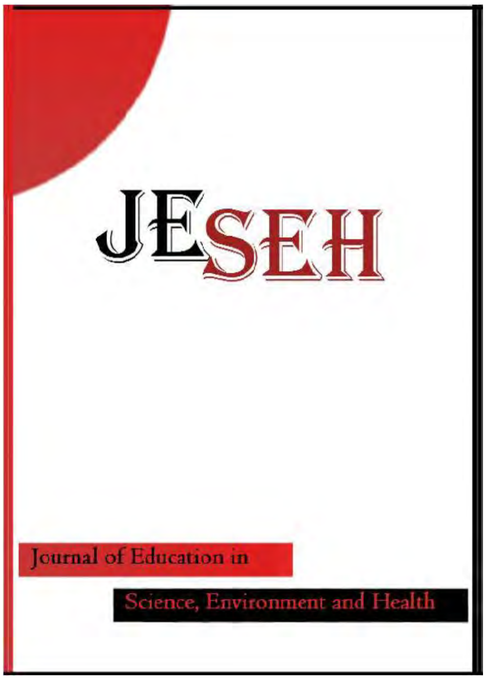

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The Effect of Flipped Learning Model on Pre-Service Science Teachers' Laboratory Practices

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Abstract

The aim of this study is to reveal the effect of the flipped learning model used in the laboratory practices course of pre-service teachers on their conceptual understanding and to evaluate their opinions about this model. In order to achieve this aim, science teaching laboratory applications course was conducted with the flipped learning model with undergraduate students studying at the education faculty of a state university in a metropolitan city in Turkey in the spring semester of the 2021-2022 academic year. The research was carried out with 47 pre-service teachers studying in the department of science teaching. The study was carried out with the mixed research method in which quantitative and qualitative models were used. In the quantitative part, the quasi-experimental design with the pre-test post-test control group was used, while the case study was used in the qualitative part. The Force and Motion Conceptual Comprehension Test, developed by Thornton and Sokoloff in 1995 and adapted in to Turkish by Kanlı and Gülçiçek in 2006, was used to collect data in the quantitative part of the study. For the qualitative part, a semi-structured interview form was used. Quantitative data were analyzed using the SPSS package program. Qualitative data were analyzed by descriptive analysis method according to the themes determined by two researchers. At the end of the study, no difference was found between the post-tests of the conceptual understanding levels of the groups. The pre-service teachers expressed the positive aspects of the flipped learning model as follows: it offers the opportunity to prepare before the lesson, being able to repeat the lessons, experience different classroom environment, facilitating the applications in the lesson, being student-centered, contributing to the individual learning speed, providing learning by understanding. In addition, according to the pre-service teachers, it was observed that this model expressed opinions such as it is difficult to cooperate, time cannot be used efficiently, interaction is low, learning by doing is limited, and it does not improve teaching skills.

Introduction

As a result of advances in technology and science, the needs of individuals and even societies have changed. In order for individuals to keep up with these changes, innovations and developments have been experienced in learning-teaching theories and approaches, and in this context, the roles of individuals have also been affected (Ministry of National Education [MoNE], 2018). The coronavirus disease (COVID-19), which emerged in 2019 and affected the whole world, has made the transition to distance education compulsory for children in primary, secondary, high school, college and vocational schools and university students (Hoofman MS2 & Secord MD, 2021; Tarkar, 2020). While the changes and developments in the field of technology contribute to the quality of education, the coronavirus disease, which causes the global epidemic, has also revealed the importance of utilizing technology in education. The COVID-19 epidemic, which has affected almost every field, especially education and training activities, which has become a global problem by affecting the whole world, has been one of the biggest problems that education systems have faced so far.

It has been tried to ensure the continuation of the education process with distance education solutions, which is a mandatory choice with the epidemic. A well-planned distance education process has the effect of providing many opportunities to students and teachers (ETF, 2018). In general, it is stated that countries continue to work to make the distance education process efficient and to increase its quality (Daniel, 2020). In higher education institutions, opportunities should be created for planning education for unexpected situations and for students and academicians to continue their education and research in a safe and healthy way.

In teaching practices, models/simulations are considered the heart of scientific research and are therefore emphasized as cornerstones for developing knowledge about the nature of science (NRC, 2000). In the framework program titled Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas on the teaching and applications of concepts in science education, the importance of scientific methods was emphasized. The understanding of avoiding monotony with different methods and techniques was adopted (NRC, 2012). In order to better understand the pedagogical functions of simulation/modeling teaching, one of the results reached in a review study conducted in the last ten years is: Conceptual understanding is the most common pedagogical element defined for simulation/modelling, but it has been noted to be of little use in developing applications and understanding science. (Campbell et al., 2015). At the same time, it is a common finding reached as a result of studies in which learning through modeling supports conceptual understanding (Hafner & Stewart, 1995; Sunyono, Leny & Muslimin, 2015; Thomson & Stewart, 2003). Another important point mentioned in the literature on this subject is that Gilbert (1991) agrees with the idea that simulation/models should be used by teachers and students in order to understand scientific knowledge and the nature of science.

Science course contains abstract concepts such as cell, DNA or molecular structure that cannot be seen or reached. In teaching such subjects, teachers use different technological approaches, simulation, video, model or modeling both in the classroom and out-of-class environments, enabling the subjects to be embodied and simplified, thus enabling them to understand science concepts and explore their functions. Simulation used in science education, etc. With these activities, students can learn cognitive skills such as matching, classification, analysis, synthesis, and problem solving by using variables. The flipped learning model, which removes the limitations of time and space and offers a brand new understanding of education as a model in which technology is actively used by simulation, gains importance in this context.

The flipped learning model contributes to learning by offering advantages such as high-level learning as a result of cooperative learning, a personalized learning environment with individual study, the opportunity to listen to the videos again whenever they want for course activities in online environments, providing student centered environments, and permanent learning with the use of multiple learning tools (Bergmann & Sams, 2012; Bishop & Vergeler, 2013).

Flipped Learning Model

Flipped learning model is defined as the process of students studying the subjects at home by watching lecture videos and then doing activities and experiments on these subjects in the classroom (Bretzmann, 2013). The flipped learning model is the teaching of the subjects learned in the classroom environment, with the guidance of the teachers, and the self-study learning of the students at home, homework/activity etc. It is expressed as doing the situations in the classroom (Bergmann & Sams, 2012; Strayer, 2012). While students spend time in the classrooms to learn the content of the subject with the traditional approach, in this model, this time spent in the classroom with the support of technology is transferred to the home environment, and the activities in the classroom become a pedagogical process in which more dynamic and interactive studies take place.

The flipped learning model, which is accepted as the education model of the future, covers the opposite of traditional learning (Debbağ & Yıldız, 2021; Ozdamli & Asiksoy, 2016). In the traditional education system, while the knowledge and concepts are transferred to the students in the classroom environment by the educator, it is tried to assimilate the knowledge with the homework and projects given to be done at home. In the flipped learning model, the videos prepared/recorded by the trainer before the day of the lesson are given through certain platforms. Before the students come to the lesson, they watch the videos about the lesson at any time and place, take notes and prepare their questions for situations that they do not understand. When it comes to the classroom environment, there are activities that support the active participation of students, such as group work, problem-solving activities, for assimilation of information and understanding of concepts.

The Role of the Teacher in the Flipped Learning Model

As the most important factor, the teacher prepares the videos that the student should watch at home and presents them to the student. In the classroom, he/she prepares materials to reinforce learning and acts as an observer and intervenes where necessary. To prepare the videos, the teacher must have the necessary knowledge and equipment. The role of the teacher is to prepare short, clear and understandable videos and to deliver them to students via online platforms. (Bergmann & Sams, 2012). It is thought that it would be appropriate to share simulation activities that will make students more active instead of videos in undergraduate education. Through simulation activities, it is possible to contribute to students' use of scientific process skills (Chang & Hwang, 2018), to reach problems to the level of invention and innovation with an interdisciplinary perspective, and to create products using the knowledge and skills they (MoNE, 2017).

The Role of the Student in the Flipped Learning Model

Students can individually control their speed by determining the time and place of study. Since students are responsible for their own learning, it has been argued that there will be a positive development in their learning (Bergmann &Sams, 2012; Cole & Kritzer, 2009). The first encounter of students with the subject content outside the classroom is described as a new learning and teaching paradigm (Lopes & Saures, 2018). Adapted from the studies of Akın and Akın (2020), the stages that teachers and students will perform according to the Flipped learning model before and during the lesson are presented in Table 1 and Table 2.

Table 1. Preparations to be made by the teachers and students before the lesson in the Flipped Learning Model

Academician-teaching preparatory phase	Student/learner preparation phase
It determines the platforms on which the instructors will first share the simulations with their students and the time when they will be uploaded.	Together with the teachers, the students determine the platforms on which the simulations will be shared and the time they will be uploaded.
Within the framework of the Flipped learning model, the subjects on which the simulation activities will be implemented are determined.	Follows simulation and lecture presentations and worksheets before coming to class.
Simulations and presentations related to the determined subject are prepared or suitable simulations are determined.	Gains knowledge about the determined subject content. Evaluates what has been learned through worksheets.
Expert opinions about the prepared simulations and presentations are taken. The final shape is given by being revised in line with the feedback received.	Since she has knowledge about the subject, she has a positive attitude about the lesson.
Questions are prepared before and after the course simulations and presentations.	The level of motivation comes to the lesson as good.
Prepared questions are reviewed with simulations and presentations.	Safely shares the experience gained through simulations with classmates.
Course simulations and presentations, worksheets are uploaded to the specified platform.	

Table 2. Situations that teachers and students should do during the lesson in the Flipped Learning Model

Academician-teaching	Student/learner
To the lesson begins with remarkable words.	She/He comes to class prepared..
Creates groups.	Determines their groups.
Provides in-group and inter-group interaction.	It interacts within and between groups.
Listens to and contributes to the simulations, presentations and worksheets they watch.	They talk about the simulation, presentations, and worksheets they watched.
It makes students talk about simulation activities and worksheets within the framework of the Flipped learning model.	Makes experiments and applications that should be done in the lesson. And it helps your classmates to do it too.
Provides general repetition of the subject.	It repeats the topic in general.
Receives criticism about course simulations and presentations.	Criticizes the course simulations and presentations. And listens to criticism.
Gets students' ideas about the next lesson presentation and determines when these presentations will be shared.	Comments on the next simulation and presentations and learns when presentations will be shared for the next lesson.

When the literature is examined, studies conducted at various grade levels and in different courses have been found (Erdem, 2018; Flick, 2019; Frydenberg, 2013; Heo & Choi, 2014; Kahramanoğlu & Şenel, 2018; Kaya, 2018; Saunders, 2014; Weiss, 2018, Wong & Chu, 2014). When the studies were evaluated, it was determined that the teaching was positively affected in the lessons conducted with the flipped learning model. In general, it was determined that the academic achievement, motivation and readiness levels of the students increased. Aydın, and Demirer, (2017), who examined the theses and articles on the flipped learning model, found that studies in foreign language and mathematics were intensified. Studies in the field of science education

(Göğebakan Yıldız, Kıyıcı, & Altıntaş, 2016; Yılmaz, 2017) were found to be limited. In his study, Karakaş (2021), who examined 126 graduate theses made in 2014 and 2020, found that 7.9% of them were studied about undergraduate students and science teaching. At the same time, he stated that these studies remained in the qualitative research method at a rate of 11.1%. When Turan (2021) examined the studies in science education, he did not state that the studies involving the flipped learning model were conducted in various categories of science education (general chemistry lessons, physics lessons, science education lessons, etc.), but that it was a study conducted for science laboratory practices lessons. When considered in general, it can be concluded that the studies carried out in the laboratory application dimension, which cover three important disciplines such as science, biology, physics and chemistry, are limited. Experiments related to these three disciplines are intensely included in Science Teaching Laboratory Practices I and II courses taken by 3rd year undergraduate students of science teaching. Considering that there are a lot of abstract and inaccessible concepts and understanding these concepts, the use of simulation activities becomes important.

Graham (2006) states that with the flipped learning model, both online and face-to-face activities can be implemented in four different ways: activity level, course surface, program level or institutional level. With the current research, course-level activities were preferred and the effects of the model were tried to be determined for undergraduate students. Considering an educational process based on the flipped learning model, teachers and students are encouraged to learn about problem solving skills, creative thinking skills, research and inquiry skills, cooperative learning, learning by discussing, and STEM (Science-Technology-Engineering Math), which has been mentioned a lot recently. ; It can be said that the development of students will be supported by training teachers in many fields such as science, technology, engineering and mathematics applications.

In this context, it is seen that it is important to comprehend scientific knowledge through the flipped learning model based on model/simulation in science classes, and the necessity of applying this model emerges. For these reasons, the subject of the research was structured in line with the development of conceptual understanding, opinions and evaluations of prospective science teachers regarding the use of the flipped learning model. Thanks to the study, it is thought that important contributions will be made to education in the relevant field and that the gaps identified in the literature on the subject can be filled.

The research problems were determined as follows:

- Is there a significant difference between the academic achievements of the experimental and control group students of the Flipped Learning model used in teaching science subjects?
- How are the opinions of the experimental group teacher candidates about the Flipped Learning model used in teaching science subjects?

Method

This section provides detailed information on the Research design, study groups, intervention process, data collection tools, and data analysis of the study.

Research Model

In this research, a mixed research method, in which qualitative and quantitative approaches are used together, was preferred in order to examine the effects of the flipped learning model. A quasi-experimental design with control and experimental groups, which includes pretest-posttest, is one of the quantitative approaches. In the qualitative dimension of the research, semi-structured interviews were conducted with the students in order to collect the data using the case study model. Permission was obtained from the ethics committee of the relevant university for the research. The model of the research is shown in Figure 1.

Study Groups

The research was carried out in the Science Teaching Laboratory Practices I course in the science education department in the 2021-2022 academic year fall semester. The participants of the quantitative dimension of the study consisted of third-year science teacher candidates (N=48; 40 females, 8males) at a state university. These students were preferred because they were an easily accessible sample group for researchers. Participants were randomly divided into groups. The experimental group is composed of pre-service teachers whose school number has an even last digit (20 females, 3 males), and the control group is composed of pre-service teachers whose school number has an odd last digit (20 females, 5 males). The experimental group students participated in the qualitative dimension of the study.

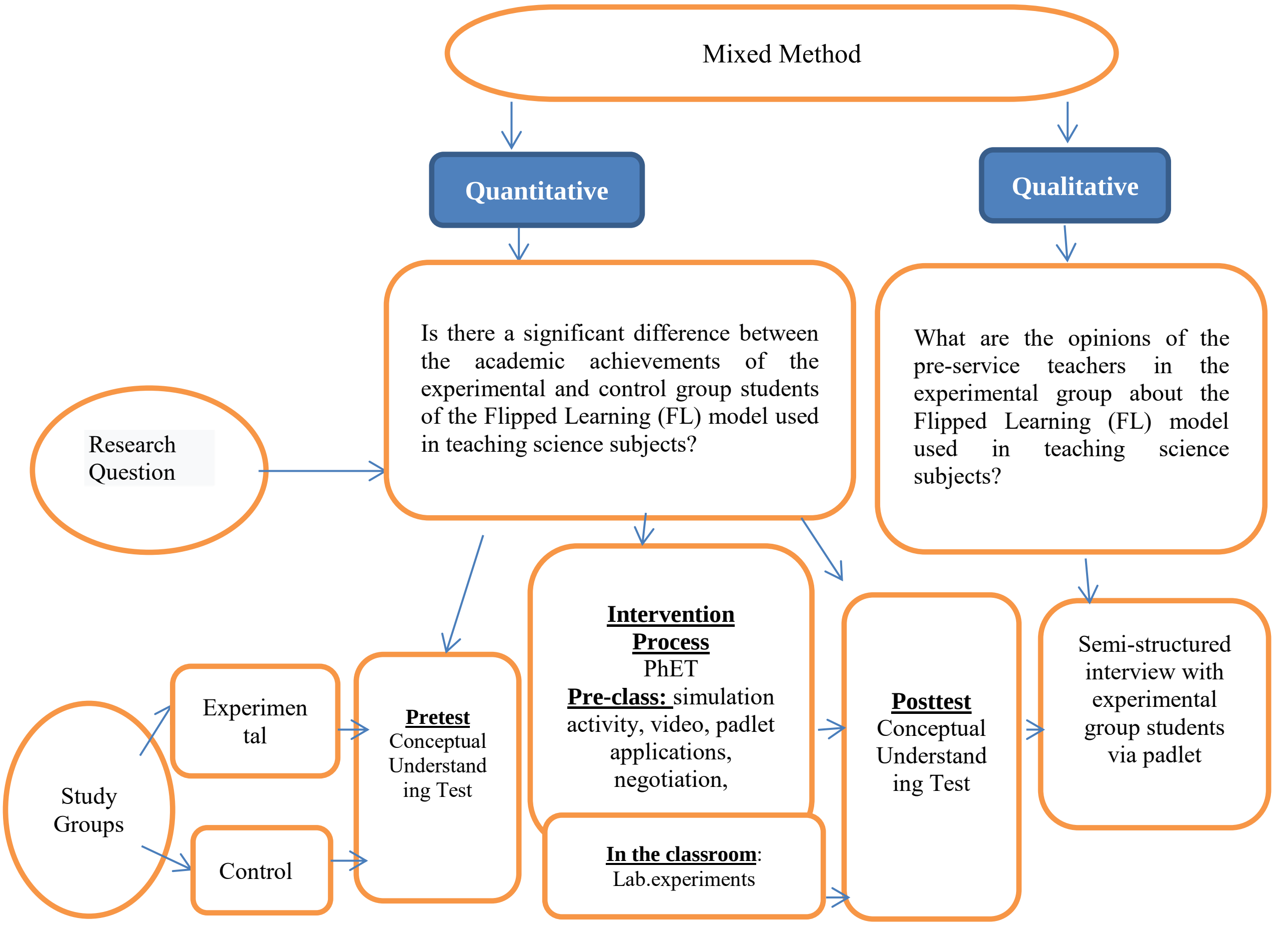


Figure 1. Diagram of the research model

Intervention Process

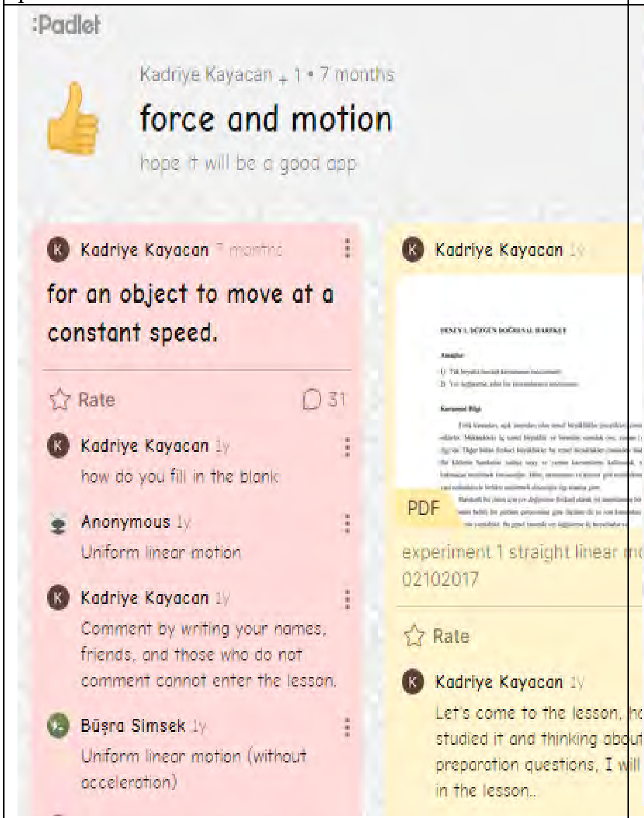
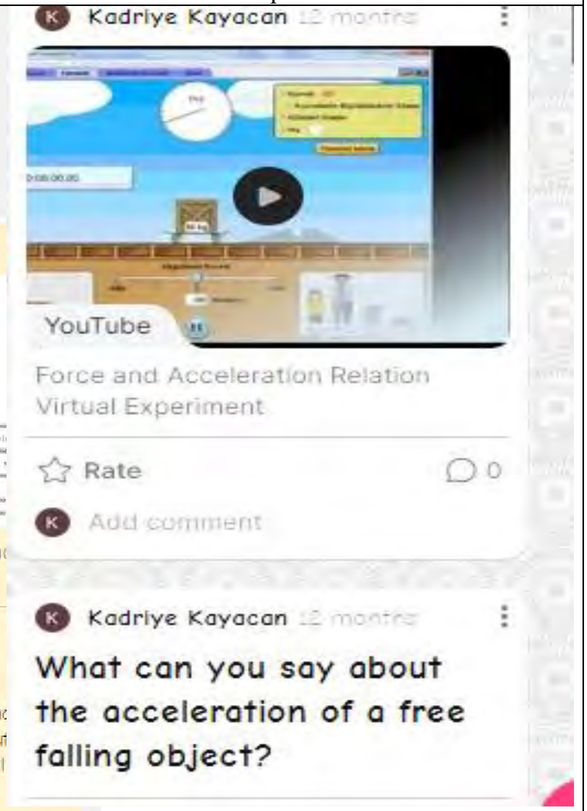
Flipped learning model was carried out in the form of students studying the subjects at home by watching the lesson videos and then doing activities and experiments on these subjects in the laboratory environment. In order to interact with the experimental group students, Padlet platform applications were used. PhET simulation laboratory programs were used for the course videos that students would follow at home. PhET is a simulation activities laboratory developed and made available to open access by the University of Colorado Boulder, founded in 2002 by Nobel laureate Carl Wieman. The topics were determined by the researchers, links to PhET simulation activities (phet.colorado.edu website), Khan Academy videos (https://www.khanacademy.org/) used, along with this, videos were prepared by the researchers for the simulations not included in the program and shared with the students. With the flipped learning model, students were provided to work in groups. Groups of about 3-4 people were formed. Before coming to the classroom environment, the students who made their preparations with shared simulations carried out the experiments with their friends in the science teaching laboratory applications course. The applications lasted for five weeks. Topics covered are listed in Table 3.

Table 3. Topics covered

Time	Topics covered
1 week	Motion, velocity and acceleration along a straight line
2 week	Velocity changes in the effect of acceleration on force and mass
3 week	Free fall motion
4 week	Momentum changes in a thrust
5 week	Inelastic collision

Experimental Group

With the flipped learning model, students were provided to work in groups. Groups of approximately 3-4 people were formed to be heterogeneous in terms of gender and achievement. The necessary simulation/model or video activities were prepared by the researchers and shared with them for the subject they determined within the scope of Science Teaching Laboratory Applications I course content. Before coming to the lesson, each group completed their learning on the subject and participated in the lesson.

a- Discussion application example on the Padlet platform	b- Question sharing example for video and discussion on the Padlet platform
	

c- Experimental samples carried out in the laboratory

Image 1. Experimental group application examples

In the classroom, they tried the theoretical knowledge they learned at home through simulations in a laboratory environment with their friends. Each group carried out experiments, presented the topic to their friends, and completed the topics in the presence of negotiations with other groups. Students followed the video and negotiation processes by registering on the online platform created by the researchers (https://padlet.com/kadriyekayacan/hynnwvzrljyb4aw6). Through this platform, it is possible to easily communicate with students and give instant feedback before the lesson. In the platform, the researchers asked the students questions about the topic of the week and the students were asked to write their thoughts (see. Image 1-a). In the experimental groups, the activities done before the lessons, watching the video/simulation, padlet applications and the negotiation phase were carried out (see. Image 1-b). When the class arrived, these questions were discussed before the lesson started, and then the experiments were carried out. During the lesson, experiments carried out in the laboratory were applied. Examples of experiments carried laboratory are given in Image 1-c.

Control Group

As in the experimental group, the students were divided into groups of 3-4 people. The students conducted an experiment in the laboratory as they understood by studying the subjects themselves with the traditional learning and they had their friends participating in the experiment. Experiments were conducted in the form of question and answer. Simple and easily accessible tools were used as test materials. Based on the observations of the first author, communication among the student groups was less, and negotiation environments did not occur as in the experimental group. Examples of Control group application examples are given in Image 2.

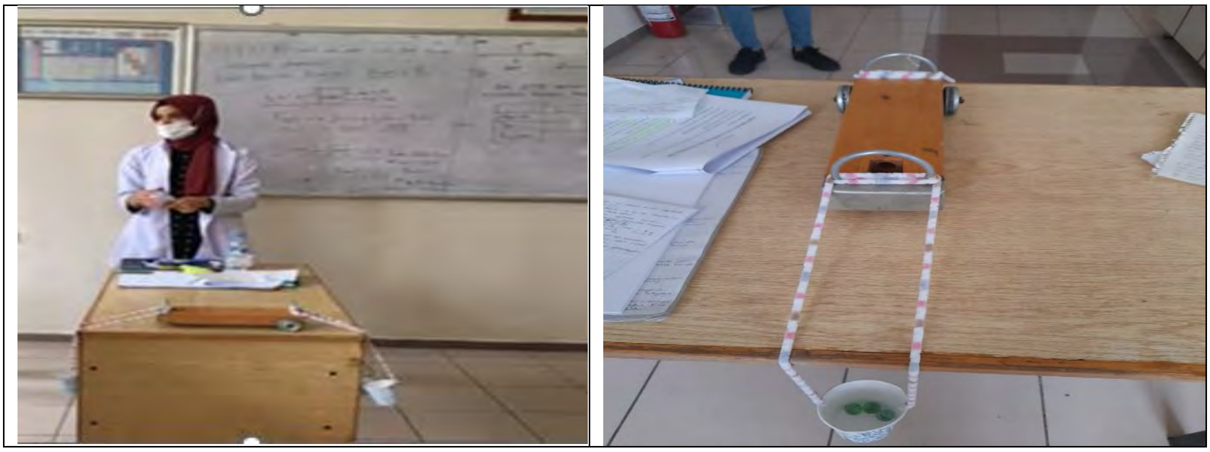


Image 2. Control group application examples

Data Collection Tools

The data were collected by conceptual understanding test and semi-structured observation forms conducted with the experimental group students. Details of data collection tools are given below.

Conceptual Understanding Tests. In the quantitative aspect of the study, a multiple-choice test consisting of 43 questions was used, which was developed by Thornton and Sokoloff in 1995 and adapted into Turkish by Kanlı and Gülçiçek in 2007, in order to evaluate the experimental and control group students' conceptual understanding of force and motion. This test is an advanced test to detect misconceptions in Newtonian physics. The reliability value of the scale (cronbach alpha) was found to be .84 by Kanlı and Gülçiçek (2007). The reliability value (cornbach alpha) found for this study is .80. The items in the test are aimed at detecting the misconceptions in the following subjects.

• Motion, Velocity and Acceleration Along a Line
• Dependence of Acceleration on Force and Mass
• Free Fall Motion
• Momentum Changes in a thrust
• Inelastic collision

The test was applied to the experimental and control groups before and after the application, and the results were analyzed with the SPSS statistical program.

Semi-Structured Interview Questions. In the qualitative aspect of the study, the interview questions were applied over the padlet platform. The semi-structured interview questions applied to the students were prepared by the researchers. The final shape was given by receiving feedback from experts in the field. In this context, the semi-structured interview questions prepared were determined as follows:

- What are the innovations brought by your online course process for you?
- What are the contributions of this process to the distribution of tasks and cooperation?
- What is the interest and motivation contribution of this process to the lesson?
- What is the contribution of this process to the learning and teaching of science subjects?
- Can you compare the online content used in this process and the face-to-face application activities in terms of their contribution to learning?
-What can be done for effective learning in the course process where online content and face-to-face application activities are used together?

Data Analysis

In the research, SPSS statistical package program was used for the analysis of quantitative data, and content analysis analysis was used for the analysis of qualitative data. For the first research question, independent t-tests were used to determine potential differences between groups. Independent t-test analyzes were conducted to determine the effect of flipped learning model on students' conceptual understanding. As the dependent variable, the achievement scores obtained by subtracting the pretest scores from the posttest scores were used and the group was accepted as the independent variable. Before performing the analysis, the assumptions of normality and homogeneity of variances were checked and met.

For the second research question, the findings obtained from the semi-structured interview questions were analyzed by content analysis method and codes and themes were created. Reliability studies in qualitative data analysis have been carried coded separately by researchers. The basic process in content analysis is to gather similar data within the framework of certain concepts and themes, and to interpret them by arranging them in a way that the reader can understand (Yıldırım & Şimşek, 2011, p. 227). In the coding phase of the data, coding was done according to the concepts extracted from the data suggested by Strauss and Corbin (1990). The analysis process was completed by following the stages of arranging the codes and themes, defining and interpreting the findings (Yıldırım & Şimşek, 2011).

Findings

In this section, the findings of the study are explained according to the research questions.

The Effect of Flipped Learning Model on Conceptual Understanding

Normality test was performed before independent t-test. Skewness and Kurtosis values were checked for normality test. It was observed that the Skewness value ranged between 1.047 and .347 and the Kurtosis value varied between .200 and .681. When Kurtosis and Skewness values are between -1.5 and +1.5, it is considered to be a normal distribution (Tabachnick & Fidell, 2013). Independent t-test results comparing the pretest scores of the experimental and control group students showed that $t(44)=-.41, p<.68$) were similar. In order to compare the conceptual understanding levels of both groups at the end of the application, the independent t-test result of the pretest-posttest achievement scores is presented in Table 4. When the results were evaluated, no difference was found between the conceptual understanding levels of the groups.

Tablo 4. Independent t-test results for the treatment and comparison groups' pretest-posttest gain scores

	Group	*n*	*M*	*SD*	*t*	*df*	*p*
Conceptual Test	Treatment	22	2,05	2,69	0,66	40	>.504
	Control	25	1,56	2,23			

Opinions on the Applications of the Flipped Learning (FL) Model

A semi-structured interview was applied to provide formative assessment and immediate feedback on the quality of pre-service teachers' learning experiences for flipped learning model applications. As a result of the interviews, three main categories were obtained. Obtained main category Scientific reasoning skills course; 1. Internal factors on the student, 2. External factors on the student, 3. Suggestions regarding online content/trainings. Findings related to each mentioned theme were explained in order by giving examples from student discourses, accompanied by tables containing descriptive statistics data.

Table 5. The code and descriptive statistics results of the FL model determined for the internal factors on the student

Main Category	Category	Subcategory Code		Code	f
Internal factors on the student		Online	Positive	Ability to repeat lessons	5
				Different classroom environment experience	3
				Pre-lesson preparation	11
				Facilitate the applications in the lesson	2
				student-centered	2
				Contribution to individual learning speed	2
				learning by understanding	2
				Ability to do homework comfortably	2
				active thinking	3
				Concrete learning	3
			Negative	It's hard to cooperate	3
				Grouping is difficult	2
				Didn't contribute	1
				Time was not efficient	2
				Interest has waned	2
				Interaction decreased	2
				Communication decreased	2
				Teaching skills are lacking	3
				Learning by doing is missing	1
				reciprocal	1
				remained at the abstract level	1
				hard to understand	3
				Suitable for theoretical knowledge	12
		Face to face		More effective/efficient face-to-face	11
				There is learning by doing	10
				more permanent	5
				sense organs are more active	3
				interactive	2
				learning oriented	1
				More concrete level	3
				easy to understand	3
				Better in apps	12
	Social skills			Collaboration increased	4
				Providing individual responsibility	2
				communication skill	2
				coordinated work	1
				Idea sharing	1
	Attitude			Curiosity and interest increased	8
				Enjoyable	1
				Striking	1
				Total	140

Internal factors on the student. It has been determined that the internal factors of flipped learning model applications on teacher candidates are in the areas of learning process, social skills and attitude. It has been determined that the effects on the learning process form a sub-category as online and face-to-face, and in this category, especially students have positive and negative opinions about online education. The code and statistical information determined for this theme are given in Table 5.

The pre-service teachers stated that the positive aspect of the online education, which is carried out with the FL model, in the learning process, offered the opportunity to prepare and repeat the lesson the most before the lesson. The other positive aspects of the pre-service teachers in this process are that they can work in a student-centered manner, thus contributing to the individual learning speed, and expressing their thoughts that meaningful learning and concrete learning are realized through active thinking. Examples of these views are as follows:

"It helped us gain different perspectives on the concept of the classroom environment."
"The fact that we have knowledge about the subject to be covered before the lesson and that we can understand and perform face-to-face applications more easily are the innovations brought by this process"
"Knowing how the course will be in advance can contribute to the student's feeling of comfort and coming prepared"
"The connection with the lesson has never been broken, as it provides continuous active thinking."
"Permanence was ensured with beautiful animations, interest in the course increased thanks to technology."
"Making a preparation before the lesson and re-applying the subject in the lesson facilitated learning and provided permanent learning"

Among the negative aspects of the process, the most consensus is that online education is effective in giving theoretical information. Pre-service teachers expressed their opinions that it is difficult to make sense of, cooperate and work with a group because the information in online education remains at an abstract level, and that interaction and communication are reduced, and therefore learning by doing and learning by doing and the use of teaching skills are lacking. Example statements are as follows:

"It is generally a process that emphasizes individuality. Group assignments etc. Sometimes it is difficult to reach friends and do homework together. There is a system that works unilaterally."
"Collaborating in this process has been more difficult. It is more difficult than usual to communicate in the virtual environment and head towards the lessons. However, we tried to communicate effectively and distribute tasks."
"In this process, interest in lessons decreased, distraction increased."
"Online content makes me memorize. It teaches face-to-face activities."

On the other hand, the view that pre-service teachers mostly agreed about face-to-face education is that it is more efficient in practice. They stated that in face-to-face education, learning by doing is dominant because the sense organs are more active, and it is easy to make sense of it because of interactive and concrete learning. Sample expressions reflecting the views of teacher candidates are as follows:

"Because experiments are activities in science teaching, it is more appropriate to do it face-to-face. I think the student needs to see and observe. There are applications online, but I think it would be more permanent to learn by doing and experiencing in real life."
"Explaining with practice in online education is more difficult than in face-to-face education. Because only virtual laboratories can be used in online education, but in face-to-face education, students learn by doing. Therefore, the application is more effective in face-to-face education.
"No matter what, I always think that face-to-face activities and lessons are much more effective"
"Face-to-face education is more effective because experience and seeing things live and touching them become much more permanent"
"As face-to-face application activities are a situation that interacts with people, I think that its effect is more than online content"
"Online content provides visual material, face-to-face content gives examples from life."
"I think face-to-face applications are much better. Online content has also been developed sufficiently, but it would be more meaningful to test it by doing and experiencing."

Pre-service teachers expressed their thoughts that online education, which is carried out with the FL model, also contributes to the learning process in terms of social skills and attitudes. It has been determined that it contributes to social skills in terms of coordinated work, formation of cooperation, increase of communication and sharing of ideas. At the same time, they stated that they found the learning process carried out with the FL model to increase their curiosity and interest, to be fun and to be interesting. Example statements are as follows:

"I developed myself in communication and exchanging ideas because we did the experiments by taking equal responsibilities with our friends and sharing something together"

"He improved his communication skills and taught him to work in coordination."

"Whether it was group discussions where ideas were shared, discussed and expanded, or closer collaboration between individuals within the learning group, it served to increase teamwork and participation and improve understanding."

"In this process, the responsibility largely belongs to the student. It allows the student to learn at their own learning pace."

"Collaborating with the class contributed to making the lesson more fun."

"I think this process has increased our interest and motivation in the course. Because, as a result of the knowledge we gained in the lessons we saw online before and the experiments we carried out at school, our interest and curiosity in the lesson increased."

"The online content used was very attractive and beautiful. Especially at a time when we are very intertwined with technology, the use of these contents aroused our curiosity."

External factors on the student. The external factors of flipped learning model applications on pre-service teachers were found to be in the category of physical conditions. The code and statistical information determined for this main category and category are given in Table 6.

Table 6. Code and descriptive statistics results of the FL model determined for external factors on students

Main Category	Category	Code	f
External factors on the student	physical conditions	Equality of opportunity in education	2
		Learning to use technology well	16
		Saving on time	13
		Independence from place	4
		Rich content	7
		visual materials	4
		Total	46

Pre-service teachers stated that they learned well how to use technology with the FL model. Another situation in which more consensus has been achieved following this opinion is that time is saved. They stated that with online education, visual materials with rich content are presented, and they can study and repeat whenever they want with independence from the place. Example statements are as follows:

"I learned the content of technological tools and applications that can be used online and how to use them much better"

"Time saving. Being able to repeat the course whenever you want, being able to participate in the course whenever you want from anywhere. It provides a more comfortable environment."

"I discovered innovations and different applications in technology and learned how they work."

"The lesson was taught with advanced tools. 24/7 training was available. Additional expenses have been eliminated."

"We became involved with Web 2 tools and included it in our learning life."

"Online education removes the barrier of space and time. Therefore, it provides equality of opportunity and opportunity in education. Provides unlimited access to educational materials"

Recommendations for online content/trainings. Pre-service teachers offered suggestions for online content/trainings such as the FL model. The codes and statistical information determined for the recommendations are given in Table 7. The suggestions of the pre-service teachers are mostly that online and theoretical education should be used together, and that online education should be done when giving theoretical information, and face-to-face education should be done when the applications are made. Other suggestions were that the online education content should be easy and understandable, accessible to all students, providing basic training to teachers and students, and sharing information by inviting different people to the courses. Examples of the recommendations are as follows:

"Theoretical parts can be given in online education and more applications can be made in face-to-face education"

"Online content should be more efficient, useful and easy to understand. Online content and applications should be compatible with each other so that students do not have difficulty in applying and making sense of the information."

"The online content used must be directly related to the achievement described"

"It should be ensured that the online content is accessible to all students, understandable and supports face-to-face application"

"It can be beneficial to use online content while doing face-to-face training, and their integration is directly proportional to the training of teachers."

"The contents of the online courses can be enriched and made more interesting. As a result of this, I think that the implementation activities to be carried out will be more beneficial."

"It can strengthen our teacher's lectures with people who will draw attention to our lesson with external connections"

Table 7. Code and descriptive statistics results for online content/training suggestions

Main Category	Category	Code	f
Suggestions	Online content/ training	Should be used in conjunction with theory	12
		It should be in theoretical knowledge and applications should be in face-to-face education.	12
		It should be easy	5
		It should be understandable	4
		Different people should be invited	2
		It should be used to reinforce face-to-face education.	9
		It should be directly related to the topics covered.	5
		Must be accessible to all students	6
		Basic training should be given	5
		Teachers should be provided with the necessary training and equipment	4
		Total	64

As a result, the effects of this model on students are that it is suitable for pre-lesson preparation, it is suitable for theoretical knowledge, and it allows learning by doing. In addition, students frequently stated that some subjects are more effective/efficient face-to-face, that the practices in the course are good, that they increase curiosity and interest, and that they allow them to learn how to use technology well. Finally, the students' suggestion is that theoretical knowledge and learning should be distanced, and applications should be in face-to-face education.

Results and Discussion

As a result of the study, it was seen that the post-test means scores of the force and motion conceptual understanding test of the students in the experimental group, in which the lessons were conducted with the FL model, increased compared to the pre-test mean scores. However, it was observed that there was no significant difference between the force and motion conceptual understanding test post-test mean scores of the control group students, in which the lessons were conducted with the traditional laboratory method. Many of the studies on the flipped classroom model have been conducted to examine the effect of students on their learning performance. The main reason for this is that it is a new model and its results are intriguing (Chen et al, 2019). Wood, Galloway, Sinclair, and Hardy (2018) As a result of their study, they stated that there is a positive relationship between the frequency of teacher-student interactions and the development levels of students' science concepts in the lessons conducted with the FL model. Similarly Gross et al. (2015) In their study, they concluded that the FL model is a model that affects students' learning performance. Similarly, studies expressing the conclusion that this model improves students' communication, cooperation and higher-order thinking skills (Canelas, Hill, & Novicki, 2017; Olakanmi, 2017) and studies expressing that it affects students' learning perceptions, attitudes and motivations (Aşıksoy & Özdamlı, 2016; González-Gómez, Jeong, & Rodríguez, 2016; Jensen et al., 2015; Sezer, 2017). However, in this model, the results may not be suitable for generalization, since students' participation in pre-lesson learning content and their behaviours in the course are factors that affect the research results at a high level. For example, one of the reasons why there was no significant difference between the average scores of the experimental group and the control group as a result of this study may be that the students in the experimental group were not able to control their pre-lesson activities.

As a result of examining the opinions of the students in the experimental group about this model in the qualitative part of the study; the effects of the model on students (internal effects and external effects) and students' suggestions were divided into themes. In the themes created, the internal factors of the FL model on the student were divided into categories as learning process, social skills and attitude. The students stated the positive aspects of the FL model in the learning process as follows: it offers the opportunity to prepare before the lesson, being able to repeat the lessons, experience different classroom environment, facilitating the applications in the lesson, being student-centred, contributing to the individual learning speed, providing learning by understanding, being able to do homework comfortably, opportunity, contribution to active thinking and realization of concrete learning. Shattuck (2016) In hir study, she stated that one of the positive aspects of the FL model is that students spend more time on learning activities. When the studies on the FL model in the literature are examined, it is seen that this model increases student achievement, similar to the results obtained in our study (González-Gómez et al., 2016), positively affects student perceptions (Baepler et al., 2014), provides a comprehensive understanding (Gariou-Papalexiou et al., 2017), it allows to watch and listen to the lectures over and over again (Aşıksoy and Özdamlı, 2016), increases the active learning time in the classroom (Lax et al., 2017provides more time to work on problems (Yestrebsky, 2015) there are studies that indicate the positive aspects of.

In the study, the negative aspects of the students about the model are It is difficult to cooperate, time cannot be used efficiently, interaction is low, learning by doing is limited, and it does not improve teaching skills. Similarly, Leatherman and Cleveland (2019) mentioned in their study that in this model, students do not have the opportunity to ask their teachers questions before the lesson, and there is insufficient interaction. In another study (Hibbard et al., 2016) stated that students found this model time consuming. In addition, there are studies in the literature stating that this model increases the workload of teachers (Torío, 2019) and students (Olakanmi, 2017).

At the end of the study, students; They stated that the contribution of this model to social skills is increasing cooperation, providing individual responsibility, improving communication skills, enabling coordinated work and sharing ideas. Flynn (2015) In his study, he stated that this model reduces the rate of students being in the background in the learning process. Similarly, Loveys and Riggs (2019) At the end of their study, they concluded that this model increased student participation. At the end of the study, it was concluded that this model increased the curiosity and interest of the students, and they found it entertaining and remarkable. Similar to these results, it affects students' opinions positively (Leatherman & Cleveland, 2019), increases students' motivation (He et al., 2018), positively affects student satisfaction (Bokosmaty et al., 2019), affect students' emotions positively (Jeong et al., 2016), positively affects student attitudes (Mooring et al., 2016) There have also been studies that have reached results such as. The students expressed the contributions of the study in terms of physical conditions as providing equal opportunities in education, learning to use technology well, being independent from the place, accessing rich content and using visual materials.

The students' suggestions about the model are It should be easy and understandable, different people should be invited, it should be accessible to all students, it should be used to reinforce face-to-face education, and the necessary training and equipment should be provided to teachers. As a result, we can say that students' opinions about this model are generally positive. As a matter of fact, in the meta-analysis study conducted by Turan (2021) on the FL model, it was stated that the flipped classroom model had a positive effect on student achievement in science education.

Based on the results of the study, the following suggestions can be given to teachers who carry out educational activities:
• The use of the flipped classroom model in different courses and subjects will increase the student's performance in the course, as it encourages students to prepare before the lesson, allows them to repeat the lesson, and contributes to individual learning.
• In addition, the use of abstract concepts in subjects and courses where there are a lot of abstract concepts will facilitate the concretization of abstract concepts.

Recommendations

Recommendations for those who want to do research on this subject can be listed as follows:
• In this study, the effects of the flipped classroom model for the science laboratory lesson were tried to be revealed, and its contributions to areas such as attitude, motivation, and success can be examined by using the flipped learning model, which is a new model, in different courses, units and subjects.
• Since the study group is university students, since there is no one to control the part of the model to be made at home, it can be ensured that the parts to be done at home are done under the supervision of parents by working with younger age groups.

• In order to carry out the work in a healthy way, it is useful to make sure that technological support such as internet and computer is accessible to everyone.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the authors.

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