# The Effects of the Flipped Classroom Model on the Laboratory Self-Efficacy and Attitude of Higher Education Students

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**ABSTRACT**

In class environments, the flipped classroom (FC) model has been found to increase students' attitudes, achievement, and motivation. However, the practical effects of the FC model in laboratory environments have not been introduced into the literature. Therefore, in this study, the effects of the FC model on the laboratory self-efficacy skills and attitudes of higher education students were investigated within the scope of the physics laboratory course. The data were purposively collected from a group of 84 first-year university students aged between 18-20, who were, then, sorted out into two groups: experimental and control. The sequential explanatory design model by Creswell was used, which is a subcategory of the mixed-methods design. While the FC model was applied to the experimental group, the traditional classroom model was used in the control group. In the data collection process, qualitative and quantitative data collection tools were used sequentially. The experimental results obtained at the end of a six-week study showed that the FC model significantly improved the laboratory self-efficacy and attitude towards the laboratory of higher education students. Therefore, the FC model was also found to have positive effects in laboratory environments.

*Keywords:* flipped classroom model, augmented reality, information technologies, physics laboratory, science education

## Introduction and Theoretical Framework

The common point of the solutions for maximizing student-teacher interactions is to make students more active by teaching them how to learn in a student-centred environment (Brewer & Movahedazarhouligh, 2018). The targeted development in the learning environment can be achieved by any method or pedagogical approach in which students are active. Active learning expresses how students participate in activities, reflect their ideas and use them. Active learning is a broad-based term consisting of different teaching methods to involve students in their learning and to develop and maintain a higher level of learning (Zepke, 2013). Therefore, active learning has made a popular teaching approach in higher education. Many studies have shown that the use of active learning methods can increase learning outcomes without compromising on the content (Owens, Sadler, Barlow, & Smith-Walters, 2017). Educators who understand the importance of active learning have developed new strategies to activate students in the learning process (Findlay-Thompson &

Mombourquette, 2014). However, the strategies developed within the scope of active learning limit the amount of time students need to actively use in the classroom. Teachers may not practise enough in their learning environment. Because they devote most of their time not to practising but to teaching theoretical knowledge, students may not be able to communicate with their peers or teachers (King & Newmann, 2001). According to some research, the FC model provides a solution to this problem. Thus, recently, educators have supported the FC model, claiming that students have more opportunities in active learning as this model promotes participation in interactive and high-level activities (Chuang, Weng, & Chen, 2016). The FC model is popular instructional model, in which activities traditionally conducted in the classroom become home activities, and activities normally constituting homework become classroom activities (Bergmann & Sams, 2012; Sohrabi & Iraj, 2016). The FC model based on active learning (Chen, Wang, & Chen, 2014) has recently become one of the most popular technology-based learning models (Jensen, Kummer, & Godoy, 2015). The FC model is seen as an important tool that provides opportunities for students in higher education to learn on their own. In addition, the FC model is widely accepted by educators because it defines the needs and capacities of individuals, offers individualized teaching and provides flexibility on planning the learning, gives homework and adjusts the pace of learning (Davies, Dean, & Ball, 2013). According to all these studies, it can be said that the FC model supports the learning environments as a process that enhances the learning experiences and encourages students to take responsibility in order to develop their learning products.

According to Awidi and Paynter (2019), the FC model can provide cooperation between instructional technologies that support appropriate student behavior and learning, and provide a driving force for students to actively participate in their learning. By encouraging discussion and collaboration, the FC model requires students to learn concepts and ideas through an in-depth study of content in contrast to passive superficial learning (Burke & Fedorek, 2017). Therefore, the use of the FC model in K12 education and higher education has been increasing (Álvarez, 2012). The FC model is defined as an innovative approach in teaching, which has the potential to create active, busy and learning-centred classes (Brewer & Movahedazarhouligh, 2018). The FC model is also called inverted instruction or inverted learning, but these terms refer to the same teaching strategy (Fidalgo-Blanco, Martinez-Nuñez, Borrás-Gene, & Sanchez-Medina, 2017). This model is a special learning type that requires active participation of students in learning activities before and during face-to-face lessons with teachers (Strayer, 2012). At the same time, in the learning environment, this model is a solid pedagogical technique that improves students' comprehension appreciation of the lesson (Samuel, 2019).

## FC Model Benefits and Limitations

There are many benefits resulting from the use of the FC model. It is suitable for all learners because it has positive effects and can focus on all the students (Sams & Bergmann, 2013). Unlike a teacher-centred teaching model based on traditional learning, the FC model has two inverted education stages (Bergmann & Sams, 2012). The first part of the FC model is the planning phase which is the stage before the course. At this stage, students acquire the basic conceptual information with online materials (Bergmann & Sams, 2012; Strayer, 2012), so they often receive most of the information transfer before attending the classroom (Abeysekera & Dawson, 2015). The second part of the FC model is the in-class learning phase. At this stage, there are active learning activities in the classroom environment such as laboratory experiments, interactive lessons and problem solving (Strayer, 2012). Class time is used for active and social learning activities in this method (Abeysekera & Dawson, 2015). In other words, the content presented in the classroom traditionally such as face-to-face learning is given to the student prior to the class as homework (Herreid & Schiller, 2013), and students can access the lessons at their own pace (Moffett, 2015). However, in order to increase

student motivation for courses with active learning activities, students should attend face-to-face courses at the preliminary information and preparation level (Hao, 2016) because teachers play a vital role in students' lives and having face-to-face interaction with teachers is an invaluable experience for them (Bergmann & Sams, 2012). Out-of-class learning is flexible in the FC model. Students can match their academic level and individual needs according to their preference, and this matching can take place at any time and in any place (Moffett, 2015). In the FC model, there remains more time for students to apply what they learn, to develop high-level thinking skills, to make classroom discussions, to focus on projects and problem solving (Hwang, Lai, & Wang, 2015). Therefore, this model increases the time spent in the classroom for active learning. Research that takes into account all these situations shows that the FC model positively affects students' learning (Davies et al., 2013; Er, Kopcha, Orey, & Dustman, 2015; Schultz, Duffield, Rasmussen, & Wageman, 2014; Shih, & Tsai, 2017; Strayer, 2012). FC practices show that students' satisfaction and motivation may lead to differentiation or decrease. The basis of this perception is the possibility of decreasing the frequency and willingness of participation in the activities as opposed to the expectations of the students. Therefore, the researchers stated that students were concerned about the resistance to participation in the activities and that this could reduce the efficiency of the FC model (Gençer, 2015; Hao & Lee, 2016; Herreid & Schiller, 2013; Missildine, Fountain, Summers & Gosselin, 2013; Wilson, 2013). If the FC model is used in all courses, this may make it difficult for students to prepare adequately for the courses (Hao, 2016; Wanner & Palmer, 2015). Students may not have the necessary digital skills to manage a technology-integrated environment (Hao & Lee, 2016).

**Self-Efficacy and Attitude in Technology-supported Science Laboratories**

The rapid expansion of technology in schools and its integration into teaching have caused the ways for teacher, student and curriculum interaction to be reconstructed. As a result, changes have occurred in learning environments. The constructivist learning environment which adopts student-centred active learning methods is also integrated with computer-assisted teaching methods (Çelik & Pektaş, 2017). Among these methods, Augmented Reality (AR) applications are the new and popular applications. Research shows that AR applications have gained popularity because of being flexible, easy-to-use, user-friendly and low-cost when supported by mobile learning (Jones & Jo, 2004). Wearable technologies can be used to integrate multimedia tools such as video, audio and graphics into learning environments (Churchill & Hedberg, 2008). As a result of its integration into written materials, learners can establish a connection between these tools; thus, learning can result in meaningful and profound (Burden & Kearney, 2016). The applications which are evaluated within the methods known as mobile learning are evaluated as the applications of Quick Response (QR) code in education (Chen, Chang, & Wang, 2008). The environments where cooperative learning is best practiced are experimental study environments in science and technology laboratories.

Combining technology with physics laboratories provides a different experience for students. This experience is an opportunity to provide an alternative to difficult-to-reach, expensive, dangerous and complex experiments (Akçayır, Akçayır, Pektaş, & Ocak, 2016). Computer technology supported by Internet applications and multimedia is used in educational activities to increase learners' motivation and learning towards physics. Students prefer to use web pages, interactive video features and recorded videos outside the classroom to support learning due to technological advances, while in the classroom they prefer to take responsibility in active learning activities such as discussion, problem solving and group work. Hence, it can be said that FC practices are the best models that can be used in laboratory courses, which can move the student's attitude with video and various animations to the upper level, and enable them to develop laboratory self-efficacy. Self-efficacy is defined as people's beliefs in their ability to achieve a certain level of performance (Bandura, 1994). Teaching strategies focusing on providing students with opportunities for performance are well aligned with the

emphasis on active achievement (actual performance gained through direct experience) as the most effective source of the knowledge of self-efficacy (Bandura, 1977). The self-efficacy component of the social-cognitive theory by Bandura is critical for academic achievement, motivation and learning, and often reviewed in academic studies (Pajares, 1996). The majority of the studies supporting this view found positive relationships between self-efficacy and performance and attitudes (Sitzmann & Yeo, 2013). This relationship can be explained by the effect of having a high level of self-efficacy belief as well as many other factors in students' performance. Therefore, it is important to consider the necessity of high self-efficacy beliefs as well as a positive attitude towards active learning in the laboratory environment in order for the students to perform laboratory activities effectively and successfully.

**Purpose Statement**

Studies in the literature focusing on using the FC model in physics teaching (Aşıksoy & Özdamlı, 2016; Akı & Gürel, 2017; Deslauriers, Schelew, & Wieman, 2011; Gómez-Tejedor et al., 2020) are very few. In addition, the laboratory self-efficacy and learning outcomes of students were largely ignored in these studies. Therefore, the integration of both the FC model and the learning outcomes in the laboratory will contribute significantly to the science education literature. The aim of this study is to determine whether the use of the TC (Traditional Classroom) model or the FC model has a significant difference on the laboratory self-efficacy of the students. To this end, the study of the subject of electricity is important in terms of its contribution to the literature because according to the literature, one of the issues that are difficult to be conceptualized and have the potential to be misunderstood is the subject of electricity in the general physics course (Akbaş & Pektaş, 2011). Studies have revealed that students face problems in understanding electricity, they have a risk of misconceptions and they have difficulty in analyzing abstract problems (Chambers & Andre, 1997; Sencar & Eryilmaz, 2004). Even adults admit that electricity is difficult to understand, similarly to other subjects in physics (Shipstone, 1998).

Physics laboratories are considered as learning environments where students make high-level conceptual learning (Çepni, Kaya, & Küçük, 2005). In the realization of this conceptual learning, attitude is in the foreground. Increasing student achievement in laboratory courses shows a relationship with student attitudes towards physics laboratory (Palic & Pirasa, 2012). Attitude is also a positive factor for students' academic achievement in science (Osborne, Simon, & Collins, 2003). In physics laboratories, it is important to investigate the effects of the use of new models such as FC on student attitudes and for the contribution of FC to the literature as well. So, the second aim of this study was to determine whether the use of the TC model with the FC model had a significant difference on the attitudes of the students. With this study, it is thought that a study into the positive and negative effects of FC will contribute to the literature through the opinions and suggestions of the students in the experimental group. The final aim of the study is to describe the practical views of the students in the experimental group in which the FC model is applied. Based on the stated purposes, the research questions (RQs) were determined as follows: *RQ #1*: Is there a significant difference in terms of the laboratory self-efficacy between the experimental and control group? *RQ #2*: Is there a significant difference in attitude scores between the experimental and control groups? *RQ #3*: What is the opinion of the experimental group for the FC model?

**Methodology**

This study employs the sequential explanatory design model under Creswell's mixed models, which is suitable for both qualitative and quantitative data analysis. On the other hand, qualitative data was used to increase, expand or support quantitative data. An analysis of the data is conducted in an

interrelated manner and is often combined in the data interpretation and discussion (Creswell, 2003). The internal validity of the qualitative dimension of the research was ensured by variations and participant confirmation. The external validity was attained by making direct quotations from the basic features of a descriptive analysis and by interpreting the data in detail (Özmen & Karamustafaoğlu, 2019). The indicator was that the qualitative data (created as a result of direct quotation as qualifying confirmation) coincide with each other. In addition, the activities used in the study were prepared within the framework of a plan accompanied by an expert in the field in both groups and this plan was implemented from start to finish.

## The Participants

Since the study is a mixed-methods research, there is a need to collect qualitative and quantitative data from the participants. Therefore, we preferred purposive sampling in the study. According to Patton (2002), it provides ease of access to critical information for research purposes in addition to providing a wide range of information in terms of knowledge. Critical sampling was used in this study. In accordance with this method, students' participation in the physics laboratory course was chosen as the main criterion. Participants are undergraduate students of science education at one of the state universities in Turkey in 2017-2018 academic year. In this program, there are two cohorts (A and B) in which the students were assigned randomly into Class A experimental group with 42 (36 female, six male) students and Class B control group with 42 (40 female, two male) students. 84 students aged between 18-20 participated in the study. The technology itself can have a positive impact on the student's motivation to participate in the activity, but it can also be a limiting factor depending on competences and individual differences. (Nicol, Owens, Le Coze, MacIntyre, & Eastwood, 2018). Therefore, providing all students with technology may not produce the same results. For this reason, the technology literacy of the students in the experimental group was investigated. Table 1 shows that most of the students participating in the study were smartphone, Internet and Facebook users (5 years and more).

**Table 1**
*Experiences by Participants Using Technology*

| Characteristic | f | % |
|---|---|---|
| *Experience by students using smartphones* | | |
| 1 year to 2 years | 4 | 9.52 |
| 2 years to 4 years | 16 | 38.10 |
| 5 years or more | 22 | 52.38 |
| *Experience by students using the Internet* | | |
| 1 year to 2 years | 3 | 7.14 |
| 2 years to 4 years | 12 | 28.57 |
| 5 years or more | 27 | 64.29 |
| *Experience by students using Facebook* | | |
| 1 year to 2 years | 7 | 16.66 |
| 2 years to 4 years | 16 | 38.10 |
| 5 years or more | 19 | 45.24 |

## Experimental Process

The study was conducted in accordance with the content of the general physics laboratory-II course. This course is a practical course with two lessons per week (45 min. + 45 min. = 90 min.). This course is guided by an instructor in the physics laboratory. The instructor is responsible for both

groups and provides guidance and assistance to students in case of need. In both cohorts, a group of seven people is formed, and the applications are carried out by those students under the guidance of the instructor. Thus, the experiments were conducted in a laboratory through a collaborative method. The study was conducted in a six-week period during the 2017-2018 academic year. Information about the applications was given in the first week. In the remaining weeks, electromagnetism (experiments involving electric motor and electric bell operation principles), Ohm's law (experiment of measuring the resistance of a conductor), Wheatstone bridge (Determination of current point zero), Kirchhoff's law (Calculation of current and voltage separately) and Transformer (using primary and secondary windings) tests were done. In addition, these experiments are available in the general physics laboratory-2 course.

## Control Group

A conventional method was used in the control group and the experiments were performed in a laboratory. In the first week of the application, experimental equipment was introduced to the students in the control group. In the remaining five weeks, the experimental manual including the experiments to be performed was given to the students. The experiment manual contains the following sections which students will follow in order: the name and purpose of the experiment, materials used in the experiment, brief theoretical information aiming to give information about the experiment, gradual information explaining how to conduct the experiment, findings for recording the obtained data, conclusion and discussion sections for generalizing the information and the evaluation section given for measuring performance (Open ended questions). The students in the control group perform their weekly experiments in the laboratory (in-class) through the guidance of an instructor. During the course of 90 minutes (45 + 45), they perform all the stages of an experiment in a laboratory in groups of seven participants.

## Experimental Group

The experiments were performed both in laboratory (in-class) and out-of-school environments (out-of-class) in the experimental group using the FC model. In the FC model, teaching strategies such as collaborative group work in in-class applications are used to support students' learning. Therefore, the greatest benefit that the students perceive is to gain the ability to interact and collaborate with their peers. (McLean & Attardi, 2018). In the FC model, students should be able to use interactive materials in out-of-class environments as well as to use time effectively without having any communication problems with the instructor. Therefore, QR code applications have been added by the researchers on the experiment manual for interaction. The applications developed by the researchers for each experiment are presented to the students in connection with the QR in the AR-based laboratory manual of the experimental group. Links to video, graphics and additional content were used for incremental components in the applications. Take Ohm's law as an example (see Figure 1). When supported by the digital learning environment, students can access information at any time while working in a collaborative and engaging learning environment. Therefore, it is thought to provide a more effective education to students than the traditional method.

**Figure 1**
*Students Interacting with QR Located in AR-based Laboratory Manual*
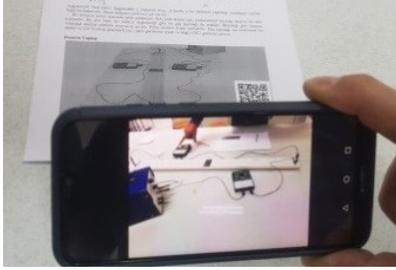


In addition, researches that test the FC model show that it can lead to differentiation or reduction in student satisfaction and motivation at a later stage. The basis of this perception lies in the possibility of reducing the frequency and willingness to participate in activities contrary to the students' expectations. Therefore, when the studies in the literature are examined, one of the factors that can reduce the effectiveness of the FC model is the resistance by students to participate in activities. (Herreid & Schiller, 2013). In order to minimize the resistance, AR-based simulations and video applications have been developed to increase the motivation by students to participate in activities with smartphones anytime and anywhere. As a result of technology integration in accordance with the application of the FC model, the AR-supported laboratory manual, which was developed by the researchers, was used in the experimental group. Access to AR applications was closed when students arrived at the laboratory (in-class). In this way, in-class activities were conducted under the same circumstances for both groups. In the applications, there were 8-10 minutes of video on the installation of the experiment, 8-10 minutes of video introducing the experimental equipment to be used by the students and explaining the objectives, and a 12-15-minute video supported by simulations and animations describing the theoretical content of the experiment (see Figure 2). One of the simulated video applications developed by the researchers and used during the research process was given in Figure 2 (Ohm's law). These videos, which made an aggregate of 28-35 minutes, were given to students in the experimental group as out-of-class activities during the study.

**Figure 2**
*Video Interaction and Simulation Applications in the AR-based Laboratory Manual*
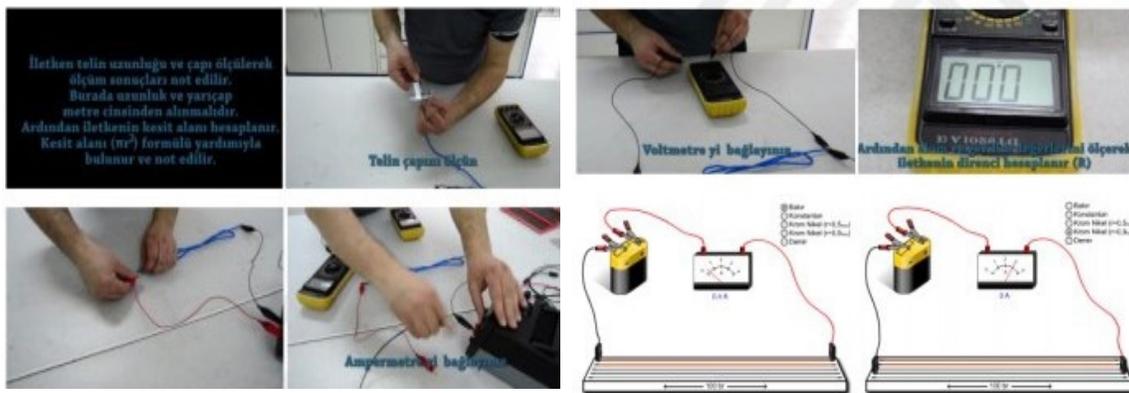


In the experimental manual for the experimental group, certain sections such as the experiment, the conclusion and the question and answer were conducted as in-class activities under the guidance of the instructor. Therefore, a total of 28-35 minutes was added in the experimental

group in the process of the experiment. This additional time provides students with more time in the conclusion and question-answer sections of the experiment and helps them better understand the unclear and complex points under the guidance of the instructor. The time distribution of a 90-minute course was given in Table 2.

**Table 2**
*Planning the Time Distribution of a 90-Minute Course*

| AR-based Laboratory Guide Sections | Flipped Classroom | Traditional Classroom |
|---|---|---|
| Aim<br>Equipment<br>Theoretical knowledge | Out-of-class activities (unlimited) | In-class activities (28-35 min.) |
| Experiment*<br>Result<br>Question-Answer | In-class activities (90 min.) | In-class activities (55-62 min.) |
| Total | 90 min. | (28+62) = (35+55) = 90 min. |

*Note.* This was carried out as both out-of-class activities (video watching for the experiment) and in-class activities (the experiment in the lab) for the experimental group.

As part of the out-of-class applications within the FC model, a Facebook group called the "General Physics Laboratory" was created in order to increase the interaction by the students in the experimental group with the instructor, to enable the students to use the time more effectively and to follow the work of the students (see Figure 3). Facebook is an online communication tool that allows users to create a custom profile for them to connect with or interact with people (Boyd & Ellison, 2007). Most undergraduate students at the university use Facebook on a daily basis (Kirschner & Karpinski, 2010). Students interact more on Facebook than online courses. In addition, some studies clearly reveal that there is the possibility that students can integrate Facebook into university courses (Bosch, 2009). Students believe that Facebook is a valuable resource as an academic tool, and that they are encouraged to develop academic connections and academic criticism, and to network and to improve the learning and learning experience (McCarthy, 2012).

**Figure 3**
*Application Examples on Facebook*
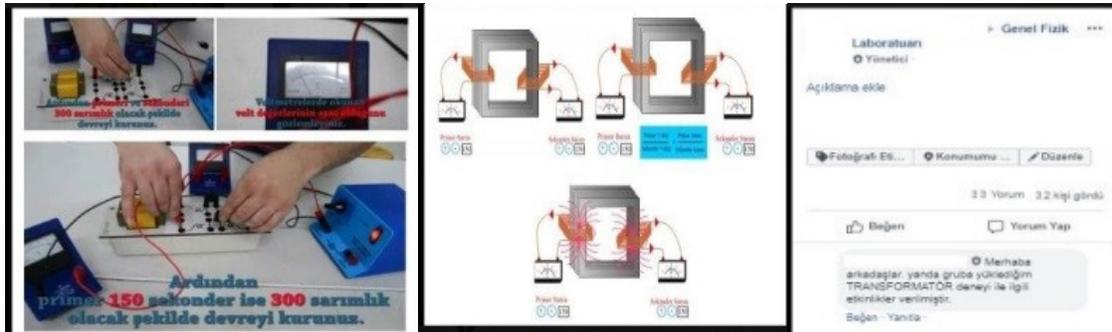


In addition, Rambe (2012) stated that Facebook has benefited students by encouraging the visibility of the common problems that students have with class-based concepts, and at the same time academics have easily recognized the difficulties faced by students. It is important to provide appropriate guidance and feedback for learning activities because feedback plays an important role in all learning activities. Therefore, the aim of the Facebook group is to motivate the students by creating

a discussion environment with the questions and answers by the researchers. In this way, the researchers were guided and provided feedback to the students. The learning model and material used in the study were classified and summarized in Table 3.

**Table 3**
*Learning Model and Material Used in the Application Process*

| Settings | Flipped Classroom Model (Experimental Group) | | Traditional Model (Control Group) | |
| --- | --- | --- | --- | --- |
| | Activities | Resources | Activities | Resources |
| Out-of-class (preparation before class) | - Preliminary study<br>- Communication<br>- Interaction | - AR-based laboratory manual<br>- Facebook application | - | - |
| In-class (active learning) | - Conducting experiments in groups<br>- Solve problem(s)<br>- Peer discussions | - Laboratory manual<br>- Guidance teacher | - Preliminary study<br>- Conducting experiments by following laboratory manual sections | - Laboratory manual<br>- Guidance teacher |

**Data Collection**

Firstly, a protocol was given to the participants in the study to obtain data on participants' technology experiences; smartphone and Facebook usage times and the time spent on the Internet. In this study designed as a mixed-methods model, self-efficacy and attitude scales were used to collect quantitative data. A semi-structured interview form was used to gather qualitative data. In order to measure the students' laboratory self-efficacy, firstly, the "Criteria for the effective use of teachers' laboratory material" which was introduced by Linn and Gronlund (1995) into the literature and developed by Çepni et al. (2005) as "Items that measure teachers' attitudes and competences towards laboratory study" was adapted to the research problem. As a result of this study, the pre-test form of the data collection tool was formed by Böyük, Demir and Erol (2010). For each question in the questionnaire used in the research, the students were asked to rate as [(1) absolutely insufficient, (2) insufficient, (3) partially sufficient, (4) sufficient, (5) absolutely sufficient]. There were 18 questions in the questionnaire, so the self-efficacy scores of the students who participated in the study were a maximum of 90 points and a minimum of 18 points. Böyük et al. (2010) calculated the Cronbach alpha reliability coefficient of the scale as .89. The Cronbach alpha, which is the reliability coefficient of the questionnaire used in this study, was recalculated for both the pre-test and the final test and the new sample was taken into account. According to the data, the Cronbach's alpha reliability coefficient was found as .82 for the pre-test and .87 for the post-test.

For the validity of the scale, content validity study was conducted because the laboratory self-efficacy scale developed by Böyük et al. (2010) was developed for science teachers. Therefore, to adapt the scale to the pre-service teachers in higher education, eight instructors (science education experts) evaluated the items in the measuring instrument. The researchers asked the experts to evaluate the scale's suitability for pre-service teachers (by scoring 1 to 4 for each item). This evaluation was carried out with the content validity index on an item basis. According to the index, the degree of consistency between the raters (instructors) should be at least .80 (Szymanski & Linkowski, 1993). The compliance of the scale was found between .812 and 1.00 and 95.66% as a whole. The degree of consistency at

this rate indicates an acceptable level. Inter-rater reliability was calculated by non-parametric Kendall's W- (Kendall's coefficient of concordance) analysis. The Kendall W test is used to determine the compatibility between more than two independent scoring (Legendre, 2005). As a result of this analysis, it was found that there was a statistically significant agreement between eight different experts for the 18 items. W (17) = .719 ($X^2$ = 97.812; p = .000). W <.70 and p> .05 can be considered high as the validity of the test (Legendre, 2005).

To determine the change in students' attitudes to physics laboratories before and after the application, the "Attitude Scale towards Physics Laboratory" which was developed by Nuhoğlu and Yalçın (2004) and tested for its reliability and validity in many studies in the related literature was used. The scale is rated with five options and four equally spaced Likert types ranging from "Strongly Agree" to "Strongly Disagree". The scale consists of 36 items related to university students' attitudes and perceptions towards physics laboratories. Nuhoğlu and Yalçın (2004) calculated the Cronbach's alpha reliability coefficient of the scale as .89. Likewise, the construct validity of the scale was provided by factor analysis by Nuhoğlu and Yalçın (2004). At the end of the rotation with Varimax Factor Analysis for scale items on attitude, it was decided that the scale was one-dimensional. Kaiser-Meyer-Olkin (KMO) coefficient and Bartlett Sphericity test were used to determine the suitability of the data for factor analysis and sample adequacy. In this respect, the compliance of the data with the sample group was found to be KMO value at .854 and Barlet Test value was found as 3386.70. The sample is adequate if the value of KMO is greater than 0.5 (Field, 2000).

For the reliability of the scales, the stability of the measured values obtained from the repeated measurements under the same conditions is an important indicator (Carmines & Zeller, 1982). The Cronbach's alpha reliability coefficient of the questionnaire used in this study was re-calculated for both the pre-test and the final test, taking the new sample into consideration. According to the data, the Cronbach's alpha reliability coefficient was found as .78 for the pre-test and .81 for the post-test.

In order to reveal the opinions and suggestions of the participants in the experimental group on the use of the FC model in physics laboratories, a semi-structured interview form was developed and interviews were conducted with the students. The purpose of these interviews is to have an in-depth understanding of the students' thoughts on any activity.

The semi-structured interview form was given to the experimental group (N = 42) in which the AR-based FC model was applied. In this form, a question like "What are the advantages and disadvantages of the FC model teaching practices for the learning process?" would qualitatively describe the views of the participants in the experimental group.

**Data Analysis**

First of all, in order to gather information about the experiences of participants using technology, the time spent using the smartphone and Facebook and the time spent on the internet were analysed through the descriptive statistics method (see Table 2). An analysis of the collected data, including reliability analysis, was performed with a computer-aided statistical program. Before that, whether the data from the experimental and control groups showed a normal distribution was examined. In this study, Shapiro-Wilk test was used because the number of students was below 50 (n = 42). When the Shapiro-Wilk test for the "Laboratory Self-efficacy Scale" (experimental group, p= .17; control group, p= .22) and "Attitude Scale Towards Physics Laboratory" (experimental group, p= .13; control group, p= .34) was applied to both experimental and control groups, there was no significant difference in the p <.05 level in the experimental group and control group. Therefore, it was concluded that the experimental group and control group data showed normal distribution in both scales. For this reason, the parametric statistical tests were used in the analysis. Thus, an independent sample t test was performed as pre-test and post-test to determine whether there is a

significant difference between the laboratory self-efficacy and laboratory attitude scores of the experimental and control groups.

An analysis of the qualitative data obtained as a result of the interview with the students who participated in the study on a voluntary basis was made by the content analysis method. Content analysis consists of a variety of processes for determining the research questions to be answered, selecting the sample to be analysed, identifying the categories to be applied, determining the coding process and coding training, applying the coding process, determining the reliability and analysing the results of the coding process (Kaid & Wadsworth, 1989). In the data analysis process, firstly the research data were coded and themes were formed. After that, codes and themes were arranged and the findings were interpreted. Students were coded in the form of Pre-service Science Teacher (PST1-PST42) numbered from 1 to 42.

With the help of expert opinions and objective coding, most content analysis studies can provide validity standard (Potter & Levine-Donnerstein, 1999). Reliability of the measuring instrument was tested with a percentage of the agreement between two field education experts (Şencan, 2005). Students' opinions were evaluated separately by two field education experts. Then, Reliability = Agreement / (Contract + Disagreement) reliability formula by Miles and Huberman (1994) was used in the content analysis of the data collected by calculating the matching ratios in the research. As a result, the reliability of the coding was calculated as 82% and considered to be reliable. The analysis of the research is expected to be more than 70% of reliability (Miles & Huberman, 1994).

## Findings

**RQ #1:** *Is there a significant difference in terms of the laboratory self-efficacy between the experimental and control group?*

In order to test whether there is a significant difference between the laboratory self-efficacy scores of the students in both groups, a t-test analysis was performed. Thus, the equivalence of both groups was investigated and no significant difference was able to be found. After the application, the groups were given the same measurement tool as the post-test and the difference between the post-test scores of the groups was significant. Pre-test and post-test t test analyses are given in Table 4.

**Table 4**
*T-test Results for the Pre-test and Post-test Means of the Experiment and Control Groups for Laboratory Self-Efficacy*

| Variable | Group | N | Mean | SD | T | p | Cohen's d |
|---|---|---|---|---|---|---|---|
| Pre-test | Control group | 42 | 3.56 | .21 | 1.52 | .13 | |
| | Experimental group | 42 | 3.67 | .34 | | | |
| Post-test | Control group | 42 | 3.77 | .24 | 2.5 | .014[*] | .545 |
| | Experimental group | 42 | 4.02 | .59 | | | |

*<.05

Although the statistical significance tests are usually used to determine the difference between the mean scores of groups in the literature, it is not possible to say the same thing for the effect size which helps to make a more accurate decision about the results obtained by eliminating the effects caused by the number of samples in those significance tests. The effect size measurements calculated according to the difference of the group means were calculated as Cohen's d (Cohen, 1988), (.545) in Table 4 and (.713) in Table 5 in this study. The Cohen's d value obtained as a result of the calculations is interpreted as follows: .20- small effect size; .50- medium; .80 large effect size (Cohen, 1988). Table 5 reveals a significant difference in the post-test in favour of the experimental group. In addition, it

was concluded that the FC model had a positive effect on the laboratory self-efficacy of university students.

**RQ #2.** *Is there a significant difference in attitude scores between the experimental and control groups?*

The attitude questionnaire was applied to both groups before and after the application to determine whether the FC model had had an effect on students' attitudes towards physics labs. As a result, no significant difference was found between the attitude scores of the groups before the application. Thus, it can be said that the attitudes of both groups are equal before the application.

**Table 5**
*T-test Results for the Pre-test and Post-test Means of the Experimental and Control Groups for Attitude Scores*

| Varible | Group | N | Mean | SD | T | p | Cohen's d |
|---|---|---|---|---|---|---|---|
| Pre-test | Control group | 42 | 3.67 | .28 | .65 | .51 | |
| | Experimental group | 42 | 3.73 | .52 | | | |
| Post-test | Control group | 42 | 4.00 | .50 | 3.27 | .002* | .713 |
| | Experimental group | 42 | 4.28 | .26 | | | |

*<.05

At the end of the application, there was an increase in the attitude scores of the students in the experimental group. Table 5 shows a significant difference between the groups. As a result, the FC model seems to have a positive effect on students' attitudes towards physics laboratories.

**RQ #3.** *What is the opinion of the experimental group for the FC model?*

The data obtained from the interviews with the students are presented in two categories. The first one is classified as the positive effects of FC model and the other one as negative effects of the FC model. Therefore, when the data obtained from the interview were examined, the students in the experimental group thought that the FC model applied in the physics laboratory provided some positive and negative characteristics. Table 6 shows the coding and frequency distributions of the student expressions obtained from interview data according to the content analysis.

Considering the data in Table 6, some of the most remarkable statements of pre-service teachers are given below.

PST*23: "At first, while experimenting in laboratores, it was the most time-consuming process because it was a very difficult process to understand. But in the videos I watched in the FC practice, I completed the experiments in a very short time because I knew the tools used in the experiments and their purposes. So, I had more time to evaluate the other parts of the experiment."*

PST*12: "Generally, the question-answer section never really achieved its goal at the end of the experiments. These sections were either ignored or given to us as homework, but with this application more time remained in the laboratory to the question and answer section."*

PST*8:* "*Before these applications, I was attending classes using both internet and textbooks. But these methods were both boring and very useless. With this application, I wanted to participate more and more in activities without getting bored through the Facebook group and watch the videos prepared remarkably. I was also able to access the videos about the experiments at any time, so I had the opportunity to study anywhere and anytime.*"

PST*2:* "*I accessed the videos prepared for us only at home, so watching all the videos took much time.*"

**Table 6**
*The Students' Comments (Advantages and Disadvantages of the FC Model)*

| Categories | Comments | Responses |
|---|---|---|
| | Experiments were completed in a shorter time | 37 |
| | More time was allowed for questions and answers at the end of the experiment | 32 |
| | I set the studying time myself | 28 |
| | Knowing the tools used in the experiment saved time | 25 |
| Advantages of FC model | Preliminary monitoring of the experiment facilitated it | 19 |
| | Videos were easily accessed | 17 |
| | As a member of the Facebook group I had the opportunity to study more efficiently | 14 |
| | I was afraid to ask questions, so I had the opportunity to watch videos again and again until I could understand them | 13 |
| Disadvantages of FC model | None | 22 |
| | Watching videos took a lot of time at home | 10 |

## Conclusion and Discussion

This study took place in a physics laboratory was conducted to measure the effects of the FC model on the laboratory self-efficacy and attitudes of university students and to find out about their opinions.

The experimental results regarding the first aim show that the FC model positively affects the laboratory self-efficacy of students. In accordance with the literature (Berrett, 2012; Deslauriers et al., 2011; Haak, HilleRisLambers, Pitre, & Freeman, 2011; Lin, 2019), this study shows that a class in which the FC model is applied can produce better learning outcomes as it increases the opportunity for more practice. Therefore, the experimental process helps students to acquire better laboratory self-efficacy (Aşıksoy & Özdamlı, 2016; Schultz et al., 2014).

Further to that, the data obtained regarding the second aim of the study show that the FC model positively affects students' attitudes towards the laboratory, which is also confirm by the related literature (See also Chao, Chen, & Chuang, 2015; Wanner & Palmer, 2015; Olakanmi, 2017). Studies on the FC practices reveal that students are more ready to participate in face-to-face, interactive and high-level activities such as problem-solving and discussion (Gaughan, 2014). However, the benefits claimed for the FC model are mainly reflected in the self-acquired perceptions and attitudes in the process rather than directly reflected in the learning outcomes (O'Flaherty & Phillips, 2015).

In contrast, Presti (2016) found that the FC model had no effect on students' attitudes. There are many studies that have negative findings as to the FC model providing a significant improvement in student performance (Blair, Maharaj, & Primus, 2016; Davies et al., 2013; Findlay-Thompson & Mombourquette, 2014; Karabulut-Ilgu, Jaramillo Cherrez, & Hassall, 2018). This situation was directly related to the change in the learning process and learning environment. Students may find the FC model uncomfortable at first sight, and some are not satisfied with the change in the traditional

approach despite learning outcomes (Strayer, 2012). In addition, students may feel under pressure or anxious to complete their inverted learning activities (Marcum & Perry, 2015). Therefore, such negative consequences are possible. On the other hand, it is a different finding that initially students do not have a positive or negative view of preparing for the course in which the FC model is followed by watching online videos, but as the time progresses, students' attitudes towards the FC model have improved positively and they have adopted access to online content (Smallhorn, 2017). Moreover, although students' participation in the FC model, a very new learning environment, has been shown to lead to a satisfactory decrease in student attitudes (Gutwill-Wise, 2001), this practice has not adversely affected student satisfaction. The lack of negative attitudes in the study can be evaluated as a result of the AR and Facebook social media interaction as a measure in the learning process.

Also, student views regarding the third aim of the study revealed important results about the FC model. The experiments were completed in a shorter time, more time remained for the question & answer section at the end of the experiment, the time of the study was determined by the students, pre-understanding of the equipment used in the experiment saved time, pre-monitoring the experiment made it easier, videos were easily accessed, and as a member of the Facebook group, the students studied more efficiently in the group that the FC model was applied. The literature review suggests that the benefits of the FC model include improved participation, more student satisfaction, more class participation time, more flexibility, immediate support and feedback, higher-level thinking, and individualized learning experiences (Sams & Bergmann, 2013; Karamustafaoğlu, & Kılıç, 2018). Therefore, the study findings are consistent with the literature. In parallel with the findings of the study, Luo, Yang, Xue and Zuo (2019) concluded that the pre-class preparations, the teaching content and the exercises of the students were clearly useful in the classes in which the FC model was applied. Similarly, the study of Bedi (2018) found that students showed positive attitudes to video conferencing and 24-hour availability and participated in online learning in their spare time by using digital learning tools such as tablets and smartphones.

Furthermore, university students could easily access the videos with their smart phones and had the opportunity to watch them again with the help of AR applications used. Similarly, in the study conducted by Butt (2014), the students commented that the video sections including difficult subjects are frequently re-monitored and that re-watching the videos about a concept creates a very positive perception in them. Similarly, Wanner and Palmer (2015) have reported students' views that reflect the tremendous flexibility of the video's ability to identify their time with the FC concept in their study. In addition, Heijstra and Sigurðardóttir (2018) reports that in their study the flipped class has a distinct advantage over the traditional class. This advantage allows recordings to be displayed online, and students to view recordings several times, to pause for note-taking, to delete back if something is not clear for the first time, and to view recordings at their own pace. The opportunity to track recordings more than once can support or motivate students to self-control and learn the subject or concept. In addition, the use of AR and smart phones in the application has provided advantages to the students. Because it has been beneficial for students who hesitate to ask questions and have the opportunity to watch the videos until they understand them. In parallel with this finding in the research, students were found to be embarrassed for asking the concepts they did not understand in the traditional classroom environment. The findings of this study are similar to those of the literature. Students watch the videos again and again without considering the thoughts of other students in FC practices (Baepler, Walker, & Driessen, 2014; Schultz et al., 2014).

Students' views, which include the first two sub-problems of this study, show that the learning process open to both independent and interactive learning is recognized in connection with the digital and social media included in the FC model. In fact, Awidi and Paynter (2019) developed a five-point model that fostered learning in a digital learning environment including having access to resources and information, support elements and motivation, participation and collaboration, evaluation and feedback and finally the process of structuring knowledge (Awidi & Paynter, 2019). Therefore, the FC

model is successful in self-efficacy and attitude with the elements considered in the study. In this study, the AR and Facebook applications intended to increase student motivation in the FC practice resulted in an increase in contrast to the decrease in motivation observed in the literature.

Considering students who expressed their views on the negative aspects of the FC model, the necessity of monitoring videos outside the classroom had a negative effect on students. They stated that watching videos took a lot of time at home. Therefore, they were negatively affected by the FC practices. If they do not follow the required courses before the lesson, they do not fully benefit from the FC practice which requires students to participate in the course (Butt, 2014). To eliminate this problem, it is necessary to create short videos and to get the opinions and suggestions of students. In addition, these applications should be frequently included in university classrooms so that students can become more familiar with them. Thus, there will be a significant increase in the positive attitudes and opinions of students towards the FC practices.

## Limitations and Future Research

Considering the participants' opinions at the end of the research, it should be noted that the video duration should be short when preparing videos to be used in the FC model in order not to reduce the motivation of learners. Because they can get bored while watching videos that take a long time in out-of-classroom environments. When preparing videos for the FC model, an interview with a group of students will increase the efficiency of learning. Considering these situations, the disadvantages of FC model will be reduced. The study was limited to only two learning products for the physics laboratory. In the studies to be carried out for the FC model, the diversity of learning products can be increased and the results of applications in different disciplines can be examined. In addition, this study, which is limited by purposeful sampling, may provide a more generalization as a result of using different sampling models.

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# References

Abeysekera, L., & Dawson, P. (2015). Motivation and Cognitive Load in the Flipped Classroom: Definition, Rationale and a Call for Research. *Higher Education Research & Development, 34*(1), 1–14. https://doi.org/10.1080/07294360.2014.934336.

Akbaş, O., & Pektaş, H. M. (2011, December). The effects of using an interactive whiteboard on the academic achievement of university students. *In Asia-Pacific Forum on Science Learning and Teaching, 12*(2), 1-19.

Akçayır, M., Akçayır, G, Pektaş, H.M. & Ocak, M.A. (2016). Augmented reality in science laboratories: The effects of augmented reality on university students' laboratory skills and attitudes toward science laboratories, Computers in Human Behavior, 57, 334–342.

Akı, F. N., & Gürel, Z. (2016). Freshman year computer engineering students' experiences for flipped physics lab class: An action research. In: *AIP Conference Proceedings: Turkish Physical Society 32nd International Physics Congress (TPS32),* Bodrum, Turkey, 6-9 September 2016, pp. 070001. Turkey: AIP Publishing. https://doi.org/10.1063/1.4976422

Álvarez, B. (2012). Flipping the classroom: Homework in class, lessons at home. *Education Digest, 77*(8), 18–21. https://search.proquest.com/docview/1008666019?accountid=16369 Accessed 09 January 2019.

Aşıksoy, G., & Özdamlı, F. (2016). Flipped Classroom adapted to the ARCS Model of Motivation and applied to a Physics Course. *Eurasia Journal of Mathematics, Science & Technology Education*, *12*(6), 1589–1603. https://doi.org/10.12973/eurasia.2016.1251a

Awidi, I. T., & Paynter, M. (2019). The impact of a flipped classroom approach on student learning experience. *Computers & Education*, *128*, 269-283. https://doi.org/10.1016/j.compedu.2018.09.013

Baepler, P., Walker, J. D., & Driessen, M. (2014). It's not about seat time: Blending, flipping, and efficiency in active learning classrooms. *Computers & Education, 78*, 227-236. https://doi.org/10.1016/j.compedu.2014.06.006

Bandura, A. (1994). Self efficacy. In V. S. Ramachaudran (ed). *Encylopedia of human behavior*. New York, pp. 71-81.http://www.uky.edu/~eushe2/Bandura/BanEncy.html#top. Accessed 08 January 2019.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*, 191–215. https://psycnet.apa.org/record/1977-25733-001. Accessed 08 January 2019.

Bedi, J. (2018). *A review of students' perceptions, engagement, and academic achievement in the flipped classroom*. Master thesis, University of Victoria, Canada. https://dspace.library.uvic.ca//handle/1828/9233. Accessed 09 January 2019.

Bergmann, J., & Sams, A. (2012). *Flip Your Classroom. Reach Every Student in Every Class Every Day*. Washington, DC: International Society for Technology in Education.

Berrett, D. (2012). How 'flipping'the classroom can improve the traditional lecture. *The Chronicle of Higher Education*, *12*(19), 1-14. https://www.chronicle.com/article/How-Flipping-the-Classroom/130857. Accessed 08 January 2019.

Blair, E., Maharaj, C., & Primus, S. (2016). Performance and perception in the flipped classroom. *Education & Information Technologies, 21*, 1465–1482. https://doi.org/10.1007/s10639-015-9393-5

Bosch, T. E. (2009). Using online social networking for teaching and learning: Facebook use at the University of Cape Town. *Communicatio: South African Journal for Communication Theory and Research*, *35*(2), 185-200. https://doi.org/10.1080/02500160903250648

Boyd, D. M., & Ellison, N. B. (2007). Social network sites: Definition, history, and scholarship. *Journal of computer‐mediated Communication*, *13*(1), 210-230. https://doi.org/10.1111/j.1083-6101.2007.00393.x

Böyük, U., Demir, S., & Erol, M. (2010). Fen ve teknoloji dersi öğretmenlerinin laboratuvar çalışmalarına yönelik yeterlik görüşlerinin farklı değişkenlere göre incelenmesi [Analyzing the proficiency views of science and technology teachers on laboratory studies in terms of different varriables]. *Turkish Science-Research Foundation, 3*(4), 342-349. https://dergipark.org.tr/en/download/article-file/799639. Accessed 08 January 2019.

Brewer, R., & Movahedazarhouligh, S. (2018). Successful stories and conflicts: A literature review on the effectiveness of flipped learning in higher education. *Journal of Computer Assisted Learning, 34*(4), 409-416. https://doi.org/10.1111/jcal.12250.

Burden, K., & Kearney, M. (2016). Future scenarios for mobile science learning. *Research in Science Education, 46*(2), 287-308. https://doi.org/10.1007/s11165-016-9514-1.

Burke, A. S., & Fedorek, B. (2017). Does "flipping" promote engagement? A comparison of a traditional, online, and flipped class. *Active Learning in Higher Education, 18*(1), 11-24. https://doi.org/10.1177/1469787417693487

Butt, A. (2014). Student views on the use of a flipped classroom approach: Evidence from Australia. *Business Education & Accreditation*, *6(*1), 33-43. http://www.theibfr2.com/RePEc/ibf/beaccr/bea-v6n1-2014/BEA-V6N1-2014.pdf#page=35. Accessed 08 January 2019.

Carmines, E. G., & Zeller, R. A. (1982). *Reliability and validity assessment.* Beverly Hills: Sage Publications.

Çelik, H., & Pektaş, H. M. (2017). Graphic comprehension and interpretation skills of preservice teachers with different learning approaches in a technology-aided learning environment. *International Journal of Science and Mathematics Education, 15*(1), 1-17. https://doi.org/10.1007/s10763-015-9667-9

Chambers, S. K., & Andre, T. (1997). Gender, prior knowledge, interest, and experience in electricity and conceptual change text manipulations in learning about direct current. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *34*(2), 107-123. https://doi.org/10.1002/(SICI)1098-2736(199702)34:2<107::AID-TEA2>3.0.CO;2-X

Chao, C. Y., Chen, Y. T., & Chuang, K. Y. (2015). Exploring students' learning attitude and achievement in flipped learning supported computer aided design curriculum: A study in high school engineering education. *Computer Applications in Engineering Education, 23*(4), 514-526. https://doi.org/10.1002/cae.21622

Chen, G. D., Chang, C. K., & Wang, C. Y. (2008). Ubiquitous Learning Website: Scaffold Learners by Mobile Devices with Informationaware Technologies. *Computers & Education, 50*(1), 77-90. https://doi.org/10.1016/j.compedu.2006.03.004

Chen, Y., Wang, Y., & Chen, N. S. (2014). Is FLIP enough? Or should we use the FLIPPED model instead? *Computers & Education, 79*, 16-27. https://doi.org/10.1016/j.compedu.2014.07.004

Chuang, H.H, Weng, C. Y., & Chen, C.H. (2016). Which students benefit most from a flipped classroom approach to language learning? *British Journal of Educational Technology, 49*(1), 56-68. https://doi.org/10.1111/bjet.12530

Churchill, D., & Hedberg, J. (2008). Learning object design considerations for small-screen handheld devices. *Computers & Education, 50* (3), 881–893. https://doi.org/10.1016/j.compedu.2006.09.004

Cohen, J. (1988). *Statistical power analysis fort he behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Creswell, J. W. 2003. *Qualitative, Quantitative and Mixed Methods Approaches.* Thousand Oaks, CA: Sage Publications.

Çepni, S., Kaya, A., & Küçük, M. (2005). Fizik öğretmenlerinin laboratuvarlara yönelik hizmet içi ihtiyaçlarının belirlenmesi [Determining the physics teachers' in-service needs for laboratories]. *J. Turkish Educ. Sci, 3*(2), 181-196. http://dergipark.gov.tr/tebd/issue/26124/275193. Accessed 06 January 2019.

Davies, R. S., Dean, D. L., & Ball, N. (2013). Flipping the classroom and instructional technology integration in a college-level information systems spreadsheet course. *Education Tech Research Dev, 61*, 563–580. https://doi.org/10.1007/s11423-013-9305-6

Deslauriers, L., Schelew, E., & Wieman, C. (2011). Improved learning in a large-enrollment physics class. *Science, 332*(6031), 862-864. https://doi.org/10.1126/science.1201783

Er, E., Kopcha, T. J., Orey, M., Dustman, W. (2015). Exploring College Students' Online Help-Seeking Behavior in a Flipped Classroom with a Web-Based Help-Seeking Tool. *Australasian Journal of Educational Technology, 31*(5), 537-555.

Fidalgo-Blanco, A., Martinez-Nuñez, M., Borrás-Gene, O., & Sanchez-Medina, J. J. (2017). Micro flip teaching- an innovative model to promote the active involvement of students. *Computers in Human Behavior, 72*, 713–723. https://doi.org/10.1016/j.chb.2016.07.060

Field, A. (2000). *Discovering Statistics Using SPSS for Windows.* London: Thousand Oaks.

Findlay-Thompson, S., & Mombourquette, P. (2014). Evaluation of a Flipped Classroom in an Undergraduate Business Course. *Business Education & Accreditation, 6*(1), 63-71. https://ssrn.com/abstract=2331035. Accessed 06 January 2019.

Gaughan, J. E. (2014). The flipped classroom in world history. *The History Teacher*, *47*(2), 221-244. https://www.jstor.org/stable/43264225?seq=1#metadata_info_tab_contents. Accessed 06 January 2019.

Gutwill-Wise J. P. (2001). The impact of active and context-based learning in introductory chemistry courses: an early evaluation of the modular approach. *J. Chem. Educ., 78*, 684–690. https://doi.org/10.1021/ed078p684

Gençer, B.G. (2015). *A case study towards the implementation of the flipped classroom model in the schools.* Master Thesis. Bahçeşehir University, İstanbul.

Gómez-Tejedor, J. A., Vidaurre, A., Tort-Ausina, I., Molina-Mateo, J., Serrano, M. A., Meseguer-Dueñas, J. M., ... & Riera, J. (2020). Effectiveness of flip teaching on engineering students' performance in the physics lab. *Computers & Education, 144*, 103708. https://doi.org/10.1016/j.compedu.2019.103708

Haak, D. C., HilleRisLambers, J., Pitre, E., & Freeman, S. (2011). Increased structure and active learning reduce the achievement gap in introductory Biology *Science*, *332*(6034), 1213-1216. https://doi.org/10.1126/science.1204820

Hao, Y. (2016). Exploring undergraduates' perspectives and flipped learning readiness in their flipped classrooms. *Computers in Human Behavior, 59*, 82–92. https://doi.org/10.1016/j.chb.2016.01.032

Hao, Y., & Lee, K. S. (2016). Teaching in flipped classrooms: Exploring pre-service teachers' concerns. *Computers in Human Behavior, 57,* 250–260. https://doi.org/10.1016/j.chb.2015.12.022.

Heijstra, T. M., & Sigurðardóttir, M. S. (2018). The flipped classroom: Does viewing the recordings matter? *Active Learning in Higher Education, 19(3)*, 211-223. https://doi.org/10.1177/1469787417723217

Herreid, C.F., & Schiller, N.A. (2013). Case studies and the flipped classroom. *Journal of College Science Teaching, 42*(5), 62-66. ttps://www.jstor.org/stable/43631584. Accessed 06 January 2019.

Hwang, G. J., Lai, C. L., & Wang, S. Y. (2015). Seamless flipped learning: a mobile technology enhanced flipped classroom with effective learning strategies. *Journal of Computers in Education, 2*(4), 449–473. https://doi.org/10.1007/s40692-015-0043-0.

Jensen, J. L., Kummer, T. A., & Godoy, P. D. D. M. (2015). Improvements from a flipped classroom may simply be the fruits of active learning. *CBE—Life Sciences Education, 14*, 1-12. https://doi.org/10.1187/10.1187/cbe.14-08-0129

Jones, V., & Jo, J. H. (2004). Ubiquitous learning environment: An adaptive teaching system using ubiquitous technology. In: *Beyond the comfort zone: Proceedings of the 21st ASCILITE Conference* (eds R Atkinson, C McBeath, D Jonas-Dwyer and R Phillips), Perth, Western Australia, 5-8 December 2004, pp. 468-474, Perth: ASCILITE. https://www.ascilite.org/conferences/perth04/procs/jones.html. Accessed 06 January 2019.

Kaid, L. L., & Wadsworth, A. J. (1989). Content analysis. In: Emmert P and Barker LL (eds) *Measurement of Communication Behavior*. New York: Longman, pp. 197–217.

Karabulut-Ilgu, A., Jaramillo Cherrez, N., & Hassall, L. (2018). Flipping to engage students: Instructor perspectives on flipping large enrollment courses. *Australasian Journal of Educational Technology, 34*(4), 123-137. https://doi.org/10.14742/ajet.4036

Karamustafaoğlu, O., & Kılıç, M.F. (2018). *A Content Analysis of The Researches In The Framework of Flipped Classroom Model*, 2nd International Symposium on Silk Road Academic Studies (ISSAS), The Book of Full Text p. 342-359, Nevşehir-Turkey.

King, B.M., & Newmann, F.M. (2001). Building school capacity through professional development: conceptual and empirical considerations. *International Journal of Educational Management, 15* (2), 86-94. https://doi.org/10.1108/09513540110383818

Kirschner, P. A., & Karpinski, A. C. (2010). Facebook® and academic performance. *Computers in Human Behavior*, *26*(6), 1237-1245. https://doi.org/10.1016/j.chb.2010.03.024

Legendre, P. (2005). Species associations: The kendall coefficient of concordance revisited. *Journal of Agricultural, Biological, and Environmental Statistics, 10* (2), 226–245. https://doi.org/10.1198/108571105X46642

Lin, Y. T. (2019). Impacts of a flipped classroom with a smart learning diagnosis system on students' learning performance, perception, and problem solving ability in a software engineering course. *Computers in Human Behavior*, 95, 187- 196. https://doi.org/10.1016/j.chb.2018.11.036.

Linn, R. L., & Gronlund, N, E. (1995). *Measurement and Assessment in Teaching*, (7th Edition), Prentice-Hall International (UK) Limited, London.

Luo, H., Yang, T., Xue, J., & Zuo, M. (2018). Impact of student agency on learning performance and learning experience in a flipped classroom. *British Journal of Educational Technology, 50*(2), 819-831. https://doi.org/10.1111/bjet.12604

Marcum, T. M., & Perry, S. J. (2015). Flips and flops: A new approach to a traditonal law course. *Journal of Legal Studies Education*, *32*(2), 255-286. https://doi.org/10.1111/jlse.12028

McCarthy, J. (2012). International design collaboration and mentoring for tertiary students through Facebook. *Australasian Journal of Educational Technology*, *28*(5), 755-775. https://doi.org/10.14742/ajet.1383

McLean, S., & Attardi, S. M. (2018). Sage or guide? Student perceptions of the role of the instructor in a flipped classroom. *Active Learning in Higher Education*. 1-13. https://doi.org/10.1177/1469787418793725

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. Thousand Oaks. CA: Sage Publications.

Missildine, K., Fountain, R., Summers, L., & Gosselin, K. (2013). Flipping the classroom to improve student performance and satisfaction. *Journal of Nursing Education, 52*(10), 597–599. https://doi.org/10.3928/01484834-20130919-03.

Moffett, J. (2015). Twelve tips for "flipping" the classroom. *Medical Teacher, 37*(4), 331–336. https://doi.org/10.3109/0142159X.2014.943710

Nicol, A. A., Owens, S. M., Le Coze, S. S., MacIntyre, A., & Eastwood, C. (2018). Comparison of high-technology active learning and low-technology active learning classrooms. *Active Learning in Higher Education, 19*(3), 253-265. https://doi.org/10.1177/1469787417731176

Nuhoğlu, H., & Yalçın, N. (2004). Fizik laboratuvarına yönelik bir tutum ölçeğinin geliştirilmesi ve öğretmen adaylarının fizik laboratuvarına yönelik tutumlarının değerlendirilmesi [The development of attitude scale for physics laboratory and the assessment of pre-service teachers' attitudes towards physics laboratory]. *Gazi University Kırşehir Faculty of Education Journal, 5*(2), 317-327. http://dergipark.gov.tr/download/article-file/15758. Accessed 06 January 2019.

O'Flaherty, J., & Phillips, C. (2015). The use of flipped classrooms in higher education: A scoping review. *The İnternet and Higher Education*, *25*, 85-95. https://doi.org/10.1016/j.iheduc.2015.02.002

Olakanmi, E. E. (2017). The effects of a flipped classroom model of instruction on students' performance and attitudes towards chemistry. *Journal of Science Education and Technology*, *26*(1), 127-137. https://doi.org/10.1007/s10956-016-9657-x

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, *25*(9), 1049-1079. https://doi.org/10.1080/0950069032000032199.

Owens, D. C., Sadler, T. D., Barlow, A. T., & Smith-Walters, C. (2017). Student motivation from and resistance to active learning rooted in essential science practices. *Research in Science Education*, 1-25. https://doi.org/10.1007/s11165-017-9688-1

Özmen, H. & Karamustafaoğlu, O. (2019). *Eğitimde Araştırma Yöntemleri* [Research Methods in Education], Ankara: Pegem Publishing.

Pajares, F. (1996). Self-efficacy beliefs in academic settings. *Review of Educational Research, 66*,543–578. https://doi.org/10.3102/00346543066004543

Palic, G., & Pirasa, N. (2012). A study of pre-service teachers' tendency for imprudent behaviour and physics laboratory attitudes. *Procedia-Social and Behavioral Sciences*, *47*, 823-828. https://core.ac.uk/download/pdf/82161005.pdf. Accessed 06 January 2019.

Patton, M. Q. (2002). *Qualitative research & evaluation methods*, 3rd ed, Thousand Oaks. CA: Sage Publications.

Potter, W., J., & Levine-Donnerstein, D. (1999). Rethinking validity and reliability in content analysis. *Journal of Applied Communication Research*, 27, 258–284. https://doi.org/10.1080/009098899096559

Presti, C. R. (2016). The flipped learning approach in nursing education: A literature review. *Journal of Nursing Education, 55*(5), 252-257. https://doi.org/10.3928/01484834-20160414-03

Rambe, P. (2012). Critical discourse analysis of collaborative engagement in Facebook postings. *Australasian Journal of Educational Technology*, *28*(2), 295-314. https://doi.org/10.14742/ajet.875

Sams, A., & Bergmann, J. (2013). Flip your students' learning. *Educational Leadership, 70*(6), 16–20. http://www.ascd.org/publications/educational-leadership/mar13/vol70/num06/Flip-Your-Students'-Learning.aspx. Accessed 06 January 2019.

Samuel, L.M. (2019). Flipped pedagogy and student evaluations of teaching. *Active Learning in Higher Education*. https://doi.org/10.1177/1469787419855188

Schultz, D., Duffield, S., Rasmussen, S. C., & Wageman, J. (2014). Effects of the flipped classroom model on student performance for advanced placement high school chemistry students. *Journal of Chemical Education, 91*(9), 1334-1339. https://doi.org/10.1021/ed400868x

Şencan, H. (2005). *Sosyal ve davranışsal ölçümlerde güvenirlik ve geçerlik* [Reliability and validity in social and behavioral measurements], Ankara: Seçkin Publishing.

Sencar, S., & Eryılmaz, A. (2004). Factors mediating the effect of gender on ninth-grade Turkish students' misconceptions concerning electric circuits. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching, 41*(6), 603-616. https://doi.org/10.1002/tea.20016

Shih, W. L, & Tsai, C. Y. (2017). Students' perception of a flipped classroom approach to facilitating online project-based learning in marketing research courses. *Australasian Journal of Educational Technology, 33*(5), 32-49. https://doi.org/10.14742/ajet.2884

Shipstone, D. (1998). Pupils' understanding of simple electrical circuits. *Physics Education, 23*, 92–96. https://doi.org/10.1088/0031-9120/23/2/004

Sitzmann, T., & Yeo, G. (2013). A meta-analytic investigation of the within-person self-efficacy domain: Is self-efficacy a product of past performance or a driver of future performance? *Personnel Psychology, 66*(3), 531-568. https://doi.org/10.1111/peps.12035

Smallhorn, M. (2017). The flipped classroom: A learning model to increase student engagement not academic achievement. *Student Success*, *8*(2), 43-53. https://doi.org/10.5204/ssj.v8i2.381

Sohrabi, B., & Iraj, H. (2016). Implementing flipped classroom using digital media: A comparison of two demographically different groups perceptions. *Computers in Human Behavior, 60*, 514-524.

Strayer, J. F. (2012). How learning in an inverted classroom influences cooperation, innovation and task orientation. *Learning Environments Research, 15*(2), 171–193. https://doi.org/10.1007/s10984-012-9108-4

Szymanski, E. M., & Linkowski, D. C. (1993). Human resource development: An examination of perceived training needs of certified rehabilitation counselors. *Rehabilitation Counseling Bulletin, 37* (2), 163-176. https://doi.org/10.1891/0047-2220.24.4.58

Wanner, T., & Palmer, E. (2015). Personalising learning: Exploring student and teacher perceptions about flexible learning and assessment in a flipped university course. *Computers & Education, 88*, 354-369. https://doi.org/10.1016/j.compedu.2015.07.008

Wei, X., Weng, D., Liu, Y., & Wang, Y. (2015). Teaching based on augmented reality for a technical creative design course. *Computers & Education*, *81*, 221-234. https://doi.org/10.1016/j.compedu.2014.10.017

Wilson, S. G. (2013). The flipped class a method to address the challenges of an undergraduate statistics course. *Teaching of Psychology, 40*(3), 193-199. https://doi.org/10.1177/0098628313487461

Zepke, N. (2013) Threshold concepts and student engagement: Revisiting pedagogical content knowledge. *Active Learning in Higher Education, 14*(2), 97–107. https://doi.org/10.1177/1469787413481127