Aşıksoy, G., & Sorakin, Y. (2018). The effects of clicker-aided flipped classroom model on learning achievement, Physics anxiety and students' perceptions. *International Online Journal of Education and Teaching (IOJET), 5*(2), 334-346. http://iojet.org/index.php/IOJET/article/view/389/238

Received: 18.01.2018
Received in revised form: 18.02.2018
Accepted: 01.03.2018

THE EFFECTS OF CLICKER-AIDED FLIPPED CLASSROOM MODEL ON LEARNING ACHIEVEMENT, PHYSICS ANXIETY AND STUDENTS' PERCEPTIONS

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Abstract

Similar to all stages of education, the use of the flipped classroom model continues to become more widespread in higher education. This paper aimed to provide insights from a pre-test and post-test experimental design-based exploration of the effects of clicker-aided flipped classroom model on learning achievement, Physics anxiety and students' perceptions. The study was conducted with the participation of 61 undergraduate students taking the Physics course. In the in-class component of the flipped classroom model, while the student response system was used with the experimental group, it was excluded during the study conducted on the control group students. The data were collected through Physics achievement test, Physics anxiety questionnaire, and semi-structured interviews, and required statistical analyses were performed: for quantitative data analysis, SPSS was applied whereas for qualitative data analysis, content analysis was performed. The gathered data were analyzed in accordance with whether the student response system was utilized in the in-class component of the flipped classroom model. The results showed that, in comparison to the control group students, the learning achievement of the experimental group students had increased and that their anxiety had decreased significantly. Furthermore, it was determined that the experimental group students had a positive perceptions of student response system's utilization in class. This study may provide aid for lecturers in integrating the student response system to the flipped classroom model.

Keywords: flipped classroom, student response system, learning achievement, anxiety

1. Introduction

In addition to the cognitive elements, the students' achievement during the teaching learning process also depends on affective elements (Turner & Lindsay, 2003). Anxiety is one of the most important elements affecting student achievement (Zeidner & Matthews, 2005). Rachman (1998) defines anxiety as the expectation of an obscure threat or a disturbing suspicion. While a limited amount of anxiety can have a positive effect on increasing learning, excessive amounts also act as a disruptor (Karakaya, 2017; Richardson & Suinn, 1972). Anxiety negatively effects short term memory's functioning ability and prevents the students from developing their knowledge (Sun, 2014; Zeidner & Matthews, 2005). Students experiencing academic anxiety have these four attributes in common which affect their academic life negatively: disruptions in mental activities, psychological distress, misoriented attention and procrastination (Ottens, 1991).

The efficient use of teaching technologies in teaching environments decreases the stress and anxiety on students and increases their participation and achievement (Çoruk & Çakır,

2017; Gilbert, 2003; Martyn, 2007; Sun, 2014). In the last decade, one of the widespread technologies used in teaching environments has been the clicker technology (Hung, 2017). The clicker technology, also known as the student response system, is based on a system which allows all student replies, to the questions asked in a classroom, to be gathered. The system involves clickers with buttons that allow the students to answer the questions, an access point which transfers the answers to the mainframe, a computer which analyses the answers and reflects the results on a screen, a projection device which enables visual aid during the classes and a software that manages the whole system. With the aid of this system, the lecturer can simultaneously ask questions to all students present, self-evaluate according to their feedback, provide necessary verbal feedback or use the visual aids for that feedback and form a discussion environment (Yılmaz, 2017).

The clickers have different uses in teaching environments. It is a solution especially used for increasing student participation in crowded classes and forming an active environment (Hung, 2017). The use of clickers has several benefits such as providing instant feedback, interpolation, recording short quizzes, showing the class's general status with a graphic, increasing reciprocal communication in large classes and managing cooperative learning activities (Beatty et al., 2006). Results in literature can be found of the positive outcomes of using clickers in both large and small classes (Ally, 2013; Cubric & Jefferies, 2015; Hung, 2017; Martyn, 2007; Smith, Trujillo & Su, 2011). However, these studies mainly focus on teacher based approaches, especially on lectures given in conference rooms. Thus, the data concerning the use of clickers in a flipped classroom environment, which is used for encouraging the class and homework components by reversing its traditional manner of functioning, remains insufficient; especially whether the use of clickers would enhance the effectiveness of teaching and learning (Bergmann & Sams, 2014). In other words, there remains a gap in literature concerning the pedagogical value of clickers for the lecturers who would aim to utilize the flipped classroom model to increase the students' learning and decrease their anxiety (Hung, 2017). In this study, clickers were used for the in-class component of the flipped classroom model during Physics lectures. In order to determine its effect on the students learning achievement and anxieties, the following were tried to have been answered:

- Can the clicker-aided flipped classroom model increase learning achievement?
- Can the clicker-aided flipped classroom model decrease anxiety?
- What are the students' opinions on the clicker-aided flipped classroom model?

2. Literature Review

2.1. Overview of Research on the Use of Clickers

When accompanied by innovative education approaches, the use of education technologies, presents an effective learning output in classes (Sarıtepeci, Durak & Seferoğlu, 2016). Used as a product of education technologies, the clickers are widely preferred in classrooms for the recent years (Beatty et al., 2006). For usability, the clickers have become a series of web based applications which allow the students click and participate in activities through any device with an internet connection (Hansu, Adesope & Bayly, 2016). Many studies are present in literature which report the positive effects of the utilization of the clicker technology on the students' learning experiences in learning environments as well as other effects such accessibility and prevalence. For example, in their studies, Blasco-Arcas et al., (2013) have stated that the use of the clicker technology in classrooms had positive effects on the internalization of knowledge and its perpetuation (Chien, Chang & Chang, 2016). In another study, Stevens et al. (2017) have reached the conclusion that the use of clickers aid in interpreting the information and increase the students' interest and motivation

towards the lectures. Furthermore, they emphasized that it decreased the possible misinterpretations while the students construct the gathered information. Another study has also shown that the clickers improve the students' reasoning skills (DeBourgh, 2008). The findings of the study by Hooland, Schwartz-Shea and Yim (2013) on the use of clickers have shown that the students enjoyed learning and displayed willing behaviors towards their lectures. In general, an abundance of studies exists in literature emphasizing on the benefits of using clickers in teaching environments (Chien, Chang & Chang, 2016; Cubric & Jefferies, 2015; Hensu, Adesope & Bayly, 2016).

2.2. Clicker Use and Flipped Classroom

As one of today's most efficient teaching models, Flipped Classroom presents us with a fresh understanding of education with its attribute of eliminating time and place boundaries and great involvement in the use of technology (Bergman & Sams, 2014; Fautch, 2015). In the flipped classroom method, the lecturer shares the content outside the classroom with the help of technology and the teaching takes place asynchronously. The classroom environment is transformed into an environment for activities supporting students' active participation such as problem solving, discussion and laboratorial applications (Ogan & Williams, 2015).

Several findings on the advantages of this model have been found in literature after conducting studies on flipped classroom. Some of these advantages are as follows: the model provides opportunity to students for learning at their own pace (O'Flaherty & Phillips, 2015), it allows the time that would be used for lecturing and revisions to be used in active learning activities (Seamen & Gaines, 2013), it increases in-class lecturer-student interaction and aids students in using their thinking skills (Sarawagi, 2013) and deems the students responsible of their own learning (Lai & Hwang, 2016). In literature, a limited amount of studies exists concerning the integration of clicker activities into the flipped classroom model. For example, Hung (2017) stated that the use of clickers in flipped classroom promotes efficient learning by establishing a bond between pre-class and in-class activities (Hung, 2017). In another study, Hwang, Lai and Wang (2015) have reached the conclusion that the lecturer can manage active learning activities in a trouble-free manner in flipped classrooms. Lucke, Dunn and Christie (2017) have integrated flipped classroom and clickers during the teaching of a third-year engineering course on Fluid Mechanics. The findings of the study have presented an increase in the students' participation and motivation. Yu (2015) has found that the flipped teaching model and the use of clickers improve the EFL proficiency. In another study, Yu & Yu (2017) have stated that clicker-aided flipped classroom had encouraged peer discussion, which may have provided the students with collaborative communication opportunities.

When considering the positive effects of utilizing clickers in active learning environments, it is believed that conducting more studies on its use with the flipped classroom model can aid in remedying the insufficient amount of studies in literature.

3. Methodology

In this study, a pre-test and post-test experimental design with a control group was used. Each student was randomly assigned into the experimental group or control group. The research design is shown in Figure 1.

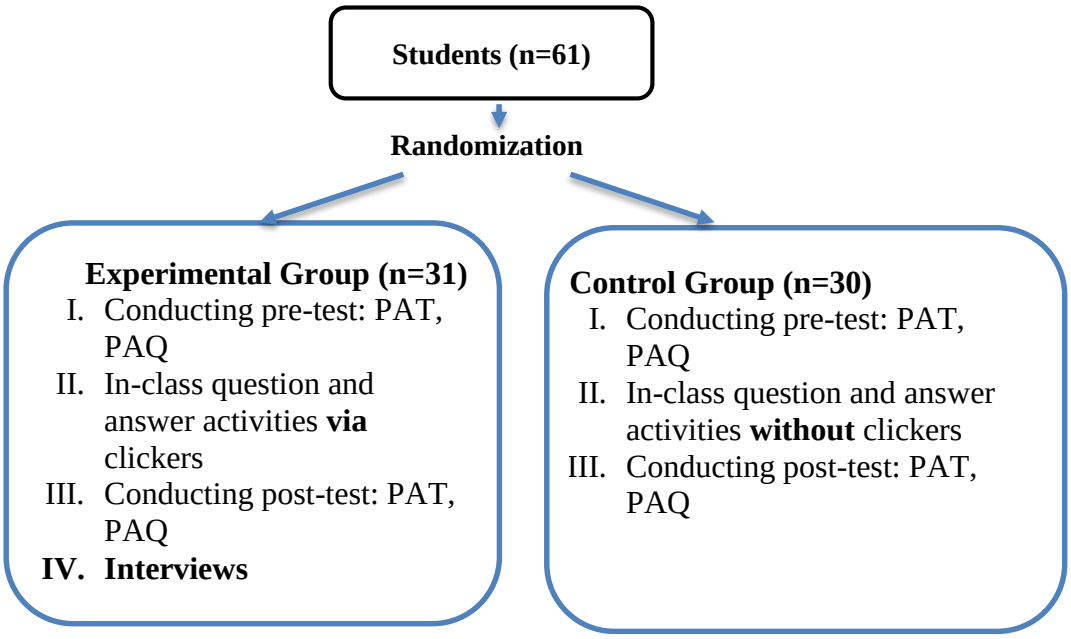

Figure 1. *The research design*

3.1. Participants

A total of 61 first year engineering students enrolled Physics course at Near East University during the fall semester of the 2017-2018 academic year. The students were randomly assigned to experimental (n=31) and control groups (n=30). The experimental group students consisted of 12 males and 19 males while the control group was consisted of 11 females and 19 males. The students were randomly assigned to the experimental and control groups. With the experimental group students, clickers were used in the in-class component of the flipped classroom model. The control group students however, did not use clickers in the in-class component of the model.

3.2. Materials and Procedure

Both groups were given information about the proceedings of their lectures before the beginning of the experiment procedure. Both groups were taught by the same instructor. A Physics course was opened by the instructor on the Learning Management System (Moodle). The students logged into this webpage with a username and a password. Each week, both experimental and control group students could watch the course video uploaded onto the page 2 days prior to their own lecture time. Both groups were taught the same course content for 4 weeks. Furthermore, both groups attended class on different days.

3.2.1. Experimental group

With the experimental group, the Physics course was held in accordance with the flipped classroom model. The students watched the course videos uploaded by the lecturer in their homes; and with the use of clickers, they participated in individual and group based questions-answers activities in class. For individual question-and-answer activities, the Quizizz application was used. The questions prepared in the Quizizz application are in the multiple-choice format and the students have a time limit for answering all the questions. During the first 25 minutes of in-class time, the Quizizz (consisted of 15 questions) was used for the individual questions-and-answers activities. The questions were prepared by the lecturer, in accordance with the basic concept of the course content, to observe whether the students had watched the course video. After the lecturer gave the code for the quiz prepared

on the Quizizz application to the students, they connected to the system via their tablets or laptops and answered the questions. After all the quizzes are completed, Quizizz reports to the lecturer about the students' performance. Thus, the lecturer could observe which questions were answered correctly (and the rate of right/false answers) and in which order the students completed the quiz.

Afterwards, the lecturer gave students 10 minutes to discuss among themselves the false answers given to the questions. The lecturer guided these groups and led them towards the right answers.

Later on, the lecturer gave new codes to the students for their access to the prepared problems uploaded on the Quizizz application. By using Quizizz's feature of extending the quiz time up to 5 minutes, the students were enabled to access the prepared problems. Thus, the results of the in-class problem solving activities were provided to the lecturer as feedback.

At the end of each course, the students were separated into groups and they used the Flipquiz application to work on group-based question-answer activities. Due to the five categories of the application, the students were separated into 5 groups; allowing a competitive environment.

3.2.2. Control group

According to the out of class component of the flipped classroom model, the control group students watched the same course videos, same as the experimental group students, in their homes. During the in-class time, they focused on activities such as questions-answers, problem solving and discussions without the use of clickers.

3.3. Instruments

3.3.1. Physics Achievement Test (PAT)

A multiple-choice achievement test, consisted of 35 questions, has been developed by researchers to determine the effects of Clicker-Aided Flipped Classroom Model on learning achievement by determining the 'Electric charge', 'Electric Fields' and 'Gauss's Law' units target behavior. After the preparation of the test entries, the test was performed with 80 students (excluded from the control and experiment groups) who had already learned the 'Terrestrial Motion' and 'Work-Energy' units in accordance with the flipped classroom (without clickers-aid) approach for determining the test's validity and reliability. After the application of this pilot test, the correct answer ratio (p: entry difficulty index) and the ratio of differentiation, between the students who knew the correct answers and those who did not, (r: entry distinguishing index) was calculated. The aim when choosing the entries is to establish the entry difficulty between .20 and .80, while maintaining the basic aim of keeping an approximate of .50 difficulty ratio without altering the examined behavior. The distinction, with the condition of being in the right orientation, should be as high as possible. 30 entries with a distinguishing index above .30 and an entry difficulty index between .40-.76, were selected to be included in the main test; while 5 entries were excluded. To determine the internal consistency of the Physics achievement test's 30 entries, the calculated KR-20 coefficient was found as .73 and KR-21 was found as .70. These values are of importance for the test's reliability in the manner of showing its questions' internal consistency. To determine the experimental and control group students' state of readiness, the achievement test was firstly used as a pre-test; and afterwards was used again with both groups as a post-test to examine their final state after participating in the application (4 weeks later).

3.3.2. Physics Anxiety Questionnaire (PAQ)

'Anxiety Scale for Science and Technology', developed by Kağıtçı and Kurbanoğlu (2013), was used in this study for determining the students' anxieties towards the Physics course. 'Science and Technology' was replaced with the term 'Physics' and scale's name was modified as the 'Physics Anxiety Questionnaire' (PAQ). The PAQ contained 18 entries that ranged from 1 (strongly disagree) to 5 (strongly agree) on a Likert-type scale. The Cronbach's alpha reliability coefficient was calculated as .89. High Scores from the scale indicate a high level of anxiety towards the Physics course.

3.3.3. Semi-structured interviews

At the end of the study (4 weeks), individual interviews were held, with volunteering students from the experimental group, during the class hours concerning the application of clicker activities. The interview questions had a semi-structured form and were oriented towards determining the students' opinions and preferences concerning the use of clickers in the flipped classroom model's in-class component. The studies present in literature were benefited from during the preparation of the semi-structured interview questions (Hung, 2017; Yu & Yu, 2017). The interview questions were presented to an expert for determining their clarity and expediency. The questions were modified in accordance with the feedback of five consulted experts (3 academicians from the field of education and 2 academicians from the field of Physics). The interview questions were; "what are your opinions on the in-class clicker activities? explain" and "what activities did you like the clicker activities? Face to face interviews were held with volunteering 24 experimental group students after the end of the experimental application. The interviews were held in the students' mother tongue (Turkish) and each lasted approximately 5-7 minutes. To prevent loss of data, the interviews were recorded and later transcribed.

3.4 Data Analysis

ANCOVA was conducted to examine the differences between pre-test and post-test scores of the experimental and control groups related to AT and PAQ. In order to neutralize any possible effects of the pre-test results on the posttest scores of the experimental and control groups, the group's pre-test scores were kept under control and the post-test scores were submitted to covariance analysis to determine the differences. Firstly, for the implementation of ANCOVA, its hypotheses were examined in the manner of whether they were met or not. These hypotheses are as follows: 1-experimental and control groups attended their classes independently and on different days, 2-the dependent variables' score distribution was normal and the variance was homogenous, 3-a linear relationship exists between the dependent variables and covariances; the tendency of the regression line is homogenous for the groups (Büyüköztürk, et. al, 2008).

The content analysis method was used in the analyzing of the qualitative data gathered during the interviews held with the experimental group students. The interviews lasted for 5-7 minutes and voice records were kept. The students' names were coded as S1, S2, S3 … for research ethics.

4. Results

4.1 Students' Learning Achievement of the Physics Course

In this section, the effects of clicker based activities on students' learning achievement were examined. The one-way ANCOVA was used to compare the two groups' learning achievement for the Physics course. Firstly, the experimental group's (Kolmogorov-Smirnov = .171, N=30, p>.05) and the control group's (Kolmogorov-Smirnov =.200, N=31, p>.05)

post-test scores were determined to be within a normal range of distribution. The homogeneity of the variances was checked via the Levene test after the normality hypothesis and no significant statistical difference was spotted (p>.05); afterwards, ANCOVA was used. For comparing the post-test means of the groups, the new averages calculated in accordance with the pretest means have been presented in Table 1.

Table 1. *PAT post-test means and the adjusted means*

Group	N	Mean	Adjusted Mean
Experimental group	30	27.37	26.99
Control group	31	22.26	22.61

As presented in Table 1, the adjusted means of the experimental group was 26.99 when compared to the control group's 22.61. The ANCOVA results showing whether a significant different exists between the two group's adjusted post-test results have been presented in Table 2.

Table 2. *ANCOVA results of post-test scores by group*

Source of variance	Sum of squares	SD	Mean of squares	F	p
Controlled variable (PAQ pre-test)	481.413	2	240.706	37.192	.000
Group	267.431	1	267.431	41.322	.000
Error	375.374	58	6,472		
Total	38285	61			

In accordance with the covariance analysis results, presented in Table 2, a significant statistical difference has been observed between the adjusted post-test results of the experimental and control groups. ($F_{(1,58)}$= 41.322, p<.05). The adjusted means indicate that the learning achievement rate for experimental group higher than the control group. So, it can be stated that the clicker activities in-class has positive effects on learning achievement.

4.2 Students' Anxiety towards the Physics Course

In this section, the effects of clicker based activities on students' anxiety towards the Physics course were examined.

The one-way ANCOVA was used to compare the two groups' anxiety towards the Physics course. Firstly, the experimental group's (Kolmogorov-Smirnov = .132, N=30, p>.05) and the control group's (Kolmogorov-Smirnov = .200, N =31, p> .05) post-test scores were determined to be within a normal range of distribution. The homogeneity of the variances was checked via the Levene test after the normality hypothesis and no significant statistical difference was spotted (p>.05); afterwards, ANCOVA was used. For comparing the post-test means of the groups, the new averages calculated in accordance with the pre-test means have been presented in Table 3.

Table 3. *PAQ post-test means and the adjusted means*

Group	N	Mean	Adjusted Mean
Experimental group	30	31.13	32.85
Control group	31	55.58	53.92

As presented in Table 3, the adjusted means of the experimental group was 32.85 when compared to the control group's 53.92. The ANCOVA results showing whether a significant different exists between the two group's adjusted post-test results have been presented in Table 4.

Table 4. *ANCOVA results of post-test scores by group.*

Source of variance	Sum of squares	SD	Mean of squares	F	p
Checked variables (PAQ pre-test)	10922.435	2	5461.217	43.783	.000
Group	6179.590	1	6179.590	49.542	.000
Error	7235.614	58	124.735		
Total	133889	61			

In accordance with the covariance analysis results, presented in Table 4, a significant statistical difference has been observed between the adjusted post-test results of the experimental and control groups. ($F_{(1,58)}$= 49.542, p<.05). The adjusted means indicate that the anxiety rate for control group higher than the experimental group. So, it can be stated that the clicker activities in-class have positive effects on anxiety towards the Physics course.

4.3 Students' Perceptions of the Clicker-Aided Flipped Classroom

Semi-structured interviews were held with 24 volunteering experimental group students on the Clicker-aided Flipped classroom model. The students were firstly asked to express their opinions on the in-class clicker activities. The data gathered from the students' answers were divided and examined in two themes; 'benefits' and 'difficulties'. The students chose one or more codes included in each theme. The results have been presented in Table 5.

Table 5. *Student's opinions on clicker activities*

Theme	Code	Frequency
Positive	Encouraged me to participate more actively in class	17
	Reduces my anxiety	16
	Increased entertainment in class	14
	Increased my attention towards the course	11
Negative	The questions-answers caused anxiety	2
	I did not like it	1

A majority of the students (n=17) stated that the clicker activities performed in the classroom had enabled their active participation. A majority of the participants (n=16) stated that their anxiety towards the Physics course had been decreased. Similarly, some stated that the clickers provided a more entertaining environment (n=14) and that they increased the students' attention towards the course (n=11). Some of the student statements are as follows:

> *"The predominance of the clicker activities we performed in the class has increased my attention. The classes were very entertaining. Additionally, the clicker quizes are better than those on paper; because, we could get instant feedback. That made me feel less stressful".* (S9)

> *"Beginning the class with a quiz helped me concentrate quicker. Also, competing with my friends was fun".* (S2)

> *"The traditional methods of conducting classes is more appropriate for me. I cannot concentrate in dynamic environments".* (S19)

During the interviews, the students were asked to identify the activities they liked among the clicker activities. The answers were examined in four themes: 'problem solving', 'discussion', 'individual quiz' and 'group based quiz'. The students chose one or more codes included in each theme. The results have been presented in Table 6.

Table 6. *Favoured clicker activities*

Theme	**Frequency**
Group based quiz	21
Individual quiz	18
Problem solving	11

Most of the students (n=21) stated that they better appreciated the group based quizzes. Also, another majority (n=18) expressed that they better enjoyed the individual quiz activities. Some of the students (n=11) expressed that they would have preferred more hours of clicker-aided problem-solving courses. Some student statement examples are as follows:

> *"I greatly enjoyed the quizzes we took as groups. We determined the correct answers by discussing amongst ourselves. The other groups did the same also. Being a part of a team made me feel good. It was very fun".* (S5)

> *"... if I am to put it in order, my favourite activity was working on the individual quizzes. There were video based questions in the individual quizzes. Those who watched carefully could easily gain success. I also enjoyed the problem-solving activities. The existence of a time limit motivated me".* (S10)

> *"I think solving quizzes as groups was very interesting. They were my favourite activities. In fact, it encouraged me to think. I enjoyed sharing my solution oriented ideas with my friends. In class, we thought about finding the right answers for the group quiz activities and discussed amongst ourselves".* (S8)

5. Discussion and Conclusion

In this study, the integration of clickers activities to the in-class component of the flipped classroom model, the use of which is rapidly widespread in higher education, and its effects on students learning achievements and course oriented anxieties have been examined. Furthermore, the effectiveness of the clicker-aided flipped classroom model activities

(individual and group based question-and-answer activities, problem solving activities) on the students' learning achievement and course oriented anxieties have been compared to that of the classic flipped classroom model (without clickers). Students' perceptions of the clicker-aided flipped classroom model were also determined.

The research results indicated the positive effects of the clicker-aided flipped classroom model on students' learning achievements. In the pre-course component of the flipped classroom model, the lecturer can identify whether the students had watched the course videos and whether they were prepared for the course materials by holding individual clicker quizzes. Additionally, the model provides feedback to both the lecturer and the student, on the students' problem-solving speed. If the student cannot perform within the determined time limit, that indicates the necessity for that student to solve more problems and focus more thoroughly on the course materials. Thus, it is believed that the clicker-aided flipped classroom model encourages students to perform the necessary preparations before class time; thus, having a positive effect on their learning achievement. After a literary review, it has been observed that the existing limited number of applications (also integrating clickers into the flipped classroom model) support the findings of this research (Hung, 2017; Yu & Yu, 2017).

Another finding of the study indicated a significant decrease in the course anxiety level of the experimental group students (who participated in the application of clicker-aided flipped classroom model) when compared to the level of control group students. It is conceived that the in-class group based quizzes had a remedying effect on the students' course anxieties. Behavioral outputs on the use of clickers show a higher possibility of student effort when participating in their classes (Hung, 2017; Oigara & Keengwe, 2013; Termos, 2013).

When the opinions of the students from the experimental group (on the clicker-aided flipped classroom model) are considered, it has been determined that they had a positive perception of the model. The students stated that they were more active during class time, their anxieties were decreased, they enjoyed their classes and their interest in the course was increased. The students' positive inclination towards the model is believed to be the result of the model's enabling attribute of their participation and it's feature of providing feedbacks. Furthermore, group based quizzes can be effective in increasing student interaction, providing a sense of belonging (to a group), decreasing their anxieties and developing positive opinions. Several seconding studies exist in literature which also present the positive student opinions towards clicker activities (Batchelor, 2015; Crossgrove & Curran, 2008; Hunsu, Adesope & Bayly, 2016; Oigara & Keengwe, 2013). The results of this study assert the importance of integrating clickers activities into the application of flipped classroom model; for attaining a better learning achievement and remedying course anxiety problems. Furthermore, it also shows that the clicker activities can be integrated into the flipped classroom model's in-class component with ease.

6. Limitations and Further Research

This research, as with any other empirical studies, has its limitations. Firstly, the participants of the study were students from a single university in North Cyprus. Thus, the results cannot be nationally generalized. It can be performed with more participants from a larger number of universities. Secondly, the interviews were held only with voluntary students from the experimental group; no interviews were held with the control group students. This decreased the qualitative data amount of the study. In future studies, interviews can be held with both experimental and control group students. Another limitation of the study is its 4 weeks long experimental process. Future studies can focus on the outputs of a longer-lasting learning environment, performed by using clicker-aided flipped classroom.

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