Comparison of Classroom Participation Technology Uses in Higher Education

Chaya Hiruncharoenvate
Department of New Media, Faculty of Informatics
Mahasarakham University
Maha Sarakham, Thailand
chaya.h@msu.ac.th

***Abstract*—Classroom participation is one simple activity that can promote students in active learning process. Research has shown that students who participate in class tend to have better learning outcomes. However, regardless of the encouragement from teachers, students rarely participate in class. Several technologies have been developed to promote participation. Web services such as Kahoot and Plickers allow student to answer multiple-choices questions in class without the need for specialized equipment. This paper presents a study that investigated the effectiveness of Kahoot and Plickers, compared to traditional classroom participation methods, in promoting learning outcomes in higher education classrooms. The results show that Plickers performed the worst and there were no differences in learning outcomes between students using Kahoot and traditional methods. The implication of this work is that teachers need to understand their classroom environment and choose the technology to use in class accordingly in order to achieve its potential.**

Keywords—classroom technology; classroom participation; classroom participation technology; kahoot; plickers; higher education

I. Introduction

Educators and education researchers have promoted active learning as a teaching style for students of all levels, especially students of higher education, because numerous research has shown that active learning promotes students' learning process, increases students' attention, and improves students' attitude towards the class [1]. However, the active learning is only loosely defined as "any instructional method that engages students in the learning process," and instructors have documented several activities that are considered as active learning activities [2]. Traditional classroom participation methods such as engaging students in a verbal question-answer session and class polling is the simplest examples of active learning activities.

In university classrooms with hundreds of students, polling students for answers or verbally asking questions to individual students do not fit with the classroom environment because of the imbalance between instructor-student ratio. Technologies such as "clickers" have been developed so that students can electronically participate in class using specialized equipment, and instructors can easily and instantly retrieve all students' responses and their summary. However, using this kind of technology creates a barrier for students who cannot afford to buy the special equipment needed. As a result, new technologies such as Kahoot and Plickers have been developed so that students can electronically participate without the needs of expensive specialized equipment.

In this work, we are interested to investigate the effects of using the classroom participation technology on learning outcomes in the context of higher education—university classrooms. We conducted an experimental study with students enrolled in an Introduction to Computer System and Programming course at the Faculty of Informatics, Mahasarakham University, Thailand. All participants were students majoring in the field related to Information Technology. The experiment was conducted in two phases; Phase 1 was conducted in a lecture hall to compare traditional classroom participation methods with Kahoot and Plickers, and in order to eliminate the inequality of internet-connected devices ownership, Phase 2 was conducted in a computer laboratory, to compare traditional classroom participation methods with Kahoot. The results of the study showed that the increases in test scores, a proxy for learning outcomes, among students using Plickers were significantly lower than those of the other two methods. On the other hand, the learning outcomes of students using traditional classroom participation methods did not differ significantly from those of students using Kahoot. Nevertheless, from classroom observations, the novelty of classroom participation technologies promoted excitement and interests in participating in classroom activities.

The major implication for instructors, especially ones at the higher education level, is that the instructors need to understand the nature of their classrooms and their students in order to choose appropriate technologies to use in class. The outcomes of classroom technology used in different context may result differently because of different classroom environments.

Next, we introduce related work that shapes this paper. Then, we explain the methods used in the study following by the results of the study. The discussions and implications of the results follow. Finally, we explain the limitations of this work and how this work can be extended in future work.

II. Related Work

Research has shown that classroom participation stimulates students' process of thinking, analyzing, and synthesizing the topics learned during class, and allows students to achieve a deeper understanding of materials taught [3]. Previous work has also shown that students who engaged in classroom participation understand the class materials better than students who didn't [4], [5]. Therefore, instructors should encourage classroom participation, especially among university students. Students will not only truly understand the class materials through classroom participation, but students will also understand the importance of the class materials and how to adapt them to use in their professions.

Nevertheless, most students still avoid classroom participation, even though instructors have used several tricks and myriad of activities such as awarding points for participation, calling out individual student to answer questions, and planning class activity where students can exchange their opinions [6]. Hence, the decision to avoid classroom participation reduces the opportunity that students can fully learn in class.

There are many technologies that have been developed to specifically for classroom participation. For example, an audience response system, "Clickers," is being used in classroom at numerous universities [7]. However, students have to buy special equipment for a single purpose of classroom participation, adding another barrier to participation. Recently, there are web services that perform similarly to Clickers without asking students to purchase additional equipment. In this work, we specifically look at Kahoot[1] and Plickers[2].

Kahoot and Plickers allow students to participate in class using their own or instructors' devices. Kahoot allows students to engage in an in-class quiz by asking teachers to create a set of multiple-choice questions on the teacher portal beforehand. Then, teachers can log back into the system to activate the "Play" feature, and Kahoot will provide the teachers with a unique code to broadcast to students. Students then log in to the Kahoot system (via website, mobile web, or mobile application) with this unique code. One by one, the question along with its answer choices are presented on the teacher's screen, in which the teacher can project to the classroom projector or read them out to students. Students will only see choice options (e.g. A, B, C, and D) on their screens, and they can select the answer from their screens. At the end of each question, the teacher's screen presents the number of students selecting each choice option along with the correct answer. Teachers can opt to create a game out of this by assigning points to students based on correct answers and the promptness of the answers. After the game ends (all the questions are answered), Kahoot will display cumulative scores along with the leaderboard.

Plickers is similar to Kahoot in a way that teachers can create a set of multiple-choice questions on the system beforehand. Additionally, teachers can create questions on-the-fly in class. The difference with Plickers is that teachers need to print out special 2D codes (similar to QR codes) from Plickers website and distribute to students beforehand. Then, during the participation session, teachers can present the questions on their own teaching materials or reading them out loud. Students answer the questions by raising the distributed codes, with the orientation of the codes according to the answer choice they choose. Teachers then use the Plickers mobile application to scan the students' codes. The number of students answering each choice option and the number of correct answers are presented on the mobile application.

In this work, we are comparing the effects of using these two classroom participation technologies on students' learning outcome. The hypotheses of this research are as follow:

H1: The learning outcomes of students who use different classroom participation technologies, namely Kahoot and Plickers, will not be significantly different.

H2: Students using classroom participation technology will have better learning outcomes than students who participate using the traditional methods.

III. Methods

To measure the effectiveness of classroom participation technologies, we conducted an experiment in classrooms using the between-group design. The classroom participation technology used in the experiments were Kahoot and Plickers.

The experiment was conducted with students enrolled in Introduction to Computer System and Programming course at Mahasarakham University in Thailand. The experiment was conducted in two phases.

In the first phase, students were assigned to one of the three experimental groups: Control, Kahoot, and Plickers, based on the class section in which they were registered. The instructors and the researcher discussed and set one week in the semester (different class sections meet on different days of the week) when this phase of the experiment would be conducted. Then, the experimental groups were randomly assigned to class sections. Students who attended the class that week were enrolled in the experiment. The instructors created a set of 10 multiple-choice questions to use during the classroom participation session. Students in the control group engaged in the traditional classroom participation activities such as oral question answering, in-class polling (showing of hands.) Students in the Kahoot group used Kahoot to answer the questions. Students in the Plickers group used the printed codes to answer the questions.

This phase of the experiment was conducted in a 120-seat lecture-style classroom with the instructors gave lecture on problem solving using pseudocodes and flowcharts. At the beginning of the class, the instructor started the lesson with a pre-test of 10 questions, a different set of questions from the one used during the classroom participation session. Then, the instructor gave a 2-hour lecture on the topic. At approximately one hour into the lesson, the instructor engaged students in a participation activity using the classroom participation set of questions. At the end of the lesson, students were again given the post-test using the same set of questions as the pre-test. The

[1] https://kahoot.com/

[2] https://www.plickers.com

difference in the pre-test and post-test scores is used as a proxy for a student's learning outcome.

To control for the difference in students' previous knowledge, the pre-test scores were used to categorize students' into three groups: low, medium, high. Then, the distribution of students based on the previous knowledge group were compared among different experimental groups using Chi-square test. Pre-tests and post-tests scores were analyzed using Student's t-test, Student's paired t-test, ANOVA, and Cohen's D to show whether there were any statistically significant effects of the classroom participation technology and the effect sizes. In addition to quantitative data, the researcher also collected qualitative data on classroom environments by observing the class and took notes on three aspects: student participation, classroom dynamic, and ease of use of technology during the class participation sessions.

From the observation of Phase 1 of the experiment, using Kahoot in a lecture hall became a barrier for students without internet-connected devices. Therefore, the second round of experiment was conducted (Phase 2) with the same group of students in a 50-seat computer laboratory, where each student was seated in front of a computer. In addition, the preliminary analysis showed that Plickers was not an effective technology to use in this context (details in Results section.) Thus, we only selected the traditional class participation activity (Control) and Kahoot for comparison in the second phase of the experiment.

Phase 2 of the experiment was conducted with the same procedures as the first one, with conditional statement in ActionScript 3.0 as the topic of the lesson. The data collected in Phase 2 was analyzed using the same statistical methods as did in Phase 1. The researcher also observed the class and took notes the same way as in Phase 1.

IV. RESULTS

A. *Phase 1*

1) *Score Analysis*

The first phase of the experiment enrolled 150 students: 50 students in Control, 57 students in Kahoot, and 43 students in Plickers. TABLE I. shows the descriptive statistics of the pre-test and post-test scores of the participants along with the paired t-test of the scores and the effect sizes (Cohen's D) of the differences. To control for the differences in previous knowledge of students in each group, students' pre-test scores were used to categorized students into three groups based on their previous knowledge of the lesson: Low (score $\leq$ 4), Medium (score = 5), and High (score $\geq$ 6). TABLE II. shows the distribution of students' previous knowledge in each experimental group. The distributions of students with low, medium, and high existing knowledge in all three experimental groups: Control, Kahoot, and Plickers, are not significantly different from each other (χ^2=2.2775, df=4, p=0.68). Additionally, using One-way ANOVA, the pre-test scores of students in all experimental groups are not significantly different from each other (F=0.149, df=2, p=0.862).

TABLE I. DESCRIPTIVE STATISTICS OF PRE-TEST AND POST-TEST SCORES IN THE FIRST PHASE OF THE EXPERIMENT

Group	***n***	**Pre-test Score**		**Post-test Score**		**Paired t-test**	**Cohen's D**
		$\bar{x}$	***SD***	$\bar{x}$	***SD***	***t (df = n-1)***	
All	150	4.55	1.9	6.73	1.67	12.335****	1.0071 (large)
Control	50	4.44	1.95	6.9	1.56	7.9191****	1.1199 (large)
Kahoot	57	4.58	2.02	7.02	1.52	10.504****	1.3913 (large)
Plickers	43	4.65	1.72	6.16	1.86	3.9631***	0.6044 (medium)
* p < 0.05, ** p < 0.01, *** p < 0.001, **** p < 0.0001							

TABLE II. DISTRIBUTION OF STUDENTS' PREVIOUS KNOWLEDGE IN THE FIRST PHASE

Group	**n**	**Number of Students**		
		Low	***Medium***	***High***
Control	50	25	11	14
Kahoot	57	29	7	21
Plickers	43	20	8	15

The conclusion from TABLE I. is that students altogether performed significantly better in the post-test than in the pre-test. Furthermore, each group individually perform significantly better in the post-test. However, looking at the effect sizes, the increases in scores of students in the Plickers group are smaller than the Control and Kahoot group.

To see whether students' existing knowledge and classroom participation technology have interaction with each other, we performed a two-way interaction ANOVA to investigate the main effects and the interaction. The analysis showed that the interaction had no statistical significance on the increase of test scores (p=0.52).

Using three One-way ANOVA with adjusted α=0.05/3=0.017 to compare the effect of using different classroom participation technology on the increases in test scores among each group of students based on their previous knowledge, increases in test scores of students with low and medium previous knowledge were not significantly affected by the classroom participation technology (low: F=0.9938, df=2, p=0.38; medium: F=0.1829, df=2, p=0.83). However, students with high previous knowledge reacted differently with different classroom participation technology, specifically the increases in test scores of students with high previous knowledge in different experimental groups were significantly different from each other (F=5.2927, df=2, p=0.008). Pairwise t-tests showed that the increases in test scores of students in Plickers group were significantly different than those of Control and Kahoot group (p=0.035 and p=0.002 respectively), but students in Control and Kahoot do not have score increases significantly different from each other (p=0.43).

2) *Classroom Observation*

The researcher observed the classroom in all groups to record the classroom environment during the class participation session. During the participation of the Control group, students sparsely answered the questions when asked verbally. As a result, this left a "dead air" in the classroom, and the instructor decided to switch to polling method by asking students to raise their hands according to the choice of answer they thought was correct. When the polling method was used, approximately half of the class participated at first. However, once the instructor verbally encouraged participation, nearly all students participated in class polling.

In the Kahoot group, the researcher noticed many students did not have internet-connected devices (cell phones or laptops with internet connection) with them. Furthermore, those that used cell phones had to spend up to 5 minutes connecting to the university's Wi-Fi network, creating a barrier for students in the Kahoot group to participate in the classroom and disrupting the classroom dynamic. Nevertheless, once students with cell phones (approximately 90% of the class) could connect to Kahoot system, the students were excited and were in a competitive spirit to reach the top of the leaderboard. The instructor reported that Kahoot was easy to use and required little effort from the instructor during the classroom participation session.

In the Plickers group, students participated during the classroom participation session more promptly, compared to the Control group. The instructor did not have to encourage students in order for them to participate. However, the process of scanning the codes took approximately one to two minute for every question. Thus, the waiting time to scan the codes disrupted the dynamic of the participation session. In terms of the ease of use, the instructor reported that Plickers required more effort than Kahoot because of the addition of code scanning process.

Upon reflecting on the results of Phase 1 of the experiment, the instructor and the researcher agreed on conducting Phase 2 of the experiment in a computer laboratory where individual student would have access to a computer with internet connection. Furthermore, the instructor and the researcher agreed that Plickers did not fit well with the classroom environment, the style of teaching and the students in higher education because the difficulty of scanning the codes disrupted the class dynamic. Therefore, Plickers was removed from the second phase of the experiment

B. *Phase 2*

1) *Score Analysis*

There were 119 students participating in the second phase of the experiment, divided into 56 students in the Control group and 63 students in the Kahoot group. TABLE III. shows the descriptive statistics of the pre-test and post-test scores along with paired t-tests and Cohen's D effect sizes.

Similar to the first phase, students were categorized into three groups based on their previous knowledge of conditional statement in ActionScript 3.0. Students in the Low group had pre-test scores ≤ 1; Medium group had pre-test scores $= 2$; High group had pre-test scores ≥ 3. Note that the scores were different from the first phase. The distributions of students' previous knowledge in both groups, as shown in TABLE IV. , were not significantly different from each other (χ^2=0.6859, df=2, p=0.71). Moreover, both groups' pre-test scores are not significantly different from each other (t=0.6793, df=115.02, p=0.50)

TABLE III. DESCRIPTIVE STATISTICS OF PRE-TEST AND POST-TEST SCORES IN THE SECOND PHASE OF THE EXPERIMENT

Group	***n***	**Pre-test Score**		**Post-test Score**		**Paired t-test**	**Cohen's D**
		$\bar{x}$	***SD***	$\bar{x}$	***SD***	***t (df = n-1)***	
All	119	1.71	1.22	4.39	1.74	14.644****	1.3424 (large)
Control	56	1.79	1.06	4.16	1.77	8.7077****	1.1636 (large)
Kahoot	63	1.63	1.36	4.6	1.70	12.129****	1.5281 (large)
* p < 0.05, ** p < 0.01, *** p < 0.001, **** p < 0.0001							

TABLE IV. DISTRIBUTION OF STUDENTS' PREVIOUS KNOWLEDGE IN THE SECOND PHASE

Group	**n**	**Number of Students**		
		Low	***Medium***	***High***
Control	56	26	18	12
Kahoot	63	34	17	12

Two-way ANOVA was performed to investigate the effect of the interaction between experimental group and students' previous knowledge. Along the same line with the results of Phase 1, there were no significant effect of this interaction (p=0.64). Furthermore, when separating the analysis to focus on each group of students based on their previous knowledge, the use of Kahoot did not have a significant effect on the increases of test scores in all groups (low: t=0.496, df=53.642, p=0.62; medium: t=1.72, df=32.874, p=0.094; high: t=0.557, df=21.992, p=0.58).

2) *Classroom Observation*

In this second phase of the experiment, the classroom environment in the Control group is similar to the one observed during Phase 1. Students were unenthusiastic with the class participation; the instructor had to verbally encourage students to participate. At the end, the instructor resorted to polling as a way to engage students in classroom participation.

On the other hand, students in the Kahoot group were noticeably more excited with the class participation than the Control group. Now that every student was provided with a computer with internet access, everyone was able to participate through Kahoot without struggle. The competitiveness of Kahoot promote students' attentiveness during the participation session.

V. DISCUSSIONS

In this work, an experiment was conducted the compare the effectiveness of classroom participation technologies, namely Kahoot and Plickers, in promoting the learning outcomes of Thai university students enrolled in the Introduction to Programming course. The experiment was conducted in two phases, with each phase situated in different classroom environment. Phase 1 was conducted in a lecture-style classroom. As a result, the lack of internet-connected personal devices among some students created a barrier in participating in class in the Kahoot group. Therefore, Phase 2 of the experiment was conducted in a computer laboratory to provide students with equal access to internet-connected devices.

Throughout the experiment, students in all groups improved their test scores significantly after the lesson. This comes as no surprise, however, as students were given the same questions in the pre-tests and post-tests. Nevertheless, in both phases of the experiments, the increases in scores among students who used Kahoot to participate in the classroom participation session were higher in effect sizes than the increases in scores of students in other experimental groups as shown in TABLE I. and TABLE III. On the other hand, Phase 1 of the experiment showed that students using Plickers as a tool for classroom participation performed worse than students using traditional classroom participation methods and Kahoot, as the effect size of the Plickers group was of the medium size while the effect sizes of the other two groups were of the large sizes.

Moreover, the observation of the classroom environment revealed that Plickers was not a suitable classroom participation technology to use in our context. Despite the novelty of Plickers as a classroom participation technology, its use disrupted the classroom dynamic during the participation session as the time took scanning the code left a "dead air" in the classroom. The results of the analysis and the classroom observation during Phase 1 led us to conclude that Plickers was not appropriate for use in a large classroom and in classrooms in higher education level. Therefore, the results of Phase 1 of the experiment invalidated H1. Consequently, *the learning outcomes of students who used different classroom participation technologies, namely Kahoot and Plickers, were different from each other*.

Comparing the use of Kahoot with traditional classroom participation methods, the learning outcomes (considering increases in test scores as a proxy) among students using Kahoot as a medium for classroom participation did not differ significantly from those of students who engaged in traditional classroom participation method. Hence, the results of both phases of the experiment also invalidated H2. As a result, *the learning outcomes of students using classroom participation technology did not differ significantly from those of students using traditional classroom participation methods*.

Despite this fact, Kahoot created a better classroom environment in both phases of our experiment. Students in the Kahoot group were more enthusiastic with the classroom participation session than students in the Control group. Furthermore, the competitiveness of Kahoot stimulated students' excitement during the class participation session.

Based on the results of this experiment, using classroom participation technology such as Kahoot and Plickers in higher education classrooms might not significantly improve students' learning outcome, in comparison to regular classroom participation methods. This is due to the fact that students in higher education are more motivated and engaged than high school students [8]. Thus, higher education students can learn the class materials without the help of motivations such as the novelty of classroom participation technology. However, making a game out of classroom participation makes students enthusiastic during the classroom participation session and creates an exciting classroom environment.

The implication of this study is that instructors and teachers should consider the nature of students and classroom settings when choosing technology to use in class. As demonstrated through this experiment, not all technologies are suitable for a given context. Therefore, instructors need to understand their students and class materials in order to apply classroom technology accordingly.

VI. Limitations

The major limitations in this study is the limited participant pool. We conducted the study with the students enrolled in the Introduction to Programming course at a Thai university. The narrow scope of participants did not allow us to explore the effects of classroom participation technology in other groups of students. Because our participations were students studying in the field related to Information Technology, and thus were used to using technology in various context, the novelty and excitement of the use of technology in classroom might not create a different environment than a regular classroom. As a result, the learning outcomes of those who used technologies to participate in class were not significantly different from those who used traditional classroom participation methods.

As a future work, we propose a latitudinal study covering broader groups of students of different disciplines. This way, we can observe the effects of classroom participation technology in a broader context.

VII. Conclusion

This paper presented an experimental study to investigate the effects of using classroom participation technology on learning outcomes among students at higher education level. The results of the experiment showed that some classroom participation technologies did not fit well in the context of classrooms in higher education. Furthermore, the use of technology did not significantly improve students' learning outcomes compared to traditional classroom participation methods. Nevertheless, if the technology is used properly, the classroom environment can become more exciting and challenging to students. Teachers and instructors in higher education need to understand the nature of their students and classroom environment in order to apply appropriate technology in the classrooms.

Acknowledgment

This research is sponsored by the Faculty of Informatics, Mahasarakham University, Thailand. The author would like to thank all students who participated in this experiment and all colleagues who provided great feedback throughout the process of conducting this experiment.

References

[1] C. Charles and A. James, *Active Learning: Creating Excitement in the Classroom*. 1991.

[2] M. Prince, "Does Active Learning Work? A Review of the Research," *Jounal Eng. Educ.*, vol. 93, pp. 223–231, 2004.

[3] C. Garside, "Look who's talking: A comparison of lecture and group discussion teaching strategies in developing critical thinking skills," *Commun. Educ.*, vol. 45, no. 3, pp. 212–227, Jul. 1996.

[4] A. L. Brown, J. D. Bransford, R. A. Ferrara, and J. T. Campione, "Learning, remembering and understanding," *Cent. study Read.*, pp. 1–256, 1982.

[5] K. Petress, "An operational definition of class participation," *Coll. Stud. J.*, vol. 40, no. 4, pp. 821–824, 2006.

[6] D. A. Karp and W. C. Yoels, "The college classroom: Some observations on the meanings of student participation," *Sociol. Soc. Res.*, vol. 60, no. 4, pp. 421–439, 1976.

[7] J. E. Caldwell, "Clickers in the large classroom: current research and best-practice tips.," *CBE Life Sci. Educ.*, vol. 6, no. 1, pp. 9–20, 2007.

[8] A. J. Martin, "Motivation and Engagement Across the Academic Life Span," *Educ. Psychol. Meas.*, vol. 69, no. 5, pp. 794–824, Oct. 2009.