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Comparison of Traditional and Gamified Student Response Systems in an Undergraduate Human Anatomy Course

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Abstract
Student response systems (SRSs) are widely used in anatomy and physiology courses as a form of active learning. While traditional SRSs (clickers) are pervasive, gamified SRSs such as Kahoot! are becoming increasingly popular. However, the impact of using both types of systems in the same course is unknown. The goal of this study was to determine the relative impact of a traditional SRS (iClickers) and a gamified SRS (Kahoot!) in an undergraduate human anatomy course. Student performance on iClicker questions and Kahoot! questions were compared to their average examination performance to determine if there were potential correlations. There were nearly identical and significant positive correlations between iClicker performance and exam performance and Kahoot! performance and exam performance. Students also perceived iClickers and Kahoot! as equally fun and effective, but reported that iClickers should be used more frequently than Kahoot!. These results suggest that iClickers and Kahoot! have positive educational impacts when used together. https://doi.org/10.21692/haps.2019.001

Key words: human anatomy, clickers, personal response systems, gamified learning, Kahoot!

Introduction
Active learning has been shown to be an effective form of pedagogy for science, technology, engineering, and math (STEM) courses (Freeman et al. 2014), including anatomy and physiology (Rao and DiCarlo 2001; Michael 2006; Shaffer 2016). Active learning can take many forms, including small group work, problem solving, brief writing assignments, and peer instruction (Allen and Tanner 2005), and the use of student response systems has recently been increasing. Student response systems (SRSs) are typically wireless devices that students use to answer questions in a classroom, allowing instructors to gauge student learning and understanding in real time (Blasco-Arcas et al. 2013). While the styles of SRSs have changed over the years (Barber and Njus 2007), as of this writing there are several popular formats including physical devices that students purchase and bring to class, systems that allow for text-based answers, and systems that make use of students' own personal devices (smartphones, tablets, or laptops) to answer questions. Questions posed by SRSs are often limited to multiple choice, but depending on the system being used, they can also include numeric entry, short answer, essay, "heat map" or identification, drawing, graphing, sorting, ranking, and uploading images.

While there are many current options for SRSs and question types, the majority of prior research on SRSs has focused on traditional SRSs where students bring a physical device to class and answer multiple-choice questions (from now on referred to as using "clickers"). The use of clickers is very common in biology (Allen and Tanner 2005, Caldwell 2007; Smith et al. 2009; Smith et al. 2011). There have been many reports on the use of clickers in anatomy and physiology courses as well. In a comparison of three teaching methods, Carpenter and Boh (2008) found that undergraduate anatomy and physiology students performed best on quizzes when taught with clickers and also that students preferred using clickers in the classroom compared to other methods. When used for pre-test reviews in an undergraduate nursing anatomy and physiology course, students reported positive attitudes and perceived benefits despite no actual gains in examination performance (Stein et al. 2006). In a medical school gross anatomy course, the use of a traditional SRS system improved examination performance for the lowest quartile of students but had limited benefits for the other students in the course (Hoyt et al. 2010). Alexander et al. (2009) found a strong significant correlation between performance on clicker questions and exam performance in medical school anatomy and histology courses. Both physical therapy students and instructors had positive views of a clicker system in a human gross anatomy class (Wait et al. 2009). Overall, these studies and others highlight the positive impacts of using traditional clickers in anatomy and physiology courses. Benefits of using clickers have also been reported in a variety of other non-biology science disciplines (Wieman and Perkins 2005; Stowell and Nelson 2007; MacArthur and Jones 2008; Morling et al. 2008; Bunce et al. 2010; Schmidt 2011; Donohue 2014).

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Gamification is a recent development in higher education in which game-like elements are used to promote learning and engagement in the classroom (Kapp et al. 2014). Gamification has been incorporated into SRSs as well by accompanying questions with music, animations, leaderboards, and trophies or badges, all designed to give the educational experience a more game-like environment. One of the most popular gamified SRSs is Kahoot!, which has reported to have over 50 million unique monthly active users as of May 2017 (Chowdhry 2017). Kahoot! is a free web-based SRS where students answer questions anonymously with their own smartphone, tablet, or laptop and earn points based on correctness and speed. While research on gamification of SRSs is still in the early stages, there have been some studies showing possible benefits of these systems. Students in a medical microbiology course had very positive views towards a gamified clicker system and reported that they enjoyed the competition with their peers and the high degree of focus on the game (Pettit et al. 2015). Kahoot! was used in an undergraduate psychology class and students who engaged with Kahoot! earned significantly higher exam scores than students who did not (Iwamoto et al. 2017). Additionally, positive student attitudes have been reported towards using Kahoot! (Bicen and Kocakoyun 2017; Ismail and Mohammad 2017; Plump and LaRosa 2017; Licorish et al. 2018). However, one study demonstrated a "wear out" effect of using Kahoot! wherein the more often it was used in a course the less excited students were when they played it (Wang 2015).

While there are clear benefits of both traditional and gamified SRSs, to our knowledge there has been no direct comparison of the use of both in a single course. In this study, we sought to determine the impact of using both a traditional SRS (iClickers) and a gamified SRS (Kahoot!) in an undergraduate human anatomy course. Specifically, we were testing the hypothesis that performance on iClicker questions would more strongly correlate with exam performance than the correlation between Kahoot! question performance and exam performance and that students would prefer using Kahoot! more in class because it would be perceived as more fun than iClickers. Our results demonstrate that student performance on exams was equally correlated with iClicker and Kahoot! performance and that students equally preferred the use of iClickers and Kahoot! in class.

Materials and Methods

Course and student description.

This study examined a high structure undergraduate human anatomy course taught in the ten-week quarter system at a large, research-intensive university in the southwestern United States. The course included three 50-minute lecture periods a week and three hours of laboratory a week for a total of 25 hours of lecture and 30 hours of laboratory over the ten-week course. The lecture portion of this course was taught by one of the authors (JS) with a systems approach and included pre-class textbook readings and graded online assignments, in-class active learning, and graded online weekly review quizzes. The in-class active learning used iClicker questions and Kahoot! questions. The laboratory portion of the course was taught by trained graduate student teaching assistants using custom laboratory guides designed to facilitate student interactions with plastic anatomical models and animal dissections (sheep brain, heart, and kidney). Cadavers were not used in this course. For more information on this course please see Shaffer (2016).

The study surveyed 255 students in two sections of this course: Winter 2016 (n = 127) and Spring 2016 (n = 128). Students enrolled in this course majored in biological sciences (65.6%), nursing sciences (16.0%), pharmaceutical sciences (10.9%), or other (7.4%). The majority of the population was female (70.3%) and Asian (71.5%). The remaining ethnic breakdown was 13.3% Caucasian, 12.9% Latino/a, and 1.6% African-American. A passing grade of "C" or better in a human physiology lecture course was a pre-requisite for enrolling in this human anatomy course. The course was an elective for all majors (except nursing science) so only students who wanted to enroll in this course did so.

Data collection

This study analyzed data obtained from 255 students in two sections of this course: Winter 2016 (n = 127) and Spring 2016 (n = 128). To be included in this study, students had to give their consent, complete all major summative assessments (lecture and laboratory practical exams), complete an end of course survey, and participate in a minimum number of iClicker questions and Kahoot! questions (see the following section). The data collected from each course section were combined in this analysis as similar results were obtained for individual sections. The Institutional Review Board of the University of California, Irvine approved this study (HS# 2013-9959).

iClicker data were collected as follows. At the beginning of the course, students registered their personal iClicker device with their student ID number via the iClicker website so that all iClicker responses were identifiable. On each class day, iClicker questions were asked (total of 200 questions over 23 days of class, average 8.7 questions per 50 minute class, min = 3, max = 12) and students responded using their iClicker. Students were given ~30 to ~60 seconds to answer each iClicker question and their performance for each question depended only on whether they determined the correct answer and not on how long it took for them to answer the question. The response data were recorded using the iClicker 7.0 software and exported to Microsoft Excel for analysis.

Kahoot! data were collected as follows. During seven non-consecutive days of class, Kahoot! sessions were played using the Kahoot! website (Kahoot! 2018). As Kahoot! is anonymous and not tied to an individual student ID number, students

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were allowed to use any name they liked while playing. However, students were encouraged to use the same name every time so that their total points could be tracked since a certificate was awarded at the end of the course to the student who earned the most Kahoot! points. In seven days of class, Kahoot! was used to ask a total of 48 questions (four on one day, six on five days, and 20 on the last day of class). Students were allotted a maximum of 20 seconds to answer each Kahoot! question and their score for each question was proportional to how quickly the correct answer was selected. Students answered the Kahoot! questions using their personal devices (laptop, tablet, or phone) and their responses were recorded along with the number of points earned per question (scale of 0 to 1000, with incorrect answers scored as 0 and correct answers scored from 1 to 1000 depending on how fast the answer was submitted). The response data were then downloaded from the Kahoot! website and exported to Microsoft Excel for analysis.

Since Kahoot! is anonymous, when first analyzing the Kahoot! scores we were unable to match the responses to student ID numbers and thus to exam scores. To aid with this, students were asked to complete an online survey at the end of the course to list the Kahoot! name(s) they had used during the class. Of the 255 students in these classes, 215 students (84%) completed this survey.

To determine student perceptions towards using iClickers and Kahoot! in the human anatomy course, students were asked to complete an online survey at the end of the course. In this survey, students were asked to rate the use of both iClickers and Kahoot! individually as "a fun and an effective way to learn," "a fun but not an effective way to learn," "not fun but an effective way to learn," and "not fun nor an effective way to learn." Students were also asked to rate how often iClickers and Kahoot! should be used in class from "every day," "once a week," "once a month," and "once during the entire class," and "never." Students in the Spring 2016 class completed this survey, and of the 127 possible students in the class, 106 students (83%) completed this survey and thus were included in the analysis of perception data.

Data analysis

iClicker data were analyzed as follows: For a given question, student responses were scored as correct or incorrect. Each individual student's percent correct on iClicker questions was then calculated by dividing the total number of correct responses by the total number of questions that the student responded to and multiplying by 100. To eliminate potential biases of students who only answered a small fraction of the 200 iClicker questions, students had to attend and answer iClicker questions for at least 20 out of the 23 days of class that included iClicker questions. Out of the 255 students in these classes, 211 students (83%) met this condition and thus were included in the analysis of iClicker data.

Kahoot! data were analyzed as follows: Each individual student's scores on Kahoot! questions were summed and their percent possible Kahoot! score was then calculated by dividing the total number of points earned by the total possible number of points (1000 times the number of questions they responded to) and multiplying by 100. To eliminate potential biases of students who only answered a small fraction of the 48 Kahoot! questions, students had to attend and answer Kahoot! questions for at least 4 of the 7 days of class that included Kahoot! questions. Additionally, students had to provide their Kahoot! name via an end of course survey (described above). Of the 255 students in these classes, 107 students (42%) met this condition and thus were included in the analysis of Kahoot! data.

Once iClicker percent correct and Kahoot! percent possible score were calculated for each student. Multiple linear regression models were constructed to determine possible correlations between these parameters and exam performance in the course. The models included average exam score (as a percentage out of 100) for the four written course exams as the response variable, and iClicker percent correct or Kahoot! percent possible score and college GPA to control for student aptitude. The models were developed using the statistical program R, version 3.1.2 (Team 2014).

Results

Student performance on iClicker questions

Student performance on iClicker questions was compared to their exam performance to determine if there was a relationship between them. As shown in Figure 1, there was a positive correlation between performance on iClicker questions and average lecture exam scores ($p < 0.001$). To control for student aptitude as a potentially confounding factor, a multiple linear regression model was built that incorporated college GPA as a variable. Even when controlling for GPA, there was a significant positive correlation ($p < 0.001$) between iClicker performance and exam performance (Table 1). In terms of the model output, on average, when controlling for college GPA, for every one percent increase in iClicker performance there was a corresponding 0.36 percent increase in exam average.

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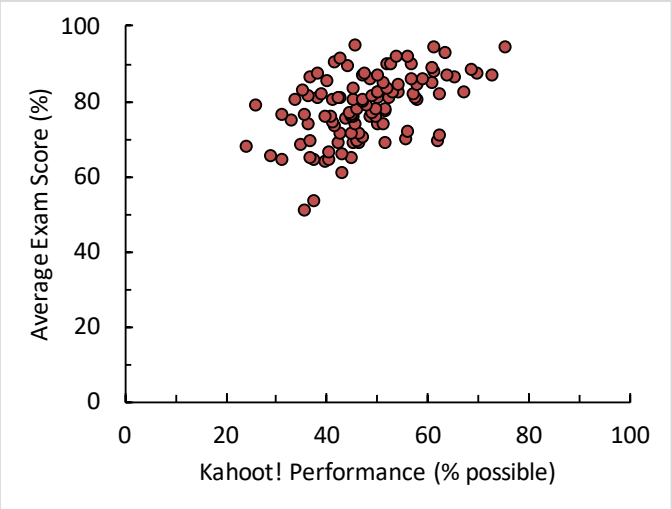

Figure 1. *Summary of iClicker performance and average exam performance (n = 211). There was a significant positive correlation (p < 0.001) between iClicker performance and exam performance when controlling for GPA (see Table 1).*

Table 1. *Multiple linear regression model summary for average exam performance as a function of iClicker performance. There were significant positive correlations between average exam score (as a percentage out of 100) and iClicker performance. College GPA was included as a control variable for student aptitude. Values for the estimates are provided as the mean +/- the standard error.*

Regression coefficient	Estimate ± SEM	*p* value
Model intercept	16.98 ± 4.35	0.0001
iClicker score	0.36 ± 0.05	6.3e-12
GPA	11.98 ± 1.34	< 2e-16
Adjusted R^2	0.4572	

Student performance on Kahoot! questions

Student performance on Kahoot! questions was compared to their exam performance to determine if there was a relationship between them. As shown in Figure 2, there was a positive correlation between performance on Kahoot! questions and average lecture exam scores. To control for student aptitude as a potentially confounding factor, a multiple linear regression model was built that incorporated college GPA as a variable. Even when controlling for GPA, there was a significant positive correlation ($p < 0.001$) between Kahoot! performance and exam performance (Table 2). In terms of the model output, on average, when controlling for college GPA, for every one percent increase in Kahoot! performance there was a corresponding 0.32 percent increase in exam average. It is worth noting here that the Kahoot! scores included both correctness and speed of answering the question, as opposed to the iClicker performance which only included correctness and was independent of how long it took to answer the question.

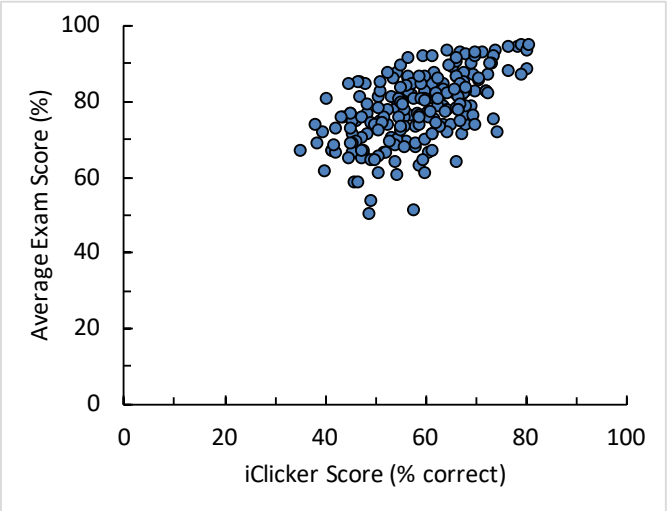

Figure 2. *Summary of Kahoot! performance and average exam performance (n = 107). There was a significant positive correlation (p < 0.001) between Kahoot! performance and exam performance when controlling for GPA (see Table 2).*

Table 2. *Multiple linear regression model summary for average exam performance as a function of Kahoot! performance. There were significant positive correlations between average exam score (as a percentage out of 100) and Kahoot! performance. College GPA was included as a control variable for student aptitude. Values for the estimates are provided as the mean +/- the standard error.*

Regression coefficient	Estimate ± SEM	*p* value
Model intercept	21.31 ± 6.36	0.001
Kahoot! score	0.32 ± 0.06	3.7e-6
GPA	12.52 ± 1.91	2.18e-9
Adjusted R2	0.4488	

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Student perception of iClicker and Kahoot! questions

An end-of-course survey was given to determine how students perceived using iClickers and Kahoot! in an undergraduate human anatomy course. When asked about what students thought about using iClickers and Kahoot! in class, somewhat surprisingly, >80% of students reported that iClickers and Kahoot! were both fun and effective for learning (Figure 3A). However, when asked about how often we should use iClickers and Kahoot! in class, >95% of students reported that iClickers should be used every day, whereas ~70% of students reported that Kahoot! should only be used once a week, and a small fraction (~15%) thought it should only be used monthly (Figure 3B).

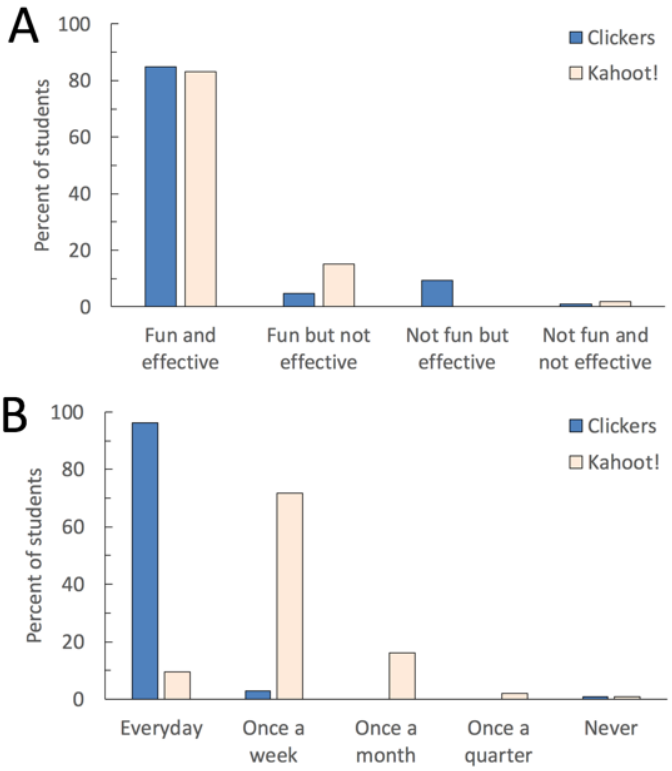

Figure 3. *Summary of student perceptions of iClicker and Kahoot!. Students (n = 106) responded favorably to both systems (A), but reported different recommended frequencies of use for each system (B).*

Discussion

In this study we compared the effectiveness of two types of student response systems (SRSs) in a single undergraduate human anatomy course. We found that student performance on both a traditional system, iClickers, and a gamified system, Kahoot!, were nearly equally predictive of exam scores. Additionally, both systems were rated as equally "fun and effective" by students, but students reported that Kahoot! should be used more sparingly than iClickers. These results have important implications for the implementation of different types of SRSs in undergraduate courses.

We found a significant positive correlation between student performance on iClicker questions with exam performance in an undergraduate human anatomy course. These results agree with prior studies that reported positive relationships between the use of traditional SRSs and exam performance in anatomy and physiology courses (Carpenter and Boh 2008; Alexander et al. 2009). Additionally, we found that students had favorable views towards the use of iClickers, with the vast majority rating them as "fun and effective," which also agrees with past studies that demonstrated favorable student views towards traditional SRSs in anatomy and physiology courses (Stein et al. 2006; Carpenter and Boh 2008; Wait et al. 2009). This research therefore supports prior findings and future use of SRSs should be considered when designing and teaching anatomy and physiology courses as there are clear benefits to using these systems.

We also found a significant positive correlation between student performance on Kahoot! questions with exam performance that was nearly identical to that between iClicker performance and exam performance. This was at first somewhat surprising, as the Kahoot! questions are scored based not only on correctness but also on how fast the question was answered. Initially we thought that due to the "speed" element of the Kahoot! Questions, the relationship between performance on Kahoot! questions and exam scores would be less strong than that between exam performance and iClicker performance, which is only based on correctness. However, our results suggest that Kahoot! has a positive educational impact since performance on Kahoot! was significantly correlated with exam performance. Thus Kahoot! can be used as a predictive formative assessment tool in the classroom and not just as a "game" that is used to change the pace of flow of a class session. Since the development and adoption of Kahoot! has been relatively recent (the beta version was released to the public in September 2013 (Kahoot! 2018)), there has been limited assessment of this form of gamified SRS and thus limited results to compare with ours. One study has shown similar results. Iwamoto et al. (2017) found that undergraduate psychology students who participated in Kahoot! earned higher exam scores than those who did not participate. While our study and this other study provide support for the positive educational impact of using Kahoot!, additional research is warranted to determine the broader impacts of Kahoot! in undergraduate anatomy and physiology courses.

Since Kahoot! is a gamified form of an SRS, there is the possibility of a "burn out" or "wear out" effect. The concept of "wear out" derives from the advertising industry where frequent exposure to advertisements may result in the loss of effectiveness leading to potential consumers becoming

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uninterested in the product (Pechmann and Stewart 1988). With regards to Kahoot!, "wear out" may occur if it is played too often and thus students lose interest and are not as enthusiastic about Kahoot! as they were initially. Indeed, in this study, while we did not measure longitudinal engagement with Kahoot!, we did anecdotally notice that students were not as motivated to play Kahoot! near the end of the course after it had been used multiple times. This result was echoed by Wang (2015) who found that overall student motivation and engagement declined through repeated usage of Kahoot!, most noticeably related to classroom dynamics in terms of how students interacted with each other while playing Kahoot!. This result and ours suggest that careful consideration must be taken when implementing Kahoot! into a course or curriculum so as to not induce "wear out" from high usage rates.

Given our experience of using Kahoot! in an undergraduate human anatomy course, and that Kahoot! is a relatively new type of student response system, we would like to offer the following suggestions for instructors interested in adopting it in their courses. First, because Kahoot! is intended to be used as a "game" with short time limits (ranging from 5 to 60 seconds) we recommend using Kahoot! for lower-level Bloom's questions such as identification or brief descriptions of structure and/or function. In our experience the shorter the time limit the better (we recommend 10 seconds and no more than 20 seconds per question) since it allows students to very quickly answer questions, thus earning points for correctness and speed. Lower level Bloom's questions are preferred due to the shortness of the suggested time period. There is also a text character limit for the question stem and answer options, so lengthy stems and options are not allowed by the system.

Second, as described above, there really does seem to be a "wear out" effect of using Kahoot! in a course. While early Kahoot! sessions were received extremely positively by our students, by the end of the course there was noticeably less enthusiasm every time we played (which was only a total of 7 sessions in a 10 week course). Due to this, we recommend playing Kahoot! sparingly, ideally every two to three weeks and at most once a week. In addition, Kahoot! sessions should likely use a limited number of questions (perhaps less than 10) as longer sessions may also lead to "wear out." If you do play Kahoot! more frequently, we suggest that you use it "randomly" and not on a set schedule (e.g. the start of every Friday class) as this will become routine and it may lose its novelty and effectiveness.

Third, Kahoot! requires students to use their own devices to play (tablet, laptop, or phone) and not all students may have a device. In this case, you can set up the Kahoot! session to allow for teams, or students may simply join in with their classmates to answer questions together using a single device. Lastly, even though Kahoot! is intended be used as a game, it does have educational value as described by the results in our study. Due to this fact, make sure to let your students know that not only is Kahoot! fun but that it also is likely predictive of their exam scores, so the better they do on Kahoot! the better they may perform on exams.

Limitations of the Study

While we demonstrated that student performance on iClicker and Kahoot! questions were equally predictive of exam performance based on multiple linear regression models, we cannot say for certain whether one response system is more valuable than the other in terms of learning or predictive ability for course grades. The reason for this is that different questions were used for each response system and thus we cannot directly compare the performance or predictive capabilities of iClickers and Kahoot! in this study. If direct comparisons are warranted, then identical questions should be used with two different groups of students to determine if there is indeed an advantage or difference between using iClickers versus Kahoot!.

Our survey results showed that students thought that iClickers and Kahoot! were equally "fun an effective". However they reported that iClickers should be used more frequently (on a daily basis) than Kahoot! (on a weekly to monthly basis). This result may be biased because these were the actual frequencies in which iClickers and Kahoot! were used in the course of this study, so students may have been influenced based on their experience. For a potentially unbiased view, students could be asked about frequency of use at the start of the course before they were exposed to the usage of both systems in the course.

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