The Effect of Digitizing and Gamifying Quizzing in Classrooms

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Abstract: The use of game-based learning in the classroom has become more common in recent years. Many game-based learning tools and platforms are based on a quiz concept where the students can score points if they can choose the correct answer among multiple answers. The article describes an experiment where the game-based student response system Kahoot! was compared to a traditional non-gamified student response system, as well as the usage of paper forms for formative assessment. The goal of the experiment was to investigate whether gamified formative assessments improve the students' engagement, motivation, enjoyment, concentration, and learning. In the experiment, the three different formative assessment tools/methods were used to review and summarize the same topic in three parallel lectures in an IT introductory course. The *first* method was to have the students complete a paper quiz, and then review the results afterwards using hand raising. The *second* method was to use the non-gamified student response system Clicker where the students gave their response to a quiz through polling. The *third* method was to use the game-based student response system Kahoot!. All three lectures were taught in the exact same way, teaching the same syllabus and using the same teacher. The only difference was the method use to summarize the lecture. A total of 384 students participated in the experiment, where 127 subjects did the paper quiz, 175 used the non-gamified student response system, and 82 students using the gamified approach. The gender distribution was 48% female students and 52% male students. Pre- and a post-test were used to assess the learning outcome of the lectures, and a questionnaire was used to get data on the students' engagement and motivation. The results show significant improvement in motivation, engagement, enjoyment, and concentration for the gamified approach, but we did not find significant learning improvement.

Keywords: Game-based learning, Student response system, Student engagement, Evaluation, Formative assessment, Kahoot!

1. Introduction

Prototypes of student response systems (SRSs) have been around since the sixties (Judson 2002), and these systems started to be used in biology and chemistry teaching in the early seventies (Bessler and Nisbet 1971, Casanova 1971). The first generation of SRSs was based on special hardware that allowed the students to give their answers using clickers, key-pads, handsets or zappers (Caldwell 2007). A major disadvantage with this first generation of systems was that they required investment in hardware devices and infrastructure as well as administration and maintenance of the hardware and software. The Bring Your Own Device wave has opened up for a new generation of SRSs, where students can use their own devices to respond. After the introduction of smart phones and tablets, easy access to wireless network access and support for HTML5, many new SRSs and similar tools have populated the market: for example Socrative (Coca and Slisko 2013), Quizlet (Gruenstein, McGraw et al. 2009), Poll Everywhere (Sellar 2011), iClicker (Lucas 2009), and Learning Catalytics (Schell, Lukoff et al. 2013). The use of HTML5 web-technology makes it possible to use these systems without installing any applications, and opens up for a range of new ways of interacting in the classroom. Kahoot! is a game-based SRS (GSRS) that was introduced to the public in the fall 2013. The main difference between a GSRS and a SRS is that the game-based version focuses more on engaging and motivating the students through attractive graphical user-interfaces and audio, as well by gamifying the whole student response experience. The gamification is done by temporarily transforming the classroom into a game show as shown on TV, where the teacher plays the role of a game show host and the students are the competitors. Well-designed video games are said to be learning machines (Gee 2003), and they have the potential to get the players so motivated and engaged that they are not aware that learning is actually happening. In K-12 , games have been found to be beneficial for academic achievement, motivation and classroom dynamics (Rosas, Nussbaum et al. 2003). Games have also been found to have a similar effect in higher education (Sharples 2000). Previous research indicates that games can be made an integrated part of traditional classroom lectures to improve learning, motivation and engagement (Carver Jr, Howard et al. 1999, Carnevale 2005, Wang, Øfsdal et al. 2007, Wang, Øfsdal et al. 2008, Wu, Wang et al. 2011).

This article presents an experiment where the GSRS Kahoot! was compared to a SRS, as well as to the usage of paper forms for formative assessment. Section 2 presents material and methods including related work, a description of the formative assessment tools used in the experiment, the data sources used, the research context and participants of the experiment, the experiment procedures, and the data analysis. Section 3 presents the results from the experiment. Section 4 concludes the article.

2. Related Work

There have been many experiments and studies conducted on SRSs, and a literature study from 2007 reports that such systems have been found to have a positive effect on student exam-performance, and that they create a more positive and active atmosphere in classrooms (Caldwell 2007). More specifically, students using SRSs were twice as likely to work on a problem presented during class (Cutts, Kennedy et al. 2004), student attendance rose to 80-90% (Burnstein and Lederman 2001), and about 88% of the students either "frequently" or "always" enjoyed using the SRS in class (Caldwell 2007) Further, Caldwell's survey summarized some common uses of clicker questions found in the literature: to increase or manage interaction, to assess student preparation and ensure accountability, to find out more about students, for formative assessment, for quizzes or tests, to do practice problems, to guide thinking review or teach, to conduct experiments, to make lectures fun, to differentiate instruction, and to prompt discussion. Another study summarizes similar findings of benefits of SRSs in the three areas Classroom environment, Learning, and Assessment (Kay and LeSage 2009). SRSs were found to improve attendance, provide more focused students, provide anonymous student participation, improved student engagement, increase learning performance, improved teaching, and generally improve interaction between teacher and students. The benefits listed in these surveys are all benefits we have experienced from using game-based SRS in classrooms as well.

There are several studies on the effects of educational games related to learning outcome and increased motivation, and we will present some of these studies here. One study explored the impact of using a game named Supercharged! on pre-service teachers' understanding of electromagnetic concepts compared to students who conducted a more traditional inquiry oriented investigation of the same concept (Anderson and Barnett 2011). The effectiveness was investigated through an experiment that used both qualitative and quantitative data that included pre- and post-scores, student notebooks, video recordings of laboratory activities and observations. The results of this study showed that the group using the video games outperformed the group that did not use the video game in terms of learning outcomes (statistically significant). In another study, the video game relative asteroids was used to teach physics (Carr and Bossomaier 2011). A pre- and post-test with 8 questions was used to measure the learning outcome. The results showed improvement of the test scores for new learners. The students also found that learning physics through a game was motivating and engaging, and it was effective at improving their comprehension of physics. In a chemistry class, an experiment was conducted to compare students' achievement and attitude from traditional vs. game-based teaching methods (Tüysüz 2009). The statistically significant conclusion of the study was that game-based learning increased the students' achievement in chemistry compared to traditional learning methods. The study also showed that game-based learning increased the students' interest in the course: they enjoyed the course more, and were more focused and engaged on the subject being taught. Similar results on improved learning outcome were also found for using a web-based adventure game to teach neuroscience (Miller, Schweingruber et al. 2002), in an experiment comparing teaching computer memory knowledge with a game vs. a non-game application (Papastergiou 2009), and for using a mobile game to engage students in arithmetic practices (Liao, Chen et al. 2011). In the computer memory study, the students that used a game found this learning approach significantly more appealing and educational fruitful than the students with the non-game application (Papastergiou 2009). The same students also found their learning approach more engaging, more effective, more active and relaxed compared to the students that used the non-game approach. There are also studies that show that introducing games into the classroom not always produce positive results and can result in complaining students and lack of motivation (Squire 2005).

Kahoot! represents a new generation of student-response systems that has a main focus on student motivation and engagement through gamification. The tool is a result of the research project Lecture Quiz that started in 2006 (Wang, Øfsdal et al. 2007), where results from experimentation of early prototypes showed positive results in terms of increased engagement, motivation and perceived learning (Wang, Øfsdal et al. 2008, Wu, Wang et al. 2011). Educational games compared to mainstream entertainment games are known to suffer from running on very few platforms (usually Windows PCs), too simplistic, being single player and offline, offering low production value, and are typically more targeted towards parents, teachers and formal learning curriculum than being fun for the students (Kirriemuir and McFarlane 2004). This is especially true when educational games try to copy existing game concepts and add some learning on top of it. Kahoot! was not designed to copy any existing game, but rather to find a game concept that could fit a classroom setting and that could be alignment with Tom Malone's theory of intrinsically motivating instructions (Malone 1980). Malone's theory lists three categories that make things fun to learn: *Challenge* (goals with uncertain outcomes), *Fantasy* (captivate through intrinsic or extrinsic fantasy), and *Curiosity* (sensor curiosity through graphics and audio, and cognitive curiosity). As the game should be used in the classroom, it was also important to incorporate a social game play. The result was to develop a game concept where the *fantasy* is that the classroom temporarily is changed to a game show where the teacher is the game host and the students are the competitors. The *challenge* is to answer questions and compete against other players, and the *curiosity* is provided through inspiring graphics and audio, as well as solving a cognitive puzzle. The lack of variety in game play is compensated by the competitive nature of playing against a whole class of students. Reports from happy teachers and students all over the world give an indication that the concept works as intended. Learning games are commonly used to review facts using multiple-choice questions similar to what is done in Kahoot!. However, such games can also be used to teach skills, judgment, behaviors, theories, reasoning, process, procedures, creativity, language, systems, observation, and communication using various approaches (Prensky 2005).

3. Material and Method

This section presents the three assessment tools used, the data sources, the research context and participants, research procedures, and the method for data analysis.

3.1 Research Questions and Research Approach

The research goal of the experiment presented in this article was to investigate how digitizing and gamifying quizzing in the classroom affects the students' motivation, enjoyment, engagement, concentration and learning. Specifically, this experiment investigates the impact of choice between running a quiz using pen & paper, using a student response system (SRS) and using a game-based SRS affects the students' perception of the quiz. The research method used is based on the Goal, Question Metrics (GQM) approach (Basili 1992) where we first define a research goal (conceptual level), then define a set of research questions (operational level), and finally describe a set of metrics to answer the defined research questions (quantitative level).

3.1.1 Research Goal and Research Questions

The research goal of this study was defined as the following using the GQL template:

The purpose of this study was to *evaluate the effect of choice of quiz tool* for *review taught material* from the point of view of a *student* in the *context of a lecture*.

The following research questions (RQs) were defined by decomposing the research goal:

- RQ1: How does the choice of quiz tool affect the students' motivation?
- RQ2: How does the choice of quiz tool affect the students' enjoyment?
- RQ3: How does the choice of quiz tool affect the students' engagement?
- RQ4: How does the choice of quiz tool affect the students' concentration?
- RQ5: How does the choice of quiz tool affect the students' learning outcome?

3.2 Three Methods for Running Quizzes in a Classroom

In the experiment presented, three different approaches were used to run a quiz as a part of a lecture. The quiz was used to review what being taught in the lecture and consisted of 12 multiple-choice questions. The quiz methods used were paper forms, a simple student response system named Clicker, and a game-based student response system named Kahoot!. Figure 1 shows pictures from the three lectures of students doing the quiz (left: paper quiz, middle: Clicker, right: Kahoot!). The three quiz methods will now be described more in detail.

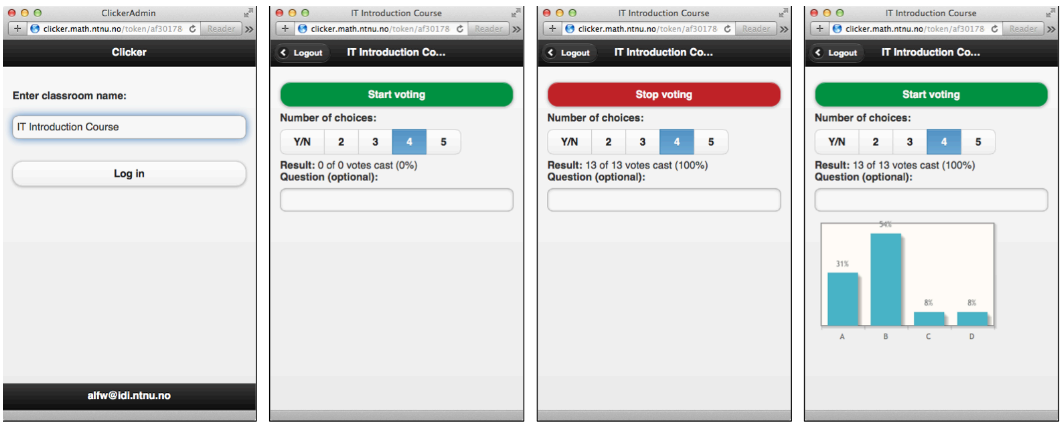
Figure 1 Pictures from lectures using three different quiz methods

3.2.1 Paper Form and Hand Raising

The paper quiz is an analogue, well-known and proven approach for running quizzes in a classroom. Before a lecture, the teacher prepares paper forms with multiple-choice questions where students can tick of one of two to four answers using a pen or a pencil. During the lecture, the teacher hands out the paper forms, and the students answers as well as they can. The normal procedure for such quizzes is that the teacher then collects the paper forms, and the students get feedback in the following lecture on how they have performed. In our experiment, we changed the review part to be more compatible with the digital counter-parts. After the students had completed their forms, the teacher reviewed their answers by going through the questions asking students to raise their arms for the alternative they had answered. In this way, the teacher got to know how the students had answered and gave him the chance to give feedback to the class. The paper forms used consisted of a quiz of twelve questions, all with four alternative answers.

3.2.2 The Clicker Student Response System

Clicker is a simple student response system (SRS) allowing students to give their responses to questions being asked using a web-browser on any digital device. The questions and answers are typically shown using another tool like Keynote, Prezi or PowerPoint, and Clicker is used to collect "votes" from the students. Figure 2 shows an overview of the Clicker SRS and the steps needed to get responses from students. First, the teacher needs to name a classroom which will be the ID used for students to connect (Figure 2a). Second, the teacher chooses how the students can response to a question (Figure 2b). Third, the teacher has to show the questions and answers on the screen using PowerPoint or similar tool as well as he starts the voting process (Figure 2c). In this step, the teacher can monitor how many students that have given their answers. Forth, the teacher stops the voting, and a distribution of how the students have voted is shown (Figure 2d). The distribution of answers is also shown on the student client. The Clicker SRS does not directly give the teacher or students any feedback on correctness of answers. It is up to the teacher to comment on correctness of the students' responses based on the given distribution of votes.



a) Enter classroom b) Choose choices c) Collect votes d) View results

Figure 2 Overview of the Clicker Student Response System

3.2.3 The Kahoot! Game-based Student Response System

Kahoot! is a game-based student response system (GSRS) launched by the teacher in a web-browser on a laptop connected to a large screen. Unlike the Clicker SRS, Kahoot! provides a tool for creating quizzes including adding pictures and YouTube videos to the questions. Kahoot! also makes it possible to publish and share your own quizzes, and edit quizzes made by others. Another difference is the way Kahoot! is played. Students will log into the system using a gamepin (a number) and a nickname. The goal for the students is to answer the correct answer as fast as possible to get as many points as possible. Figure 3 shows how Kahoot! is played. A question is shown on the large screen along with four or less alternatives in different colors with associated graphical symbols. The students give their answers by choosing the color and symbol she or he believes corresponds to the correct answer.

Figure 3 Playing Kahoot!

Between every question, a distribution of how the students answered is shown before a scoreboard of the five best players. The students get individual feedback on their questions in terms of correctness, the number of points, the ranking, how far the student is behind the student ranked above, and the correct answer if wrong answer is given. At the end of a Kahoot! session, the winner's nickname and points will be shown on the large screen. During the quiz, Kahoot! uses a playful graphical user interface as well as music and sounds to give it a playful and competitive atmosphere similar to a game show on TV. The students are also asked to give feedback on the quiz they have played through giving scores on whether the quiz was fun, educational, can be recommended to others, and how you generally feel about the quiz. Finally, Kahoot! provides the functionality for the teacher to download the results from the quiz in an Excel spreadsheet.

3.3 Data Sources

The instruments for collecting data in our experiment included a domain knowledge test and a questionnaire on students' engagement and motivation. The domain knowledge test consisted of seven multiple-choice questions developed by a domain expert, and this questionnaire was used both as a pre-test and a post-test to measure the knowledge before and after the lecture.

The motivation questionnaire was developed to measure the motivation and the engagement of the students. The questionnaire was adapted from the course motivation survey (CMS) (Kebritchi, Hirumi et al. 2010) to our research context, and integrated with relevant questions in the Motivated Strategies for Learning Questionnaire (MSQL) (Pintrich 1991) and (Lepper, Corpus et al. 2005). The questionnaire used a five-point Likert scale from strongly disagree to strongly agree.

3.4 Research Context and Participants

The experiment was performed in the IT introductory course (TDT4105) at Norwegian University of Science and Technology (NTNU). There were two reasons for choosing this particular course for doing the experiment. *First*, the IT introductory course is a large course with many students, meaning that it would be possible to collect data from many subjects. *Second*, due to the size of this course, the same lecture has to be taught in three parallels. This means that the same teacher will teach exactly the same lecture for three parallels of students. The IT introductory course is a mandatory course for all first year students at the university, giving that the groups of students in the experiment should be fairly uniform. The experiment was conducted over three days at the end of September 2013, and the topic of the lecture was on basic computer knowledge. 384 students participated in the experiment where the distribution of the subjects that completed the questionnaires was 127 subjects for paper quiz (58% female vs. 42% male), 175 subjects for clicker quiz (37% male vs. 63% male), and 82 subjects for Kahoot! (54% female vs. 46% male).

3.5 Procedures

The lecture in the experiment was conducted according to Figure 4. First, the teacher introduced the lecture by presenting the agenda and the current topic, before the students carried out a paper pre-test on the lecture's topic. Second, the teacher taught the topic basic computing using Power-point slides. Third, a quiz on the topic was carried out in three variations for the three parallels (Paper, Clicker, and Kahoot!). Forth, at the end of the lecture, the students had to fill in a motivation questionnaire as well as doing the paper post-test (same as the pre-test).

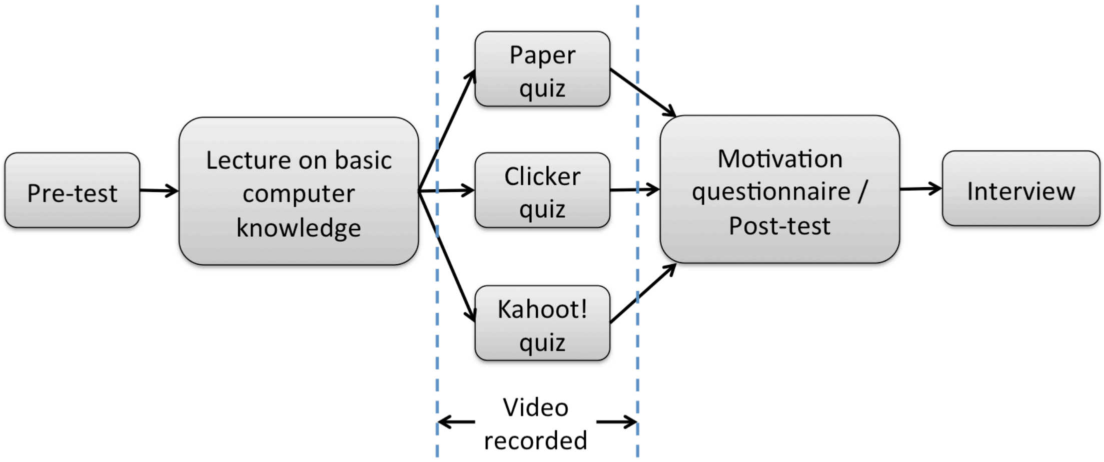


Figure 4 Experiment Procedures

3.6 Data Analysis

The answers from the pre- and post-tests were evaluated to a score from 0 to 7 points, where each correct answer contributed one point to the total score. The learning outcome was computed by comparing the difference between the post- and the pre-test scores. The Mann-Whitney test was used to compare the difference in the learning outcomes from the different quiz methods (Paper, Clicker and Kahoot!). The Mann-Whitney test is a nonparametric test for the significance of the difference between the distributions of two independent samples of difference sizes.

The Kruskal-Wallis test was run on the data from the motivation questionnaire to investigate the differences between the responses from the three groups Paper, Clicker, and Kahoot!. The Kruskal-Wallis test is a nonparametric test for the significance of the differences among the distributions of in our case three independent samples that had difference sizes.

4. Results

This section presents the results from the controlled experiment. In the analysis we looked at differences in students' motivation, enjoyment, engagement, and concentration in regards to the used quiz method. This section also reports on differences in the learning outcome.

4.1 RQ1: Effect on Motivation

Table 1 shows the descriptive statistics and the results from the Kruskal-Wallis test for statements related to *motivation*. The results show that there is a statistically significant difference in the students' motivation for doing the quiz (statement 1). There was not much difference between the Paper and the Clicker quiz where half of the students had internal motivation for doing the quiz. For Kahoot! almost four out of five students had an internal motivation, and only 5% did the quiz only because the teacher told them to. However, there was no significant difference related to the motivation of the lecture as a whole (statement 2), nor the motivation for learning more about the topic (statement 3). There is a tendency that the students were more motivated for a lecture using game-based quizzes (statement 2), but not statistically significant.

Table 1 Results on Motivation

Statement	Group	Disagree	Neutral	Agree	H	P
1. I did the quiz only because the teacher told me to	Paper	50%	25%	25%	14.2	**0.0008**
	Clicker	56%	29%	15%		
	Kahoot!	**77%**	**18%**	**5%**		
2. I do not think this lecture was worth my time and effort	Paper	56%	29%	15%	2.79	0.2478
	Clicker	51%	32%	17%		
	Kahoot!	63%	24%	12%		
3. I enjoyed the quiz so much that I want to know more about the topic	Paper	37%	43%	20%	1.4	0.4966
	Clicker	34%	39%	27%		
	Kahoot!	35%	49%	16%		

4.2 RQ2: Effect on Enjoyment

Table 2 shows the descriptive statistics and the results from the Kruskal-Wallis test for statements related to *enjoyment*. The table shows that there is a statistically significant difference regarding the engagement of the quiz itself (statement 5) where the game-based approach was clearly perceived as more engaging compared to the paper quiz and the Clicker student response system. No statistically significant differences were found related to completing the quiz (statements 4 and 6), although there is a tendency that the game-based approach to a larger degree gave students a satisfaction on completion compared to the two other approaches.

Table 2 Results on Enjoyment

Statement	Group	Disagree	Neutral	Agree	H	P
4. To complete the quiz gave me satisfaction	Paper	35%	33%	32%	3.1	0.2122
	Clicker	28%	41%	31%		
	Kahoot!	22%	38%	40%		
5. The quiz was boring and not engaging	Paper	60%	34%	6%	9.59	**0.0083**
	Clicker	63%	26%	10%		
	Kahoot!	**84%**	**12%**	4%		
6. It gave me satisfaction to complete the quiz in a satisfactory way	Paper	18%	41%	41%	1.65	0.4382
	Clicker	16%	40%	44%		
	Kahoot!	15%	34%	51%		

4.3 RQ3: Effect on Engagement

Table 3 shows the descriptive statistics and the results from the Kruskal-Wallis test for statements related to *engagement*. The table shows that there was a statistically significant difference in how the students perceived the engagement of the quiz for both statements. For Kahoot! over half of the students expressed that the most satisfactory in the lecture was to do well on the quiz. There was even a larger difference for the statement on whether the quiz cause increase pulse where about half of the students doing the game-based quiz claimed to have increased pulse, compared to around 10% for the other two approaches.

Table 3 Results on Engagement

Statement	Group	Disagree	Neutral	Agree	H	P
7. To do well on the quiz was the most satisfactory in the lecture	Paper	38%	40%	22%	15.91	**0.0004**
	Clicker	35%	37%	27%		
	Kahoot!	**22%**	**26%**	**52%**		
8. I felt increased pulse when I answered questions in the quiz	Paper	65%	22%	13%	31.78	**<0.0001**
	Clicker	66%	26%	8%		
	Kahoot!	**34%**	20%	**46%**		

4.4 RQ4: Effect on Concentration

Table 4 shows the descriptive statistics and the results from the Kruskal-Wallis test for statements related to *concentration*. The table shows that the statistically significant difference for students doing a game-based quiz to a large degree wished to do better on the quiz than their fellow students (statement 11). Almost 70% of the students doing the Kahoot! quiz had a higher wish to do well on the quiz, compared to around 40% for the two other approaches. On the statement directly related to concentration on doing the quiz, there is a tendency that students doing the Clicker quiz concentrated more than students doing the paper quiz, and the students doing the Kahoot! quiz concentrated more than the students doing the Clicker quiz. Interestingly on the question regarding working independently (statement 10), there is a tendency that the students using the student response systems to a larger degree wanted to work on their own compared to those doing the paper quiz.

Table 4 Results on Concentration

Statement	Group	Disagree	Neutral	Agree	H	P
9. I concentrated on the quiz to get correct answer	Paper	8%	31%	61%	4.59	0.1008
	Clicker	7%	22%	71%		
	Kahoot!	6%	16%	78%		
10. I wanted to answer quiz without help from others	Paper	20%	20%	60%	5.19	0.0746
	Clicker	10%	17%	73%		
	Kahoot!	9%	20%	72%		
11. I wished to do better on the quiz than most other students in the class	Paper	24%	39%	38%	20.66	**<0.0001**
	Clicker	16%	41%	43%		
	Kahoot!	**4%**	**28%**	**68%**		

4.5 RQ5: Learning Outcome

We were able only to compare the learning outcome from the two parallel lectures where Paper and Kahoot! were used as the results from the post-test in the Clicker quiz lecture were incomplete due to lack of time at the end of the lecture.

Results from the Mann-Whiney test along with the descriptive statistics are shown in Table 6. The Min, Max, Mean and Median shows improvement from pre-test to post-test in number correct answers in the test. There is a tendency for a higher mean value for the lecture with Kahoot! quiz compared to the lecture with the Paper quiz, but the difference is not statistically significant.

Table 5 Learning Outcome from Paper Quiz vs. Kahoot! quiz

Treatment	N	Min	Max	Mean	Median	U_A	Z	P
Paper	127	0	7	3.669	4	5655.5	-1.05	0.1469
Kahoot!	82	1	6	3.817	4			

5. Conclusion

In this article, we have presented an experiment to investigate how the usage of quizzes in review-lectures affects motivation (RQ1), enjoyment (RQ2), engagement (RQ3), motivation (RQ4), and the learning outcome (RQ5). Our experiment revealed that students using a game-based student response system compared to paper forms and a simple non-game-based student response system were more engaged, motivated and concentrated, and enjoyed it more. The statistically significant differences were only related to activity of doing the quiz itself, and not the lecture in general. Regarding the learning outcome, the results from the experiment did not show any statistically significant differences between the quiz methods (only paper and Kahoot! was tested). In future studies, we will investigate more thoroughly whether the learning outcome varies by the method or by the quiz-tool used for a longer period of time.

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