Participants commonly felt the best use of the tool was to review lecture content and key topics, with Kahoot!-related course content favoured over those unrelated to the course. By repeating the content in a novel way through Kahoot!s, students felt they were more likely to remember the concepts. In particular, participants mentioned Kahoot!s being useful for allowing a deeper understanding of theoretical concepts. Kahoot! also offered a brief and concise understanding of the basic concepts in the course, which was then reinforced and enriched by a class discussion that encouraged more in depth thinking.

"It helped with the revising what we'd already been taught more so than actually learning the stuff because you were already asking questions about things you'd already taught us [and] I guess that does help in the long run of actually understanding" (Student 7)

Discussion (evaluation of answers). Eleven participants' responses indicated that the discussion generated by Kahoot! was often where the most valuable learning took place. Specific benefits to post-Kahoot! discussions provided perspective, highlighted diverse opinions, and allowed students a chance to evaluate their knowledge in comparison to other classmates. Kahoot! and the following discussion also gave students feedback to immediately correct their own mistakes, knowing if they got an answer right or wrong, and more importantly, why. Exploring the answers and understanding why they were right or wrong generated a deeper understanding that strongly aided participants' engagement and retention of knowledge.

"The Kahoot! itself almost seems like a fun tool to get people back engaged and then the conversation afterwards is where the learning actually occurs. You're not actually learning from it directly but more indirectly from the discussion afterwards" (Student 4)

Increasing and retaining knowledge. Nine participants mentioned that Kahoot! helped them remember information during and after class. A few students also felt that Kahoot! added to their knowledge, as when new information was introduced they were more likely to remember it through a

Kahoot!. Regarding knowledge retention, respondents appreciated that it was a quick and simple way to refresh their memory and continue to engage with the material. Respondents indicated that within the two-hour lecture a lot of material was presented to them, making it hard to retain key concepts and facts. Kahoot!s supported students to re-grasp and retain key points from within the lecture, providing a reminder of what was covered. Participants also noted that they were more likely to remember Kahoot!s that they got wrong, as they had to consider why they got the question wrong and seek to understand the correct answer.

"It's often good to go back because then ones you got wrong, you remember them because you are like oh I got that one wrong and it's easier to remember them" (Student 12)

Fun and enjoyment

As a game-based student response system, fun and entertainment lie at the core of Kahoot!. The data showed that respondents enjoyed the Kahoot!. Twelve participants specifically pointed out that Kahoot! was fun. The element of enjoyment and fun underlies the positive aspects of all three aforementioned themes.

"It was definitely a positive interest … it wasn't a standard boring lecture where you could sit there and read the notes later on….." (Student 1)

The firm preference for using Kahoot! among participants was attributed to the game features. Participants said they enjoyed the game, they liked the use of it in class, and they enjoyed the course because of the Kahoot!. Further, the aspect of fun and enjoyment seems to have helped a number of students overcome barriers to interaction that they face in a typical lecture environment.

"It was just a fun way of interacting and learning the stuff and seeing if you knew your stuff with the quizzes and stuff for me that was useful" (Student 7)

Throughout the data it is evident that striking a balance between fun and learning is vital to effectively using Kahoot! as a valuable tool in the classroom (see negative reactions below). However, one participant specifically mentioned that they enjoyed fun 'off-topic' Kahoot!s because it allowed them to have a break and restore their cognitive and self-regulatory resources for the second half of the lecture.

Negative reactions

Twelve students reported negative aspects of Kahoot! use, which they believed had detrimental impacts on attention and focus, and learning. Criticisms were predominantly associated with the interrelated themes of competition, guessing (irrelevant content), and distraction. Rushing to answer questions and guessing rather than problem solving are considered consequences of the competitive environment, which once excessive, creates a distracting maladaptive rather than innovative learning environment. Guessing was also associated with the presentation of irrelevant content or facts that students had not previously been taught, and consequently they did not find Kahoot! to be useful in this context.

Competition outweighs learning. Despite the positive experience associated with the competitive nature of Kahoot!'s utilisation, two participants felt that the use of Kahoot! had a negative competitive effect on their learning experience. They mentioned that negative aspects of competition came into play when students were more concerned with gaining higher scores than other students rather than learning and retaining content in depth. In their desire to compete, some students rushed to answer questions, not taking the time to understand and read the questions or answers carefully. In some instances, students would skim read a whole paragraph in order to answer questions before their peers, and this was further exacerbated by the short time-frame of the Kahoot!.

"I enjoyed it, I think towards the end we probably all got a bit distracted with names and being competitive, I think sometimes you lose sight of trying to learn new things because you are just trying to win and have fun with friends instead of learning" (Student 8)

Guessing. Competition also increased students' rates of guessing as students were motivated to respond before others without taking time to systematically problem solve to reach the correct solution. In addition to the two students who noted that competition was a problem, five students noted that lecturers often presented factual survey questions associated with different percentage options which required memorizing and could not be solved through problem-solving applied knowledge strategies. Often these factual questions were not based on previously presented course material and were therefore considered less useful and had no impact on learning. One student, who did not raise issues with competition or guessing, also expressed a dislike for the survey style of Kahoot! questions because of the pressure to memorize the answers, which they felt increased boredom.

"A few cases I think, through some of [lecturer's] ones, but I felt like some of them were also trying to get us to guess statistics and I felt like those were reasonably useless since they were just figures that most of us either knew or didn't know" (Student 13)

Distracting. Although Kahoot! enhances fun and enjoyment and greatly improves classroom dynamics. Four students felt that fun and enjoyment only increased learning up to a point. When the lectures were moderately enjoyable (i.e., motivating but not distracting), learning reached optimal levels. However, an excessively fun environment caused a shift in focus away from the content, which two of the four students strongly felt negatively impacted learning and was an inefficient use of Kahoot!.

"It didn't feel directed enough … I was kind of like why are we doing this, it just seemed like a random fun activity… I mean it's fun but there's not point to it in the grand scheme of things." (Student 6)

Students became distracted and no longer took the Kahoot! sessions seriously, as demonstrated by some students' choice of whacky or funny names in the Kahoot!s, which further increased the humour and disruption. It was also noted that the anonymous nature of Kahoot! potentially contributed to students' misuse of the tool as individuals were able to cause disruption and hilarity without being identified.

"I found myself getting distracted by the hilarious names and some of them had whacky pictures or answers and you find yourself laughing along and it's like okay can I find the right question so I can get back to laughing." (Student 9)

Technical issues. Three students mentioned issues related to bandwidth as there were times when the internet connection dropped and students were unable to complete Kahoot! quizzes. At other times, students were automatically logged out of Kahoot!.

Improvements and suggestions

Again, 12 of the 14 students provided constructive suggestions as to how Kahoot! could be more effectively used in class. The predominant themes discussed concerned making changes to the time of day, the number/frequency of Kahoot! quizzes, the length of Kahoot!s, and the content of the quizzes. This latter improvement related to several sub-themes including facilitating the use of Kahoot! as a revision tool and highlighting the need for a discussion forum so students can draw on problem solving tips and more easily relate the Kahoot!s back to the lecture content while revising.

Time of day. Five students commented that lecturers should modify the point in the lecture at which Kahoot! is presented. Three of these five students believed that Kahoot! should be presented at the end of the lecture to revise the material that had been newly taught within the class. However, other students expressed a preference for presenting Kahoot! during the middle of the class as a "re-

fresher" to break up the long periods of listening to the lecturer and processing course content. Rather than commenting on the point at which Kahoot! should occur, one student felt that lectures should take place in the morning when students are more attentive and have more energy.

"I'd say it's good either in the middle or right at the end, because in the first half you are nice and fresh you can cover the good stuff, you can actually take in information, and then you start getting a little foggy, especially around 4 or 5pm, then I think getting something like this where you are actually engaging." (Student 12)

Frequency of Kahoot!. Eleven students made suggestions about how often they should use Kahoot! over the course of the semester. Eight of these students felt that Kahoot! was so useful to revise and test recently acquired knowledge that it should be used in every lecture, and most argued that this should take place at the end of class. Two students noted that Kahoot! should be used more often in class, but not in every lecture. For instance, one of these students felt that they should use Kahoot! at the end of every topic to give students a sense of the knowledge retained. Only one student felt Kahoot! should be used every six weeks (marginally less often than its current use).

"You know how every two weeks we had a quiz, maybe just the quiz to be on "Kahoot!"… maybe every second week so then it's a quiz and it's a revising quiz, more than just a quiz." (Student 3)

Length of Kahoot!. Four students suggested that the time allocated to solve Kahoot! questions should be longer. One of these students felt 50 seconds to one minute was sufficient whereas at least two students believed they needed between 5-15 minutes to solve the problems effectively. An additional student commented that the current length of Kahoot! was ideal. Rather than commenting on the time allocated for Kahoot!, one student commented on the number of questions that should be included in a Kahoot!, recommending 5-10 questions per quiz.

Content of Kahoot!. Six students commented that the type of material and questions used in tests and quizzes needed re-thinking. Four of these students felt that the lecturers too often presented questions and answers that the students had never seen before. Some of these questions were presented as surveys during which students were asked to process different facts and statistics and make educated guesses in the form of percentages, which, as noted above, enhances negative competition. These students preferred to be tested on relevant content from previous lectures that they have had time to process, which related to their perceived usefulness of Kahoot! as a revision tool. Students enjoyed questions for which there were many possible answers as those generated discussion.

"I think definitely making the questions around more theoretical things that we can actually use, so more like either theoretical or practical things… as I said earlier some of the "Kahoot!" were just a bit based on almost interesting facts." (Student 12)

Junior Versus Senior Students' Perceptions (RQ3)

Using a selective coding strategy, we compared the similar and different themes that emerged from the thematic analyses for first- and third-year students (junior vs senior students). We have also presented two effects matrices in Tables 5 and 6 (adapted from Miles & Huberman, 1994) to summarize the similarities and differences on the effectiveness of Kahoot! as a learning tool between these cohorts.

Similarities

Ninety-two percent of first-year (junior) INFO111 students reported improved attention and focus when using Kahoot! compared to 100% of third-year (senior) INFO322 students. Both cohorts of students reported that Kahoot! provided students with an interesting learning tool due to its clever programming and attention-grabbing features (e.g., suspenseful music and bright colours). However, more importantly, students felt that Kahoot! is an alternative and innovative learning approach that strongly contrasted with their typical PowerPoint lectures. More third-year students (64%) valued Kahoot! as a refreshing break from lectures compared to first year students (46%). Both first-year

and third-year students felt it necessary to attend more carefully to the content than they ordinarily would in a lecture because they were required to answer questions and participate. However, this careful focus was related to first-year students' fears of embarrassment if they made public mistakes when answering questions, whereas it was associated with third-year students' preferred learning style and comfort in their in-class interactions.

Enhanced interaction and engagement when using Kahoot! also emerged as a prominent theme for both first-year (92%) and third-year students (100%). Students similarly valued Kahoot! for encouraging a two-way communication exchange between the lecturer and the students and for creating a comfortable dynamic in which they can interact and engage with the lecture content. Third-year students particularly valued Kahoot! as a catalyst for promoting social interactions with their peers, whereas first-year students treated Kahoot! sessions as a time to compare scores and discuss answers. In other words, they treated discussion time as a learning opportunity rather than a chance to socialize.

Across student cohorts, students reported increased fun and enjoyment when using Kahoot!. Students felt that the change in learning method was exciting and restored their energy levels during class. They consistently reported positive improvements to classroom dynamics, including more discussions with the lecturer and comfortable and light-hearted interactions with the other students. However, marginally fewer first-year students (69%) reported that Kahoot! increased fun and enjoyment compared to third-year students (86%), which potentially reflects first-year students' tendency to learn what is necessary rather than participate in a wider range of course related activities for the sake of enjoyment. In other words, third-year students may have greater academic self-efficacy and optimism regarding their chosen major, which positively influences academic performance and adjustment (Chemers et al., 2001). Thus, they are better able to embrace in-class interaction and recreational breaks.

In terms of the negative aspects of Kahoot!, a similar proportion of students from both cohorts found Kahoot! quizzes to be distracting when students engaged in unproductive behaviour and when the need to compete outweighed the importance of learning. Furthermore, most students found Kahoot! useful for testing previously learnt information and recently acquired knowledge rather than new content. Across both cohorts, students recommended that the lecturer refrain from using questions that require memorization of new facts and, instead, include questions that require problem-solving and applying existing knowledge.

Differences

There were many similarities in students' perceptions of Kahoot! as an innovative teaching tool and its impact on classroom dynamics. However, there were some differences between student cohorts in terms of the perceived usefulness of Kahoot! for learning and knowledge retention, its effectiveness as a revision tool, and in students' recommendations for frequency of use, time allocation, and content coverage.

Similar proportions of first (junior) and third-year (senior) students found Kahoot! to be a useful revision tool (85%); however, more third-year students (64%) associated Kahoot! use with acquisition and storage of domain concepts and, more broadly, course units in long-term memory for future use. In contrast, first-year students felt Kahoot! emphasized their gaps in knowledge rather than enhanced their learning.

Given that the INFO111 lectures were taught in one-hour, rather than two-hour slots, first-year students were concerned about the limited time allocated to learning new course material and felt that Kahoot! was not the best use of time. While most third-year students felt Kahoot! was underutilized as a revision tool and should be used to track learning progress and test recently acquired knowledge, more first-year students believed that Kahoot! restricted content coverage without providing students enough time to gain the thorough feedback they needed from the post-quiz discussions. Third-year

students externally review and revise PowerPoint lecture slides to prepare for the in-class Kahoot! sessions, thus suggesting they place greater importance on their scores in the Kahoot! quizzes. In contrast, first-year students use Kahoot! as a guide to identify which sections of the lecture slides need to be studied in more detail. This perception of Kahoot! as a supplementary tool for lecture slides and preferences for the traditional learning approach may indicate a lack of confidence as to what types of questions are relevant for mid-term assessments and final-year exams (Chemers et al., 2001).

Although first-year and third-year students reported the same themes of frequency of Kahoot! use and time allocated for Kahoot!, their recommendations were different and often opposing. Firstly, third-year students strongly recommended that Kahoot! should be used more often. Most believed it should be used at the end of every lecture, or at least, as a longer, in-depth quiz at the end of each topic. On the other hand, four first-year students believed Kahoot! should be used less often, with one student even recommending that it is restricted to twice a semester. Secondly, given the short one-hour lecture slot, first-year students felt Kahoot! should be restricted to a maximum of five minutes, while third-year students who reported less time pressure believed Kahoot! should be longer and recommended lecturers allocate 5-15 minutes per Kahoot!.

Furthermore, third-year students provided specific recommendations for the type of questions lecturers should integrate into Kahoot! quizzes. They disliked the quizzes that required memorization of factual information and statistics and preferred more applied questions in the Information Systems domain, enabling them to problem-solve using knowledge they had already revised. In contrast, first-year students were unclear about the types of questions they wanted to see included in Kahoot! and were more concerned about only practising what would be relevant to their final exams. However, they suggested that the lecturers increase the difficulty level of Kahoot!s over the course of the semester.

More minor themes emerged reflecting student confusion in INFO111. Unlike third-year students, some first-year students reported confusion over the external availability of Kahoot! as they did not realise they could download the questions from Blackboard and practice in their own time. Interestingly, third-year students provided minor hints as to how Kahoot! could be designed and implemented better (i.e., user-friendly fonts and a more stable internet connection), and experiences of technical difficulties were more prevalent among first-year students.

Overall, across cohorts, students reported positive effects of Kahoot! use on their attention and focus, interaction, and engagement, and fun and enjoyment, despite a greater proportion of third-year students reporting greater enjoyment. However, first-year students reported more negative aspects of Kahoot!, namely their scepticism of Kahoot! as a revision tool and their concern about wasting valuable lecture time. In contrast, third-year students' criticisms were more constructive, and they were more forthcoming about potential improvements for question design and time use. Tables 5 and 6 provide summaries of the similarities and differences in perceptions of the junior and senior students.

Table 5. Effects matrix of the comparative effectiveness of Kahoot! between junior and senior Information Science Students

	Effectiveness of Kahoot!	Junior students (n = 13)	Senior students (n = 14)	Similarities	Differences
1.	Improved attention and focus	++	++	Increases attention/focus, perceived as a more innovative approach to traditional methods.	
	Having a break from lecture	+	++		
	Point of difference	+	++		
2.	Enhanced interaction/engagement	++	++	Two-way communication exchange, comfortable dynamic for interactions/discussions over lecture content.	A catalyst for social interactions for SS but a chance to discuss answers for JS.
	Classroom Dynamics	+	++		
	Interaction and Discussion	+	++	Productive, positive interactions with lecturer and peers	
	Competition	-	+		
3.	Learning/knowledge Retention	++	++		
	Discussion and comparison	++	+	Useful post-quiz discussions of possible answers.	
	Evaluating knowledge	+	++		
	Revision	+	++	A useful revision tool for both cohorts, but perceived as more effective for SS.	Helped SS acquire and store information in memory, but negatively emphasized knowledge gaps for JS.
	Increasing/retaining knowledge	+	++	More useful for testing retention of previously learnt material than for learning new knowledge.	
4.	Fun/enjoyment	+	++		Fewer JS reported increased fun and enjoyment but found tool useful as an ice-breaker.

Notes. Major themes are numbered, minor themes are italicized. ++ Highly prevalent, + Prevalent, - Less common. JS = Junior Students, SS = Senior Students

Table 6. Effects matrix of the comparative negative impacts of Kahoot! and suggestions for future use between junior and senior Information Science Students

Negative impacts and Kahoot! use improvements	Junior students (n = 13)	Senior students (n = 14)	Similarities	Differences
Embarrassment	+	-	NA	Greater attentiveness was assoc. with embarrassment at providing incorrect arguments among Junior students but assoc. with stimulation from positive classroom dynamics for Senior students.
5. Distraction	+	+	Similarly distracting across cohorts when need to compete outweighed learning.	
6. Restricts content coverage	+	-		SS felt tool was under-utilized while JS felt Kahoot!s were time consuming, taking time away from learning new material and post quiz discussions.
7. Not a useful revision tool	+	-		SS perceived tool as a replacement of traditional learning methods, but only a supplementary tool for JS.
Guessing	-	+		
8. More frequent Kahoot!s	-	++		SS believed Kahoot! should be used once per lecture or topic. JS felt tool should be used sig. less.
9. Increase the length of Kahoot!s	-	++		SS preferred Kahoot!s of 5-15 minutes to reduce time pressure. JS suggested restricting tool use to 5 minutes.
10. Increase complexity of Kahoot! contents	+	++		JS too unfamiliar with course content but wished for further post-quiz elaborations. SS prefer questions that allow for problem-solving rather than memorization.

Notes. Major themes are numbered, minor themes are italicized. ++ Highly prevalent, + Prevalent, - Less common. JS = Junior Students, SS = Senior Students

STUDENTS' PERCEPTIONS, GENDER, LEARNING STYLE AND ACADEMIC PERFORMANCE (RQ4 AND RQ5)

In Table 7 we tested whether there were associations between the students' subject knowledge (junior versus senior), demographic characteristics, hours dedicated to course work per week (i.e., study habits), overall academic performance in the course, and perceptions of Kahoot!. Being an INFO322 student positively correlates with course work dedication (per week), attention/focus, interaction/engagement, and learning/retention, but was not associated with fun/enjoyment (refer to Table 7). INFO322 students were also more likely to make suggestions as to how Kahoot! can be improved. Making suggestions about improvements to Kahoot! also positively correlated with hours dedicated to course work per week, attention/focus, interaction/engagement, and learning/retentions. Hours dedicated to course work correlated with attention/focus, interaction/engagement, and learning/retention, but not fun/enjoyment. However, age only correlated with attention/focus, and gender was unrelated to perceptions of Kahoot!. Table 7 shows that overall duration of tertiary study positively correlated with interaction and engagement but was not associated with the other perceptions of Kahoot!. Attention and focus, interaction and engagement, and learning and knowledge retention were positively correlated. However, fun and enjoyment was only positively related to interaction and engagement. Overall, academic performance (across written assignments and examinations) was not associated with student subject knowledge, demographic factors, coursework dedication, or positive perceptions of Kahoot!. However, higher academic performance correlated with negative reactions of Kahoot!.

Table 7. Correlational Analysis for All Variables

Measures	1	2	3	4	5	6	7	8	9	10	11
1. Knowl											
2. Age	.29										
3. Gender	-.33	-.05									
4. DurStudy	.35	.45*	-.10								
5. CWDed	.70**	.43*	-.31	.33							
6. AP	.32	-.19	-.19	-.04	.19						
7. A/F	.52**	.44*	-.20	.11	.55**	-.04					
8. I/E	.81**	.14	-.33	.43*	.39*	.22	.48*				
9. L/R	.72**	.20	-.14	.16	.47*	.04	.66**	.70**			
10. F/E	.30	-.10	-.08	.10	.22	-.06	.29	.56**	.37		
11. Neg	.13	.12	.02	.16	.12	.47*	.13	.26	-.07	.40*	
12. Impv	.63**	.22	-.12	.17	.49*	.32	.54**	.56**	.55**	.24	.32

Notes. $p < .01$** $p < .05$* Knowl = Student subject knowledge, DurStudy = Duration of study, CWDed = Dedication to course work, AP = Academic Performance, A/F=Attention and focus, I/E = Interaction and engagement, L/R = Learning and knowledge retention, and F/E = Fun and enjoyment, Neg = Negative reactions, Impv = Improvements/suggestions.

Treating student participants as the units of analysis, in separate univariate between-subjects ANCOVAs, we tested the effect of subject knowledge (junior vs senior students) on attention and focus, interaction and engagement, learning and knowledge retention, fun and enjoyment, negative reactions, suggested improvements, and academic performance, while allowing for duration of study to

co-vary in the model (refer to Table 8 for summary statistics). Subject knowledge did not predict duration of study, which allowed for the latter variable to be included as a covariate, $F(1, 25) = 3.49$, $p > .05$. Furthermore, duration of study did not interact with subject knowledge to influence any of the error variances, thus indicating homogeneity of regression slopes. Although hours dedicated to course work (study habits) correlated with subject knowledge, positive perceptions of Kahoot!, and suggested improvements, it shared variance in the data with the independent variable and therefore did not meet the criteria for inclusion as a covariate, $F(1, 25) = 24.37$, $p < .001$.

The skewness and kurtosis values for attention and focus, $S = .98$, $S_{SE} = .45$, $K = 1.18$, $K_{SE} = .87$, interaction and engagement, $S = .72$, $S_{SE} = .45$, $K = -.43$, $K_{SE} = .87$, learning and knowledge retention, $S = .43$, $S_{SE} = .45$, $K = -.76$, $K_{SE} = .87$, and academic performance, $S = -.33$, $S_{SE} = .45$, $K = -.74$, $K_{SE} = .87$ were not significant, thus meeting the criteria for a normal distribution. However, negative reactions, $S = 1.59$, $S_{SE} = .45$, fun and enjoyment, $S = .1.07$, $S_{SE} = .45$ and suggested improvements, $S = 1.19$, $S_{SE} = .45$ were positively skewed. Also, the test for homogeneous error variances was violated for fun/enjoyment $F(1, 25) = 10.65$, $p < .01$, interaction/engagement, $F(1, 25) = 5.70$, $p < .05$ and suggested improvements, $F(1, 25) = 10.54$, $p < .01$. The other variables had equal variances ($p < .05$). Therefore, we analysed the effects of cohort on negative reactions, fun and enjoyment, interaction/engagement, and suggested improvement variables separately in a Kruskal-Wallis test.

Table 8. First-year and Third-year Students' Perceptions of Kahoot!'s Use

Kahoot! Perception	First-year students (INFO111)		Third-year students (INFO322)	
	Mean	Std. Dev.	Mean	Std. Dev.
A/F	5.83	5.33	13.05	7.00
I/E	4.25	3.10	22.61	8.97
L/R	11.30	6.27	26.11	8.50
F/E	5.95	5.66	11.23	10.73
Neg	6.53	6.00	8.42	9.13
Impv	6.70	3.14	20.62	12.04
AP	70.50	11.77	77.94	10.85

Notes. A/F=Attention and focus, I/E = Interaction and engagement, L/R = Learning and knowledge retention, and F/E = Fun and enjoyment, Neg = Negative reactions, Impv = Improvements/suggestions, AP = Academic Performance.

The ANCOVA revealed that third-year (senior) students reported significantly more themes of attention and focus, $F(1, 24) = 8.47$, $p < .05$, $\eta^2 = .26$, and interaction/engagement, $F(1, 24) = 38.4$, $p < .001$, $\eta^2 = 0.62$, compared to first-year (junior) students. Also, compared to first-year students, third-year students reported that Kahoot! use had a large positive effect on learning and knowledge retention, $F(1, 24) = 25.03$, $p < .001$, $\eta^2 = .51$. Finally, third year students made more suggestions for future improvements of Kahoot! use, $F(1, 24) = 14.67$, $p < .01$ However, there was no main effect of subject knowledge on fun and enjoyment, $F(1, 24) = 2.14$, $p > .1$, negative reactions, $F(1, 24) = 0.13$, $p > .1$ and academic achievement, $F(1, 24) = 3.60$, $p > .05$. Duration of study did not significantly covary in any of the models.

The Kruskal-Wallis test confirmed that third-year students reported more themes of interaction and engagement, $\chi^2(1) = 19.07$, $p < .001$ and made more suggestions for improvement than first-year students, $\chi^2(1) = 10.57$, $p < .01$. Again, student subject knowledge had no effect on experienced fun/enjoyment, $\chi^2(1) = 1.15$, $p > .1$ and negative reactions of Kahoot!, $\chi^2(1) = 0.6$, $p > .1$.

DISCUSSION AND IMPLICATIONS

Previous research revealed that GSRS use increased students' attention/focus, engagement, and enjoyment during class. However, there was limited and conflicting evidence as to whether GSRSs improved learning and knowledge retention beyond that of traditional methods, such as "chalk and talk" style lectures and PowerPoint presentations. Kahoot! researchers have drawn from successful implementations of video and computer games (Ebner & Holzinger, 2007; Jui-Mei et al., 2011; Papastergiou, 2009) without taking into account unique components of the learning platforms that have different impacts on student learning, such as the promotion of anonymous responding and deeper learning through student-teacher discussions based on the Kahoot! quiz answers. Prior to this study, limited research had explored the antecedents to successful implementation of Kahoot!, such as when Kahoot! is most effective, how often it should be implemented, and what types of questions to include.

To our knowledge, our mixed-methods exploratory study was the first to investigate whether Kahoot! use improved on or, at least, supplemented traditional teaching methods. Of particular importance, this study revealed that Kahoot! use increased students' interaction and engagement to such an extent it stimulated students' learning and knowledge retention. Regardless of their preferential uses of Kahoot!, students found the two-way discussions with their lecturers useful for distinguishing between correct and incorrect answers and for improving their abilities to problem-solve and evaluate knowledge. More broadly, use of GSRSs, like Kahoot!, provide a more engaging approach to problem-based learning (e.g., Hmelo-Silver, 2004; Ketelhut & Schifter, 2011). Secondly, our study also identified individual-level and cohort-level factors that influence the effectiveness of Kahoot! as a learning tool. Our findings revealed that students with greater subject knowledge are better able to incorporate Kahoot! use into their well-regulated learning strategies to revise previously taught content and to acquire new knowledge, even after accounting for students' duration of tertiary study. We revisit our research questions in the next five sub-sections to discuss the implications of our findings for researchers, tertiary educators, and tertiary students.

RQ1. What are Students' Perceptions of Kahoot!'s Use on Classroom Dynamics, Their Engagement, Motivation and Learning when Completing a First-year University Course?

All first-year (junior) students interviewed perceived Kahoot! to increase their learning and retention of knowledge, attention and focus, interaction and engagement, and fun and enjoyment during lectures. Kahoot! provided a point of difference, enabling timely breaks from listening to the lecture and heightening students' attention, which then led to enhanced learning. Interaction and engagement was enhanced as the classroom dynamics united students and allowed them to participate in a judgement-free environment. This was particularly noteworthy as students typically listened to the lectures and shied away from volunteering answers to questions in a traditional learning environment, whereas they were now interacting with the lecturers and their peers. One strategy used with junior students was a Kahoot! to introduce students and identify similarities and differences in their experiences, which students felt served well to encourage later conversations.

Interaction and engagement was associated with learning and knowledge retention, due to increased opportunity to compare peers' and the lecturers' viewpoints and discuss students' areas of weakness and difficult topics in the post-Kahoot! discussion. These in-class comparisons and revision efforts, driven by the anticipation of course content in future Kahoot! questions, allowed students to evaluate their knowledge and make refinements to their mental models. Those enrolled in the first-year course made Kahoot! quizzes a tool for exam revision and at times tried to link questions asked on this platform to simulated test questions. A surprising observation made by students was that Kahoot!'s visually appealing interfaces also enhanced their memory for course content. The game-like atmosphere enhanced fun and excitement in the classroom and made learning enjoyable. Students particularly

liked that Kahoot! lifted their mood and the enhanced interactions allowed them to connect with a wider group of peers beyond what would be expected in a traditional lecture presented on PowerPoint slides.

The findings of this study indicated that Kahoot! use is consistent with Malone's (1980) theory of intrinsic motivation instruction required for effective learning. In particular, the majority of students reported that the game-show format of Kahoot! increased their attention and focus, which verified that Kahoot! activates students' cognitive curiosity (e.g., Connolly et al., 2012; Wouters et al., 2013). First-year students reported themes of sensory activation as the suspenseful music, bright colours, and anticipation of score presentation increase attention, focus, and physiological arousal. However, our study also indicates that the two-way interactions between students and lecturers are crucial to stimulate learning and help less experienced students identify where they made errors. Thus, researchers could consider re-evaluating Malone's (1980) theory of intrinsic motivation instruction in light of an "interactive" component. Our results were also consistent with A. I. Wang and Lieberoth's (2016) findings that the overall Kahoot! experience rather than any single component predicted students' concentration and engagement.

That said, there were ways that Kahoot!'s use in first-year student courses could be improved. Junior Information Science students particularly felt that Kahoot! was effective for revision but could not replace lecture slides. It was also suggested that in a 13-week semester there should be a maximum of five Kahoot! sessions after specific lectures, and questions asked should mirror typical exam questions. Therefore, tertiary educators should incorporate Kahoot! (or similar GSRSs) to emphasize key facts from a unit of work or examinable material. However, aside from Kahoot! use, tertiary educators should provide clear guidelines as to what material or topics will be examinable, so that first-year students, in particular, are able to more productively structure their revision sessions.

Finally, this tool invoked some negative reactions among junior Information Science students that need to be addressed before Kahoot! is implemented in other first-year university courses. For instance, students felt that Kahoot! should be short and focussed, covering around six minutes for a one-hour lecture. Restricting the length of these sessions may reduce unproductive behaviours (Kiili, 2005), such as the use of offensive and inappropriate names which first-year students felt was particularly detrimental to learning. More importantly, content for quizzes should be introduced prior to Kahoot! sessions, allowing students sufficient time to revise. In addition to clearer expectations around examinable material, students should be informed around whether more in-depth study is required beyond the instructional capabilities of Kahoot! software. Our study suggests that adjusting the length and frequency of Kahoot! sessions and clarifying the relevance of their content should increase first-year students' experiences of fun and enjoyment using the tool. These changes should make revising existing content easier, and consequently first-year Information Science students may experience similar gains to their learning and knowledge retention as the third-year Information Science students.

RQ2. What are Students' Perceptions of Kahoot!'s Use on Classroom Dynamics, Their Engagement, Motivation and Learning when Completing a Third-year University Course?

Third-year students emphasised Kahoot!'s enhancement of their attention and focus, interaction and engagement, and learning and retention of knowledge. These students also experienced increased fun and enjoyment, although there were opportunities to improve Kahoot! deployment given that the tool also resulted in some negative feelings at times. As with the first-year students, third-year students paid more attention in classes when they anticipated a Kahoot! session would begin. These students appreciated the change in learning styles and found Kahoot! useful for breaking up two-hour lecturers (i.e., a fun break). Thus, Kahoot! use mitigated detrimental effects of boredom on learning (Baker et al., 2010).

Similarly, Kahoot! provided opportunities for interaction and wider participation; although it improves student motivation through friendly competition, overly competitive behaviour can result in hasty responses, guessing, and poor performance. Kahoot! could be a more effective learning tool if it was modified to increase on-topic communication and team collaboration. Similar to ClassCraft (a game-based learning platform), students could play in groups where individual's poor (or strong) performance will affect the team's overall score (Papadakis, & Kalogiannakis, 2018), thus further supporting learning. However, consistent with previous research (White & Dorman, 2001), anonymity particularly helped with enhanced interaction and participation for the third-year students. Students noted that anonymity allowed them to focus on comparing the content of Kahoot! and differences of opinion, rather than comparing aptitudes of others. Interestingly, some third-year students described funny names used by others when playing Kahoot! as adding positively to the element of fun and social learning in game-based environments (Squire, 2011). The fun and enjoyment seem to have helped a number of students overcome barriers to interaction that they faced in a typical lecture environment.

Beyond the fun aspects, Kahoot! encourages revision and discussion which then enhanced third-year students' learning and knowledge retention. In particular, students enjoyed Kahoot!s that were relevant to the course, that explored complex concepts, and that offered insight into applications of theory. It is likely that their greater subject knowledge allowed senior (third-year) Information Science students to more easily regulate their learning (Ellis & Zimmerman, 2001) and use more sophisticated problem-based learning strategies (e.g., Hmelo-Silver, 2004). Overall, senior students provided more suggestions about how to improve the content and duration of Kahoot! questions rather than report negative perceptions of Kahoot!. Our findings have important implications for how senior students' can further enhance their learning through Kahoot! use. For instance, they should be encouraged to create their own Kahoot!s and provide useful feedback to the lecturer for course improvements. Furthermore, lecturers should adapt Kahoot! to keep more experienced students engaged by, for instance, focussing on previously taught and examinable material. For more experienced students, Kahoot! should ideally be used once in every two-hour lecture, for a duration of 15 minutes.

RQ3. Are There Differences in the Perceptions of Kahoot!'s Use for These Two Cohorts That may be Associated with Students' Subject Knowledge?

Our comparative analysis provided insight into students' perceptions of Kahoot! as a learning tool both during lectures and as a revision tool. Across domain experience, students reported that Kahoot! use boosted their attention, increased their engagement and interactions with peers, and positively impacted their perceived learning. Students believed that Kahoot! provided them with a clear picture of their knowledge base and allowed them to practice questions in a time pressured environment. Similar percentages of first- and third-year students reported positive perceptions of Kahoot!; however, third-year students more frequently reported themes of increased attention/focus, interation/engagement, and learning/retention for Kahoot!, which implied they more strongly valued the tool and had a deeper insight into how this tool improved their learning.

Across domain experience, Kahoot! also increased students' interaction and engagement by providing them with a comfortable platform in which they could participate through problem-solving and contribute answers either privately or overtly through discussions with classmates or even the class as a whole. Thus, Kahoot! greatly increased classroom dynamics and a sense of fun competition and enjoyment. Contrary to A. I.Wang (2015), there was no evidence of a "wear-off effect" in classroom dynamics with repeated use. However, peer interaction through discussion of Kahoot! answers was considered more valuable and fun for senior students than for junior students, who were more concerned with building on their existing knowledge and evaluating their progress in relation to other students. This may reflect first-year students' apprehension about their performance in the course

and their difficulty adjusting to the expectations of the university and different styles of learning associated with higher education (e.g., Bowles et al., 2014; Denovan & Macaskill, 2013). While those completing the third-year course strongly valued peer interactions, first-year students considered student-teacher interactions to be more beneficial to learning and felt Kahoot! strengthened these interactions.

Although third-year students were better able to embrace Kahoot! as a fun break from the course work, there were no significant (quantitative) differences in perceived fun and enjoyment between cohorts. Regardless of subject knowledge, students perceived the structure of Kahoot! sessions to be a novelty and experienced greater fun and enjoyment using Kahoot! compared to traditional lectures. This supports the necessity for an "enjoyability" factor (Ebner & Holzinger, 2007), or an "interactive" component to be incorporated into Malone's (1980) model. Indeed, it is likely that a positive classroom dynamic is the strongest antecedent of fun and enjoyment rather than the structure of Kahoot! itself. For instance, in the absence of classroom dynamics outside of the lecture, students practiced Kahoot! questions for revision rather than purely for fun. Across both cohorts, students felt that "too much fun" detracted from learning, especially when the quiz environment encouraged students to guess through trial-and-error rather than actively reflecting on their learning (see Kiili, 2005). Van Eck and Dempsey (2002) found that students were less able to use contextualized advice (i.e., clues and instructions on how to complete a task) to correctly solve applied mathematical problems when competition was present. Thus, they do not recommend that competition is integrated into game-based learning platforms when contextualized advice is given.

We observed that first-year students were less satisfied with Kahoot! as a revision tool; however, the prevalence of negative reactions did not differ as a function of student cohort. Instead, the analyses revealed that third-year students suggested more improvements rather than complaints for how Kahoot! should be implemented. Third-year students believed that Kahoot! should be used more often in class, with some students suggesting this should be included at the end of every lecture. Compared to first-year students, they were also more forthcoming about the types of questions (i.e., practical applications within the domain) they wanted lecturers to include in the Kahoot!. In contrast first-year students, raised concerns over the relevance of Kahoot! questions to formal assessments, which may indicate a potential break-down in communication around the curriculum structure. However, students unanimously agreed that quizzes with statistics and facts that required memorization and could not be solved through problem-solving should be removed from the Kahoot!.

Overall, both first-year and third-year students reported that their learning and retention improved through discussing their problem-solving strategies and why certain answers were correct. Students from both cohorts found Kahoot! useful for evaluating knowledge and exploring difficult concepts in more depth, thus enhancing retention for future recall. However, as noted above, learning was more strongly emphasized as important to the senior students.

RQ4. Which Individual Difference Factors (e.g., Gender, Duration of Study, Study Habits) are Associated with Students' Perceptions of Kahoot!'s Use, and Do They Influence the Effect of Student Subject Knowledge on Perceptions of Kahoot! Use?

Consistent with previous game-based learning research (Jui-Mei et al., 2011; Papastergiou, 2009), gender differences were not associated with learning and knowledge retention using Kahoot!, indicating that males and females found Kahoot! similarly useful as a learning tool. However, older students devoted more time each week to course work, which suggests that students' self-regulation and learning strategies improve with maturity.

Hours dedicated to coursework per week (study habits) correlated with positive perceptions of Kahoot! and suggested improvements; however, the quantitative analyses suggest that greater subject knowledge may be responsible for this association. Firstly, as noted above, third-year students, who have greater academic self-efficacy in their domain have adopted more effective revision, planning, and goal setting strategies and are more committed to their chosen major. Thus, they devote more time to course preparation and study, which is consistent with previous self-regulation research (e.g., Sabourin et al., 2013; Zimmerman, 2002). In contrast, first-year students, who have lower academic self-efficacy, have limited insight into their knowledge base and personalized learning style and therefore find it more difficult to test this knowledge using GSRSs. Secondly, it is likely that more experienced students (from INFO322) dedicate more time to studying and course preparation per week because they are given a heavier workload (Ruiz-Gallardo et al., 2011). The results suggested that the impact of student subject knowledge on perceived effectiveness of Kahoot! outweighed potential effects of individual differences, such as gender, age, and duration of tertiary study, the latter of which did not significantly co-vary in the students' domain experience - Kahoot! effectiveness model.

Overall, our results have implications for how Kahoot! can be tailored to suit individual differences in learning style and experience. Kahoot! can be adapted to suit the different learning styles of first-year and third-year students, while allowing for flexibility in learning approaches between individuals. As noted above, first-year students indicated significantly more apprehension and uncertainty about the relevance of Kahoot! use in revising lecture content and, thus, prefer traditional lecturers, whereas third-year students preferred questions that required cognitive effort, problem solving, and applications of course material. Therefore, lecturers should take care to provide first-year students with guidance as to what material is relevant and examinable. They should also encourage first-year students to practice answering multiple-choice and short answer Kahoot! questions to strengthen their knowledge base and their ability to extract important information and apply it in a different context. For third-year students, Kahoot! can be implemented more frequency and involve more challenging questions that support peer interaction and discussion. Differences in the preference for particular types of questions between first-year and third-year students likely reflected a change in learning styles over time. The tendency for first-year students to memorize only content that is examinable develops into a holistic, broad knowledge of the area by their third year. This development thus allows for more flexible, innovative, and student-centred methods of learning, such as Kahoot! (e.g., Lea et al., 2003), and contradicts previous scepticism that more experienced students would be willing to adopt GSRSs (Squire, 2005). Finally, it is important that students are able to effectively use online learning tools (including Kahoot!) to supplement their lecture slides in learning contexts when face-to-face tuition is unavailable. For instance, tertiary students in New Zealand rapidly adapted to learning entirely online during the Covid-19 outbreak. Kahoot! could be invaluable under such conditions.

RQ5. Are There Associations Between Students' Perceptions of Kahoot!'s Use and Their Academic Performance?

Students who critiqued Kahoot!'s use tended to also perform higher in their course overall; however, academic performance did not vary as a function of subject knowledge. In other words, students who reflected more on their learning searched for ways to better use Kahoot!. However, despite this, all students from both cohorts ranked Kahoot! highly for improving their attention, increasing their engagement and interactions with peers, and positively impacting their learning. Aside from explicit performance measures (e.g., scores in tests and exams), subject knowledge was associated with positive study habits and predicted improved attention and focus, interaction and engagement, learning and knowledge retention, and constructive feedback for improved learning methods after using Kahoot!.

Furthermore, across subject knowledge, students perceived gains in learning and knowledge retention were not associated with their objective academic performance scores. Learning styles and preferences of use may have differentially accounted for the absence of an effect on academic performance for each cohort. For instance, first-year students may have developed effective strategies for revising content using Kahoot! but, due to lower academic self-efficacy, are yet to translate these strategies into examination performance, especially if there are unclear guidelines as to what content is examinable. On the other hand, for third-year students, Kahoot! may be unlikely to improve their already effective strategies to learn, revise, and evaluate their progress, especially if there are other learning tools at their disposal (e.g., Barron, 2004).

However, all students from both cohorts ranked Kahoot! highly for improving their attention, increasing their engagement and interactions with peers, and positively impacting their learning, which suggests that, overall, students believe Kahoot!s improve on or at least supplement traditional learning methods. The post-Kahoot! discussions allowed students to discuss lecture content at a deeper-level and distinguish between correct and incorrect answers, under the guidance of the lecturer. Students are able to modify their lecture notes based on the responses to Kahoot! quizzes to aid future revision. Through this process, students develop greater insights into their knowledge areas of strengths and weaknesses, which allow them to better self-regulate their learning through strategies implemented and monitoring success through feedback (Sabourin et al., 2013; Zimmerman, 2002). These perceptions of learning through discussion and knowledge evaluation also support Lave's Situated Learning Theory, in which students learn through problem-solving, knowledge testing and observation (Lave, 1988). In this way, GSRSs, like Kahoot!, may be even more effective learning tools than games as students are able to critique and shape their own learning through revision of quiz content and make suggestions to the lecturer about the type and complexity of content they wish to practice.

CONCLUSION

Overall, this study expanded beyond previously documented effects of GSRS use on students' attention, engagement, and enjoyment by examining students' perceptions of Kahoot! as a useful learning tool and its impact on their learning and retention through a mixed-method approach. We pursued several enquiries, including junior and senior students' perceptions of Kahoot!'s use on classroom dynamics, their engagement, motivation, and learning, and the differences in perceptions for these cohorts. We explored the potential factors that may impact students' perceptions of Kahoot!'s use, with particular emphasis on gender, age, overall duration of tertiary student, and study habits, all of which impact their individual learning style. We finally explored associations between students' perceptions of Kahoot!'s use and their academic performance. Our mixed-methods study indicates that Kahoot! increased the attention and focus, interaction and engagement, fun and enjoyment and enhanced knowledge evaluation and learning and retention (or remembering) for both both first- and third-year Information Science students. However, subject knowledge impacts students' ability to adopt non-traditional learning methods, such as the use of Kahoot!, whereas individual differences such as gender, age, and overall duration of tertiary study had less of an impact. For instance, first-year students perceived Kahoot! as a supplementary tool to the PowerPoint presentations of lecture content and found Kahoot! to be a less effective revision tool, which was also indicated by their study habits (i.e., hours dedicated to course work per week) compared to third-year students.

However, we did not measure within-cohort differences in self-regulation and academic self-efficacy that may weaken the subject knowledge effect. For instance, it is likely that there were students in each cohort for whom gamification features were more likely to distract rather than motivate (see Sabourin et al., 2013). Similarly, given limitations to Kahoot!'s interface, we were unable to control for differences in student learning styles. According to Felder-Silverman's learning style theory (e.g., Carver et al., 1999; Filippidis & Tsoukalas, 2009), student learning styles can be categorized as either sensing vs. intuitive, visual vs. verbal, and sequential vs. global, with the latter being manipulated in educational games. Sequential learners address tasks or missions in a step-by-step linear order,

whereas global learners adopt a holistic approach and study the "bigger picture" of the problem. If Kahoot!s can be designed to meet the needs of sequential vs. global learners, we may be able to control for this within-cohort difference in future analyses. Furthermore, by collecting students' reports of their preferred learning styles (i.e., sequential vs. global), lecturers can adjust their quiz content accordingly, especially given that Kahoot!s also allow images to be embedded in questions. Sudents are more likely to be motivated to learn and perform better on subsequent formal assessments if Kahoot!s are tailored to their learning style (Hwang et al., 2012).

The comparative analysis provided insight into the strengths of Kahoot! and how Kahoot! can be better implemented so that students can maximise their learning. It is important that the post-quiz discussion environment supports student meta-cognition and self-assessment as does the game-based learning platform (Sabourin et al., 2013). Students could also be encouraged to create their own quizzes in their revision time to suit their study habits and learning needs. There are also likely to be other possible scenarios for the use of this tool beyond what the Information Science students experienced, and thus, students' perceptions may vary given other experiences with the tool. That said, we have carefully considered how Kahoot! was used with a view of stimulating classroom dynamics, students' engagement and motivation, and, ultimately, their learning, and so we believe our approach to the use of this tool was exhaustive.

Furthermore, the collection of data around students' social interactions and cognition while using Kahoot! through learning analytics libraries could be useful for capturing the learning process throughout the Information Science courses rather than only measuring success at assessment points (Vidakis et al., 2019). Learning analytics provide classroom-level metrics on GSRS and game-based learning use (e.g., number of students failing to complete a game, ratios of correct responses) that may indicate where educational instructional changes or adjustments to the game mechanisms are required to improve learning.

Finally, our sample was relatively small for quantitative analyses, and thus the associations between subject knowledge, overall duration of study, and study habits may not be generalizable to all lecture environments. We aim to improve this in future studies by increasing the sample size, by collecting data on individual learning styles, and by applying a multi-level model approach in which individual responses are nested within lecturers and courses. For instance, students' perceptions of Kahoot!'s use may be influenced not only by subject knowledge, but also differences in lecturers' teaching styles and students' abilities to self-regulate their learning. That said, the data saturation achieved in our thematic analysis revealed that perceptions of Kahoot! and learning outcomes do vary with domain experience (supported by the ANCOVA). The results should be generalizable to undergraduate university students who are using similar GSRSs (e.g., Socrative, Quizlet, and Buzz!) as learning tools in other tertiary-level Information Science programmes. Thus, our study has achieved high transferability and auditability (Daniel, 2018). In summary, Kahoot! can be an effective learning tool depending on how it is implemented, what course material is included and when it is implemented.

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BIOGRAPHIES

Helen E. Owen is an Assistant Research Fellow in the Department of Preventive and Social Medicine at the University of Otago, New Zealand, where she previously completed a PhD in Psychology in 2016. Helen has since undertaken mixed-methods interdisciplinary research in Education, Ergonomics, Public Health, and Health Management areas. Her broad research interests include exploration of game-based learning tools on student motivation and achievement, the usability of mobile phone fitness apps, integrated care and well-being of health providers, and the mobility and health of older adults.

Sherlock A. Licorish is a Senior Lecturer in the Department of Information Science at the University of Otago, New Zealand. He was awarded his PhD by Auckland University of Technology (AUT), and his research centres on the use of games in Information Science education. Sherlock's research involves the use of data mining, data visualization, statistical analysis, and other quantitative methods (e.g., social network analysis, linguistic and sentiment analysis, natural language processing (NLP), and probabilistic modelling techniques). He has also used qualitative methods in his research, including qualitative forms of content analysis and dilemma analysis.