Evaluation of Interactive and Gamified Approaches for Teaching ICT Theory – A Study of PowerPoint, Sembly, and Kahoot!

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Abstract: This paper presents the experiences and results from an evaluation of using interactive and gamified approaches for teaching theory lectures in an ICT introductory course at the Norwegian University of Science and Technology. The course consists of two main parts: One part is an introduction to procedural programming, and the other part is a theoretical introduction to hardware, digital representation, network, and algorithms. The theory part is taught in one 45-minute lecture per week throughout the semester. Over the years, a significant challenge has been to keep the students' engagement, attention, and motivation high. In fall 2017, the five teachers in this course experimented with three different approaches for giving theory lectures to their respective groups of students. The first approach was traditional *PowerPoint* presentations and encouraging students to ask questions and interact verbally. The second approach was to use the classroom interaction-tool *Sembly*, where the teacher first gave a short introduction to the topic, the students then participated in a short warm-up quiz, and then they were asked to compose questions on their own using *Sembly* followed by a vote on which questions were the most important. Finally, the lecturer went through the slides for the lecture with the emphasis on answering the highest rated student questions. The third approach was to play a *Blind kahoot* (gamified approach), where the students played through several questions related to the topic using *Kahoot!* without any background knowledge, and the teacher provided explanations between the questions. The evaluation is based on data from observations in class, a survey where 469 students responded, a course evaluation with 363 respondents, and feedback on the *Blind kahoot*. The results indicate that most of the students prefer the gamified approach and that there was no difference in terms of gender. This study focuses on students' perception and not on the learning outcome of the three approaches.

Keywords: Game-based learning, Interactive learning, Improving classroom teaching, Evaluation, Student perceptions, Kahoot!

1. Introduction

Teaching theoretical topics in large university classes is a challenge, and the use of traditional teaching approaches, such as slides and blackboard, do not always work well. One of the main challenges in this setting is to provide enough interaction in the classroom and avoid the learning experience to be unidirectional (passive). For smaller classes, it is easier for the students to engage in conversations with the teacher through questions, but such interaction does not scale well for larger classes. The average human attention span is no more than 20 minutes, and a suggested approach to restart the attention clock is to use classroom interaction systems such as a student response system (SRS) (Caldwell, 2007). The use of SRSs has been found to have a positive effect on student performance on exams and to create a more positive and active atmosphere in classrooms (Caldwell, 2007). Studies show that use of SRSs can make students twice as likely to work on a problem presented during class (Cutts et al., 2004), increase the attendance by 80-90% (Burnstein and Lederman, 2001), and result in more engaged and motivated students (Kay and LeSage, 2009). Another challenge many lecturers face is to cover all the material in a course in the limited amount of lecture time provided. In some cases, this might result in rushing through too many slides in one lecture and not leave much time for students to interact. Another problem is to provide enough variation to keep the lecture interesting. Results from research in organizational learning show that variation itself can improve the learning rate significantly (Schilling et al., 2003). The use of interactive classroom tools is one way to provide such variation in lectures, to improve the learning experience.

Student motivation is essential for learning, and research shows that there is a strong relationship between student motivation and learning outcome (Christophel, 1990). This relationship makes it crucial to keep students motivated and engaged in what they are learning and to enable a learning environment that stimulates the students. The most common approach for increasing motivation in the classroom is to provide ways for the students to engage and interact. If the students are engaged with the learning material, their motivation will be stimulated. It is easier to keep students engaged and motivated in smaller classrooms, as

the teacher can directly interact with individual students vocally and by using eye contact. In larger classrooms, this is not possible – and thus, the use of interactive classroom tools such as mobile-based assessment tools is a potential solution (Nikou and Economides, 2018). This study investigates the students' perceptions of using three different teaching approaches for teaching theoretical topics in large classrooms. The differences between these teaching approaches concerned the degree they supported student interaction and whether they provided a game-like experience. Our study does not investigate the learning outcome, but rather the students' learning experiences, which is related to their motivation.

In addition to investigating the effect of using interactive classroom tools, this study also focuses on game-based learning. The motivation for game-based learning is to increase the students' motivation through making the learning process immersive and fun (Prensky and Prensky, 2007). Several quasi-experiments comparing traditional teaching to gamified approaches have been published. These studies show that the gamified approaches resulted in:

- significantly improved learning, motivation and classroom dynamics (Rosas et al., 2003);
- higher attendance and higher final grades in programming (Fotaris et al., 2015);
- higher motivation and concentration of math students (Stoyanova et al., 2016);
- enhanced vocabulary acquisition (Filologiczna, 2016);
- positive influence on performance, perception, and preferences in English (Hung, 2017);
- significant positive impact on exam scores (Iwamoto et al., 2017, Sarkar et al., 2017); and
- increased motivation and interest in lessons (Bicen and Kocakoyun, 2018).

There are also similar studies investigating the effect of using different tools in the same settings. One such study compares using a paper quiz, *Clicker* SRS, and *Kahoot!* to review high-lights in lectures and provide interaction (Wang et al., 2016). The results of this study showed that the game-based approach significantly improves motivation, engagement, enjoyment, and concentration, but no significant improvement for learning was found. In a quasi-experiment in Thailand, the effect on concentration, enjoyment, perceived learning, motivation, and satisfaction from using three tools Google Forms, *Quizizz,* and *Kahoot! was evaluated* (Chaiyo and Nokham, 2017). The results from this study showed that the students learned from all three tools, but there were found significant differences in concentration, engagement, enjoyment, motivation and satisfaction: Kahoot! performed better than Quizizz, and Quizizz better than Google forms. A quasi-experiment from a bioengineering course in the USA compared the effect of using *SurveyMonkey* and *Kahoot!* in the classroom (Tan and Saucerman, 2017). It was found that both tools encouraged collaboration and made the students more likely to complete problems and to achieve correct answers compared to not using the tools.

Further, Kahoot! was found to have a significantly higher impact on motivation, enjoyment, and encouragement to collaborate than Survey Monkey. A quasi-experiment from Turkey compared how student engagement and academic achievement were affected by using oral questioning and answers (control group), Quizizz, and Kahoot! (Göksün and Gürsoy, 2019). The results showed that Kahoot! had a more positive but not significant impact on academic achievement and students' engagement compared to the two other groups. Quizzes was found to have a less positive impact than the control group and Kahoot!, and this was explained that Quizizz provides limited visual feedback and that questions progressed at an individual pace.

There are also several studies that compare how using traditional teaching vs. Kahoot! affects students' attitude and academic achievement, where most of them show significant improvement for the game-based approach (Iwamoto et al., 2017, Hung, 2017, Esteves et al., 2017, Wichadee and Pattanapichet, 2018, Kinder and Kurz, 2018, Bawa, 2018).

The paper is organized as follows: Section 2 presents the research questions and the background for this study, Section 3 presents the results, and Section 4 concludes the paper.

2. Material and Method

This section presents the research questions, the research approach, and the three teaching approaches tested.

2.1 Research Questions and Research Approach

The goal of this study was to investigate the effect of three different approaches to teach ICT theory in an ICT introductory course. A motivation for this goal is to find if are approaches work better than others for teaching

theoretical topics in large classes in higher education. Further, the motivation was to investigate if game-based learning had a positive impact on students' motivation and engagement. The research method used is based on the Goal, Question Metrics (GQM) approach (Basili, 1992) where the research goal is first defined (conceptual level), then a set of related research questions are defined (operational level), and finally a set of metrics to answer the defined research questions are described (quantitative level). The research goal of the study was defined according to the GQL template (Basili, 1992) as:

The purpose of this study is to *investigate students' preferred teaching approach* for *teaching theoretical concepts* from the point of view of a *student* in the context of *large introductory ICT lectures at a university*.

Specifically, we wanted to investigate which of the following teaching approaches the students preferred: Studying alone, a *PowerPoint* presentation (traditional approach), an interactive lecture using the classroom interaction tool *Sembly*, or the game-based approach using a *Blind kahoot*. This study does not investigate the learning outcome of the teaching approaches. The null hypothesis was that the teaching approaches using *PowerPoint*, *Sembly,* and *Kahoot!* would be equally preferred among the students while studying on their own would be the least attractive. Based on the research goal, the following research questions were defined:

- RQ1: Which teaching approach is preferred by the students?
- RQ2: Are there any gender differences in the preferences for the teaching approach?
- RQ3: What is the feedback from students on the various teaching approaches?
- RQ4: Does the game-based teaching approach improve engagement over the other teaching approaches?

To give answers to the research questions above, a combination of data sources was used:

- Observations: Observations from lectures as well as a video recording of the lecture using *Sembly*.
- Survey: Survey at the end of the semester asking about preferred teaching approach and gender.
- Course evaluation: Course evaluation at the end of the semester with both closed- and open-ended questions, including "What has been good?"; "What has not been good?"; and "What should be improved?".
- *Kahoot!* feedback: Data from the built-in feedback system in *Kahoot!* on learning, enjoyment, recommendation, and feeling.

2.2 Three Approaches for Teaching ICT Theory

The ICT introductory course is given to all first-year students with programs where ICT and programming are relevant. More than 2000 students take this course every year, which means that the course must be split into five lectures series. The course consists of two main parts where 2/3 of the lectures focus on teaching procedural programming and 1/3 on a theoretical introduction to hardware, binary representation, networks, and algorithms. The programming part of the course is taught through 2x45 minute lectures and 2x45 minute exercise lectures, and the theory is taught through one 45-minute lecture per week. The textbook for the theoretical part of this course is tailored to this course and combines book chapters from three textbooks (Snyder et al., 2016).

2.2.1 Using Slides and Questions

The default teaching approach for theory lectures has been to use *PowerPoint* slides based on the provided textbook. Between 23 and 40 slides are used for one 45-minute lecture, and the slides combine text, figures, and illustrations. The slides have been designed to contain enough text to be readable as a textbook summary. In the lectures using slides, the teacher spends most of the time going through the slides, uses the blackboard occasionally, and encourages the students to ask questions. Very few students ask questions in lectures hall with up to 500 students. A challenge for these lectures has been to be able to go through the whole syllabus in the provided time, which can sometimes result in rushing through the slides with little interaction. Another challenge is that for many of the students, there are a lot of new words they do not know – which makes it hard for the teacher to explain, and for the students to understand.

2.2.2 Using Sembly and Student Interaction

Sembly is a classroom interaction-tool for getting questions and feedback from students in real-time. *Sembly* also provides polling that can be used to run quizzes. When using *Sembly*, the teacher will access the system

through a web-browser shown on a projector, while the students can access the student client through a web-browser on their own devices. The log in process in *Sembly* involves institutional login, choosing a classroom, and choosing a nickname. Table 1 gives an overview of the interactive lecture where *Sembly* was used.

Table 1: Overview of Interactive *Sembly* Lecture

Time	Content
5 min	Introduction/motivation and short quiz in *Sembly*
10 min	Students in pairs submitting questions using *Sembly*
5 min	Lecturer going through highest voted questions
25 min	Teaching using slides with emphasis on topics with most votes

The theory lecture using *Sembly* started with a short motivation and an introduction to the *Sembly* system. The students were told that the motivation for introducing Sembly was to make the lecture more interactive and that active students learn more. This lecture was the third of four lectures on Computer Network. After the students were logged in to the system, they were asked to participate in a short two-question quiz on theory from the previous lecture. The distribution of answers was displayed on the projected screen, and the lecturer discussed the answers, commented on how the students had answered, and revealed the correct answers.

In the following part of the lecture, the students were asked to download the slides for the current lecture, and in pairs come up with at least three good questions with answers from the lecture's topic. The *Sembly* tool was used to collect these questions, and students could vote on which generated questions they liked the most. The lecturer then went through the questions with most votes and discussed the various answer alternatives and the correct answer.

The rest of the lecture was used to go through the slides for the lecture with an emphasis on the parts that have received most votes on the *Sembly* tool. Students were also encouraged and asked to interact vocally.

2.2.3 Blind kahoot and Game-based Learning

Kahoot! is a game-based student response system to motivate students through the fantasy of being in a game show where the teacher is the game show host, and the students are the contenders (Wang, 2015). The engagement of students is based on the use of audio, music, points, and scoreboards (Wang and Lieberoth, 2016). The most common use of *Kahoot!* is for formative assessment and review. Blind kahooting is a teaching method where *Kahoot!* is used to teach topics not known to the students (Castle, 2015). The approach is in a way similar to using slides for teaching, but the main difference is that a *Blind kahoot* stimulates the students' curiosity by first asking questions before learning more about the topic.

A *Blind kahoot* was used to teach a theory lecture on Algorithms. A kahoot was made consisting of 20 questions related to the topic being taught, with a variation in the number of answers and correct answers, as shown in Table 2. Most questions had one out of four correct answers (25% winning chance), but there were also questions with a higher chance of winning. For Blind kahoots, it is crucial to have at least one question where all the students can answer correctly and several questions with higher winning chances.

Table 2: Summary of type of questions in the *Blind Kahoot* quiz

Type of question	Winning chance	Number of questions
One correct – out of four	25%	12
Two correct – out of four	50%	3
One correct – out of two	50%	3
Three correct – out of four	75%	1
Four correct – out of four	100%	1
Total		**20**

In the lecture, the students were immediately asked to join the kahoot, and it was played through the whole lecture (45 minutes). The students had between 20 and 30 seconds to answer the question in *Kahoot!* and on average and about 2 minutes were spent between each question to talk about the question and explain the correct answers. Some questions were mainly fact-based and required little time for explanation, while other

questions were more complicated and required a more in-depth explanation and use of the blackboard. The lecturer also spent more time on the questions where most students answered incorrectly. Data from the lecture showed that the correctness percentage for the kahoot (quiz) was 67%.

3. Results and Discussion

This section presents the results from the survey, from the course evaluation, from the feedback on the *Blind kahoot*, and observations made during the lectures.

3.1 Results from the Survey on Preferred Teaching Method

Table 3 shows the results from the survey on preferred teaching approach with 469 respondents, where 41% were female students vs. 59% male. The collected information shows that the majority (64%) of the students preferred using *Blind kahoot* as a teaching approach, 24% preferred *PowerPoint*, 11% preferred *Sembly* and 2% preferred studying the theory on their own (reading). No significant gender differences were found.

Table 3: Results from the preferred teaching approach

Teaching approach	Female students		Male Students		Total	
	Count	Percent	Count	Percent	Count	Percent
PowerPoint	45	24%	60	22%	105	22%
Sembly	20	11%	38	14%	58	12%
Blind kahoot	121	64%	174	62%	295	63%
Self-study	4	2%	7	3%	11	2%
Total	190	41%	279	59%	469	100%

A one-way Chi-square test was used to test the statistical significance related to the choice of the teaching method. From previous years, the course evaluations have shown that about 6% of the students prefer to study the theory on their own. As we did not know about the students' preferences for *PowerPoint*, *Sembly* or *Blind kahoot*, we assumed an equal distribution for these three approaches (giving the expected proportion for these would be 31.33% ((100%-6%)/3). Table 4 shows the results of the one-way Chi-square test (P <.0001, significant). The results showed that about 61% less than expected preferred *Sembly* and self-study, 29% less than expected preferred *PowerPoint*, and 100% more than expected preferred *Blind kahoot*.

Table 4: Results from the One-way Chi-square test

Category	Observed Frequency	Expected Frequency	Expected Proportion	Percentage Deviation	Standardized Residuals
PowerPoint	105	147	0.31343283582	-28.57%	-3.46
Sembly	58	147	0.31343283582	-60.54%	-7.34
Blind kahoot	295	147	0.31343283582	+100.68%	+12.21
Self-study	11	28	0.05970149253	-60.71%	-3.21

Observed Frequencies:	469	Expected Frequencies:	469	Expected Proportions:	1.0

Chi-square =	225.21	Df =	3	P =	<.0001

3.2 Course Evaluation Feedback

The course evaluation questionnaire consisted of closed- and open-ended questions. Table 5 shows the responses to the close-ended questions related to the theory lectures (the question on programming lectures is included for comparison).

The collected data presented in Table 5 shows that 64.4% of the respondents attended all or most of theory lectures and that 30.2% of the respondents attended half or fewer. Further, only 23.9% of the students stated that the theory lectures were good. The results also reveal that the students perceived that the quality of programming lecture to be much better (54.2% good). Note also that the majority of the students spent 15 minutes or less preparing for the lectures in this course per week.

Table 5: **Course evaluation quantitate data related to theory lectures**

Question	All	Most	Half	Few	None
How frequently did you attend theory lectures?	35.3%	29.1%	10.7%	19.5%	5.4%
Question	**Good**	**Neutral**	**Bad**	**Did not attend**	
How was the quality of the theory lectures?	23.9%	47.0%	22.5%	6.5%	
Question	**Good**	**Neutral**	**Bad**	**Did not attend**	
How was the quality of the programming lectures?	54.2%	25.5%	12.3%	8.8%	
Question	**60 min**	**45 min**	**30 min**	**15 min**	**0 min**
Amount of time preparing for lectures per week	8.5%	4.2%	16.0%	25.4%	45.9%

Table 6 shows a count of the responses related to theory lectures made in the open-ended questions in the course evaluation (programming lectures included for comparison). The table shows that 8% of the positive comments were related to the theory lectures vs. 31% for the programming lectures). Most of these comments were general comments that the students enjoyed these lectures, including "Great theory lectures" and "Most of the theory lectures were great in teaching a topic in a structured way." *Kahoot!* was mentioned in 9% of the positive comments, while 3% specifically mentioned the use of the *Blind kahoot* in the theory lecture with comments such as "Great using *Kahoot!* in the theory lecture, with explanations between the questions." There were no positive comments related to *Sembly* nor *PowerPoint*.

Table 6: Summary of Responses from Open-questions of the Course Evaluation

Statement	Prog. lectures	Theory lectures	Kahoot!	Blind kahoot	Sembly	Power-Point	Total
What's been good?	57 (31%)	14 (8%)	17 (9%)	5 (3%)	0 (0%)	0 (0%)	181 (100%)
What's not been good?	17 (9%)	78 (42%)	1 (1%)	1 (1%)	3 (2%)	12 (6%)	185 (100%)
What should be improved?	16 (11%)	57 (39%)	5 (3%)	2 (1%)	0 (0%)	4 (3%)	148 (100%)

Regarding negative comments ("What has not been good?"), 42% of them mentioned the theory lectures in contrast to only 9% for the programming lectures. Most negative comments relate to trying to cover too much material in 45 minutes, and the lectures were boring and non-interactive with comments such as "Heavy and non-dynamics lectures." One negative comment was related to the *Blind kahoot*: "The theory lecture with only *Kahoot!* made it hard to make notes." Three negative comments (2%) were made related to the use of *Sembly* such as "I was not a fan of the lecture where we should make questions, and answer those questions afterward." Comments on what has not been good also came with suggestions for improving the theory lectures such as "The theory lectures could have been more interactive." There were also 12 negative comments related to *PowerPoint* and slides. These comments were mainly related to the content and design on the slides, as well as how the slides were used during lectures.

On the last open question, "What should be improved?", 39% mentioned the theory lectures compared to 11% for programming lectures. Most of these comments were the same as for the comments on "What has been good?" such as little interaction, and lectures trying to cover too much material. The primary suggestions for improvements were to reduce the syllabus for the theory, add more theory lectures, and make the lectures more interactive and exciting. Other comments related to what should be improved included "Use more videos in theory lectures" and "Find new interactive methods for teaching theory (such as *Kahoot!* or similar), as it often gets tiresome to listen at the lecture for a long time without pauses for reflection."

3.3 Discussion

The feedback from the course evaluation survey showed that one problem with the theory lectures is the lack of interaction. As the syllabus on ICT theory in this course is lengthy, it is tempting to cram as many slides as possible in a lecture without opening interaction. The main problem with this approach is that the students do not learn much when disengaged. Studies have shown that the human attention span is no more than 20 minutes, and then the lecturer needs to restart the attention clock, e.g., by using an SRS (Caldwell, 2007). Opening for student interaction through asking questions, solving problems, or tool-based interaction (such as polling tools or game-based tools) can be used for this purpose. The results of this study show that the introduction of interaction does not ensure good results, as the *Sembly* approach performed worse than only using *PowerPoint*. Our results showed that the preferred approach (by 64% of the students) was to use *Blind kahoot* for this kind of teaching. Table 7 refers to how students rated the *Blind kahoot*, where 93% said the

Blind kahoot was fun, 97% said they learned something, 97% would recommend it to others, and 87% felt favorable to this experience.

Table 7: Results from feedback on the *Blind kahoot* quiz

Statement	Score	Statement	Score	Statement	Score
How fun was it?	93%	Did you learn something?	97%	Do you recommend it?	97%
Feel positive?	87%	Feel neutral?	6%	Feel negative?	7%

Observations of the three different teaching approaches give a more nuanced picture. Lectures using slides can be successful in keeping the students' attention, but require some variation such as using the blackboard, or questions from students to restart the attention clock. Observations from the *Sembly* lecture showed that the students were highly engaged in the beginning when the *Sembly* tool was used, but the engagement level fell in the last part of the lecture when slides were used. Observations from the *Blind kahoot* showed that this game-based approached managed to engage the students throughout the whole lectures by having them answer questions, get a score, and check who is on the top-five scoreboard. The main advantage of this approach is that the students will interact with the topic being taught every 2-3 minute. For the teacher, it was beneficial to get an assessment of the students' knowledge before talking more about the topic. The cheerful atmosphere also made it easier for the students to ask questions in the large lecture hall. The main challenges of this teaching approach were to keep the students quiet and calm between the questions as they became excited and chatty about their scores and scoreboard, the students could not make notes during the lecture, and that they did not have slides to look at after the lecture.

4. Conclusion

This paper has presented an evaluating of three approaches for teaching theory lectures in ICT to answer four research questions. The results are based on a survey of preferred teaching approach of 469 respondents, a course evaluation survey of 363 respondents, observations, and feedback from a *Kahoot!* quiz.

The *first research question* investigated which teaching approach was preferred by the students (RQ1). The results showed that about two-thirds of the students (64%) preferred the game-based teaching approach (*Blind kahoot*) over using slides (24%), interaction using *Sembly* (11%), and studying on their own (2%). One possible explanation for this is that the *Blind kahoot* enables students to be interactive and curious during the whole lecture. The results do not consider anything about the learning outcome from the three approaches, which should be covered in another study.

The *second research question* was related to gender differences in the preferred choice of teaching approach (RQ2). The results showed no significant gender differences.

The *third research question* focused on feedback from the students on the various teaching approaches (RQ3). The data from the course evaluation showed that the majority of students were indifferent or not pleased with the theory lectures in general, but there were also positive comments. On specific teaching approaches, there were a few positive comments related to *Kahoot!* and the theory lecture using *Blind kahoot*, but the other teaching methods were not mentioned. *Kahoot!* was also mentioned in the negative comments as it made it hard to make notes, as well there were negative comments related to the use of *Sembly* and *PowerPoint*. One take away from the comments was that many students encouraged more interactivity and activity in the theory lectures to make them more engaging.

The *fourth and last research* question asked if the game-based teaching approach improves engagement over the other teaching approaches (RQ4), and for this particular study, this is the case. However, as the results from the more interactive lecture using *Sembly* showed: The way tools and teaching approaches are used might be just as important as the tool and teaching approach, as shown in a study where the way the teaching tools were integrated in the lecture had more significant effect on the students than the tools themselves (Wang et al., 2014). Another factor that has not been accounted for in this study is the teachers' ability to utilize the tools and to teach in general.

Future work should include systematic experiments exploring the students' perceptions and learning outcome of various teaching approaches that also investigate how the tools are integrated into the teaching.

Acknowledgment

Thanks to Institute for Software Research at University of California, Irvine for hosting a research visitor and providing a stimulating research environment, Fulbright for the research scholar program for financial support, and Department of Computer Science at the Norwegian University of Science and Technology (NTNU) for moral and financial support for a research visit in California where the work on this article took place.

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