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The Impact of the Flipped Classroom Model on Middle School Students' Academic Achievement and 21st Century Skills

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Abstract

The aim of this study is to investigate the effects of the flipped classroom model on the academic success and 21st century skills of middle school students in the unit of systems in our body. The study was conducted with 6th grade students studying in a state school in Istanbul. In the study, an applied study was conducted with two experimental groups (n=29) and one control group (n=18). The flipped classroom model was applied in experimental groups, and the control group was taught in accordance with the curriculum. In the study, a quasi-experimental design with a pre-test post-test control group was used, which is one of the quantitative research methods. The data of the study were obtained with the academic achievement test and the 21st century skills scale. According to the results obtained in the study, the academic success of the students differed significantly in the classes where the flipped classroom model was applied compared to the classes where the current curriculum was applied. In addition, it was determined that the flipped classroom model positively developed the 21st century skills of the students.

Introduction

When the 21st century is analyzed broadly, it becomes evident that the common characteristics of developed societies are that they are advanced in science and technology. The aim of developing countries is to focus on scientific studies and to keep pace with rapidly advancing technological developments. Adapting to this rapid change in technology can only be accomplished by increasing scientific studies, advancing in technology and starting production. In order to do all this, there is no other way than to raise generations from kindergarten onwards who are critical thinkers, problem solvers, communicators, entrepreneurs and production-oriented, in other words, generations who possess 21st century skills. It is necessary to adapt education to technology in order to keep up with the development of technology that affects societies in every aspect. (Ashiyan & Salehi, 2016)

With the advancement of technology, the number of teaching methods and techniques using technology in education and instruction is rapidly increasing. These new techniques support the training of individuals with 21st century skills (Ozturk, 2023). The flipped classroom model, which promotes self-paced learning and in-class application, has been recognized as effective for developing 21st-century skills (Tekin, 2020; Staker and Horn, 2012; Stratton et al., 2020). The Flipped Classroom model is a model in which students learn the subject at their

own learning pace with videos before the lesson and reinforce the subject with activities in the classroom.

With the development of educational technologies, digital course contents have been created and online learning has become possible without time and location limitations. The combination of face-to-face learning and online learning with different applications has led to the emergence of blended learning models. In the flipped classroom model, which is one of the blended learning models, the student learns the subject at their own learning pace at the time and place of their choice outside the classroom (Butt, 2014); and develops high-level skills with various activities during class time. (Yanardağ, 2021).

Natural sciences can be defined as examining, describing, making generalizations and predicting what might happen on the basis of all these (Kaptan and Korkmaz, 2001). Therefore, Natural Sciences is the very developing technology itself. This situation requires the continuous development and renewal of the Natural Sciences curriculum (Ünal, Coştu and Karataş, 2004). Since 2005, the main purpose of the renewed Natural Sciences curriculum has been to raise scientifically literate individuals with 21st century skills (Seren and Veli, 2018).

In the changes made in the Natural Sciences Curriculum in 2018, not only changes were made in the learning areas but also simplification was made in the learning outcomes. Although the number of learning outcomes has been reduced, it has lost its spiral characteristic with its subject organization. Especially in the 2018 'Living Things and Life' unit of learning, the spiral relationship is very weak. This makes it difficult for students to understand the 'Living Things and Life' units. In the 6th grade 'Systems in Our Body' unit, the number of topics was increased and the number of learning outcomes was reduced. The recommended time is not enough because the learning outcomes are intensive due to their content. Gürdal (2018) concluded in his study that teachers found the number of 6th grade 'Systems in Our Body' unit learning outcomes too high and the time given insufficient. Crowded classrooms and an intensive curriculum that needs to be taught in a short time make it difficult for students to learn effectively. Traditional models cannot meet the needs of individuals today. In order for efficient learning to take place in a limited period of time, it is imperative for students to use in-class and out-of-class time efficiently (Boyraz, 2014). Developing information and communication technology has enabled the use of electronic media in teaching. With the incorporation of electronic mediums into teaching, the time and space limitations of student-teacher interaction have been eliminated (Katz, 2002; Trentin, 1997). In other words, developing technology and children's relationship with technology led to the adoption of the flipped classroom model (McLaughlin et al., 2016). Flipped classrooms are environments where students come to the lesson by learning the subject at their own learning pace with materials such as videos and animations, and use their learning by structuring their learning with activities and problem solving in the lesson (Turan and Göktaş, 2016).

The flipped classroom model was first applied in the 1990s with the “peer education” activity of Eric Mazur, Professor of Physics. Students studied and learned the subject together at home and then did their homework in the classroom (Özbay and Sarıca, 2019). In the 2000s, the model took its place in the literature as the “flipped classroom” method. In 2007, Bergman and Sams, working in a high school, applied the method to help their students who had to be absent and discovered the effectiveness of the method. They prepared videos on all subjects and published their work in 2011. When Salman Khan, the founder of Khan Academy, mentioned the flipped

classroom model in his TED Talk in 2011, the method began to spread in the literature, and the number of studies on the flipped classroom model increased rapidly with the Covid-19 pandemic.

In the flipped classroom model, time and space are flipped compared to the traditional method. This situation allows students to learn the subject at their own learning pace and to do activities involving high-level skills under the guidance of the teacher. Teachers plan the learning to be carried out outside the classroom before the lesson, and students learn with the materials given at the time and place of their choice. In the classroom, teachers design activities that will develop high-level skills in students and guide students to actively participate in the activities. What is important at this point is the suitability and quality of the materials to be used before the lesson. At the same time, in-class activities should be carefully planned. When effective planning is done, teaching is individualized and the curriculum is taught effectively in a shorter period of time. Students actively use technology, become responsible for their own learning, and gain high-level skills such as problem solving, critical thinking, and effective use of time.

In the literature, there are many studies showing that traditional methods are not sufficient to raise students with high academic achievement in natural sciences and developed 21st century skills, which is the greatest need of our age (Karaismailoğlu, 2022; Arslanhan, Bakırcı & Altunova, 2022; Manresa, 2018). This situation leads to the search for new methods that will both increase students' success in natural sciences and develop their 21st century skills. Studies have shown that methods that actively use technology meet the stated purpose (Arslanhan, 2023; Chang & Hwang 2018). The flipped classroom model is one of these methods. When the literature is examined, it is seen that the flipped classroom model has been studied at different levels and with different variables (Göğebakan Yıldız & Kıyıcı, 2016; Çakır, 2017; Demir, 2018; Yurtlu, 2018; Söndür, 2020; Nacaroğlu, 2020; Ünlütürk, 2022; Verim, 2022; Kaya & Yıldırım, 2022; Yılmaz, 2023; Çelebi, 2023; Dixon & Wendt, 2021; Oppong et al. 2021; Elian and Hamaidi, 2018; González-Gómez et al., 2016). In addition, many studies have examined the effect of the flipped classroom model on students' 21st century skills (Devrim, 2023; Demirel, 2023; Bektaş Esen, 2022; Çelebi, 2023; Uçaş, 2023; Kılıç, 2023; Ukzuzoğlu, 2023; Karaaslan, 2023; Chang & Hwang, 2018; Katauhi et al., 2022).

Ünlütürk and Bakioğlu (2023) stated that students expressed positive opinions about the flipped classroom model in their study. In his doctoral dissertation study, Karaaslan (2023) examined the effect of the flipped classroom model carried out with interactive learning activities on students' academic achievement, learning retention, metacognitive awareness and self-efficacy and proved that there was a significant difference in favor of the experimental group in terms of all variables. Ukzuzoğlu (2023) claimed that the flipped classroom model had a positive effect on students' achievement and scientific skills and was an effective method in eliminating misconceptions. Kılıç (2023) stated that the flipped classroom model had a positive effect on students' taking responsibility for learning and perceived self-regulation skills. Arslanhan (2023) examined the opinions of students and parents and concluded that the flipped classroom model increased students' participation and peer communication, was instructive and permanent, provided self-directed learning, and that parents reported that students' willingness to do homework increased, they gained responsibility, and the use of negative technology decreased. Kaya and Yıldırım (2022) proved in their study that students better understand the nature of science

with the flipped classroom model. Katauhi et al. (2022) investigated the effect of the flipped classroom model on scientific skills and stated that the model was very good in improving scientific skills. Oppong et al. (2021), in their study on pre-service teachers' learning of IUPAC nomenclature of chemical compounds with the flipped classroom model, concluded that the model improved learning. Griffiths et al. (2021) conducted a case study and found that beginning teachers can also use the flipped classroom model successfully.

This study aims to contribute to the field in terms of examining the effect of the flipped learning model on academic achievement and 21st century skills in middle school students at the same time. The aim of this study is to investigate the effect of the flipped classroom model on the academic achievement and 21st century skills of middle school students in the Systems in Our Body unit. In line with this purpose, answers to the following research questions were sought.

1. Is there a significant difference between the academic achievement of middle school students in the systems in our body unit between the classes taught with the flipped classroom model and the classes taught in accordance with the current curriculum?
2. Is there a significant difference between the 21st century skills of middle school students in the systems in our body unit between the classes taught with the flipped classroom model and the classes taught in accordance with the current education program?

Method

Research Method and Design

Quantitative research method was used in the study. Quantitative research is defined as the investigation of events and phenomena by collecting quantitative data and analyzing them with numerical techniques. The aim of quantitative research methods based on positivist philosophy is to explain information in a cause and effect relationship (Ocak, 2019; Türnüklü, 2001). The research design was determined as a quasi-experimental design with pre-test post-test control group in order to examine the effects of independent variables on the dependent variable. Three 6th grade classes (two experimental and one control) participated in the study. “Systems in Our Body Academic Achievement Test” and "21st century Skills Scale" were applied to the experimental and control groups as pre and post-tests as quantitative research data collection tools.

Table 1. Research Design

Pre-test	Application	Post-test
❖ Academic Achievement Test ❖ 21st century Skills Scale Applied to all groups.	Experimental Group 1 (15 Students) Application of Flipped Learning Model	❖ Academic Achievement Test ❖ 21st Century Skills Scale Applied to all groups.
	Experimental Group 2 (14 Students) Application of Flipped Learning Model	
	Control Group (18 Students) Implementing a model suitable for the education program	

Sample

The study was conducted with three 6th grade classes in a public school in Istanbul. The first experimental group consisted of 15 students, the second experimental group consisted of 14 students and the control group consisted of 18 students. A total of 47 students, 24 girls and 23 boys, participated in the study. Although the sample size was limited to 47 students due to the availability of classes in the selected school, the controlled experimental design and robust statistical analysis (ANCOVA) ensure reliable insights into the flipped classroom model's effects. The three 6th-grade classes were selected based on convenience sampling, with two classes assigned to the experimental groups to ensure adequate exposure to the flipped classroom model and one class serving as the control group. Demographic characteristics of the students are given in Table 2.

Table 2. Distribution of Students by Groups and Gender

Gender	Experiment Group 1	Experiment Group 2	Control Group	Total
Female	7	7	10	24
Male	8	7	8	23
Total	15	14	18	47

Data Collection Instruments

Academic Achievement Test and 21st Century Skills Scale were used as data collection instruments in the study and the data collection instruments are explained below.

Systems in Our Body Unit Academic Achievement Test

The "Systems in Our Body Unit Academic Achievement Test" used in the study was developed by Bolat and Karamustafaoğlu (2019). The achievement test, which was developed in accordance with the 6th grade Systems in Our Bodies unit of the Science Curriculum, consists of 35 questions consisting of four multiple-choice items. For the academic achievement test, each correct question was evaluated as 1 point, and blank and incorrect questions were evaluated as 0 points. The evaluation system in which the wrong answer does not take away the correct answer was applied. The answers of the students in the control and experimental groups were scored over 35 points. The mean discrimination (r) of the developed test was 0.486; the mean item difficulty (p) was 0.552; and the Kuder Richardson-20 value was 0.885 (Bolat & Karamustafaoğlu, 2019). The academic achievement test was used in the study because it has high validity, reliability and is suitable for the achievements of the new curriculum. As a result of the reliability analysis of the data obtained from this study, the validity coefficient was found to be 0.806.

21st Century Skills Scale

The "21st Century Skills Scale" applied in the study was prepared by Kang, Kim, Kim, and You (2012) and

adapted into Turkish by Karakaş (2015). The scale consists of a total of 32 items consisting of three sub-dimensions: cognitive, affective and sociocultural. The 21st Century Skills Scale is a five-point Likert-type scale and is evaluated as "1" Strongly Disagree, "2" Disagree, "3" Undecided, "4" Agree, and "5" Strongly Agree. The internal consistency coefficients of the scale were calculated and found to be 0.77, 0.70 and 0.67, respectively. As a result of the reliability analysis of the data obtained from this study, Cronbach Alpha value was found to be 0.926. The scale was used in the study because it is suitable for middle school students.

Data Collection

The data obtained in the study were obtained through an experimental study and quantitative data collection tools on the systems in our body, which is the 6th grade 2nd unit of the Natural Sciences course. The Systems in Our Body unit covers 11 learning outcomes and 24 lesson hours, which were created by taking into account the knowledge and skills related to the structures and organs of the support and movement, digestive, circulatory, respiratory and excretory systems. Table 3 shows the implementation process of the experimental groups taught with the flipped classroom model.

Table 3. Implementation Process of the Group taught with the Flipped Classroom Model

Unit	**Duration** (Class Hours)	**Out-of-School Activities**	**In-School Activity**
Systems in our body	24	➢ Related subject videos from EBA were watched. ➢ Notes about the subject were written in a notebook.	➢ Activities were carried out in which they could develop high-level skills.

Before the study, videos that would provide extracurricular learning for the experimental groups were selected from EBA (Education Information Network) contents. In-class activities that would reinforce the learning that would take place before the lesson and develop high-level skills were planned and instructions were prepared. Daily plans were prepared. Before starting the unit, pre-test applications were made to the students.

First, videos related to the topic of Support and Movement System were sent as homework via EBA. Learning was tracked in the EBA reports section. Before starting the activities in the lesson, students were asked to prepare a concept map. Students' learning was checked on the map. Afterwards, students were guided in activities to develop higher level skills. Similar practices were carried out in the digestive, circulatory, respiratory and excretory systems respectively. After the study, post-test applications were made to the students. Table 4 shows the implementation process of the control group, which was taught in accordance with the education program.

Before the study, daily plans were prepared for the control group. Homework assignments to be given to the students were planned. Before starting the unit, pre-test applications were made to the students. First, the topic of Support and Motion System was presented in general terms by drawing a concept map on the board. The visual of the support and movement system was displayed on the smart board and the system elements and their tasks

were explained through the model. Students were asked to make a system model. The models were evaluated in class. Activities in the textbook were given as homework. Answers were explained in class. Similar applications were made for digestive, circulatory, respiratory and excretory systems respectively. After the study, post-test applications were made to the students.

Table 4. Implementation process of the group taught in accordance with the education program

Unit	Duration (Class Hours)	In-School Activities	Out-of-School Activities
Systems in our body	24	➢ Concept map of each system was drawn on the board. ➢ The subject was explained through the system model opened on the smart board. ➢ The subject note was written in the notebook.	➢ System model homework was assigned. ➢ Textbook activities were given as homework.

Results

Descriptive statistics of the academic achievement test pretest-posttest data obtained in the study are given in Table 5. According to these results, students' academic achievement increased in all three classes. The highest increase in academic achievement was observed in the Experiment 1 group. The findings of one-way analysis of covariance (ANCOVA), in which the adjusted data were compared according to the pre-test scores of the 3 groups participating in the study, were shared.

Table 5. Academic Achievement Test Pre-Test-Post Test Score Mean and Standard Deviation Values

Group	N	Pre-test	Standard Deviation	Post-test	Standard Deviation
Experiment Group 1	15	4.00	1.77	19.53	6.01
Experiment Group 2	14	4.21	1.81	17.29	6.01
Control Group	18	4.72	1.49	13.56	5.72

It is seen that there is a difference between the groups' academic achievement post-test mean scores (D1= 19.53, D2=17.29, K=13.56). The post-test mean academic achievement scores of the experimental groups were higher than the post-test mean academic achievement scores of the control group. Table 6 shows the adjusted posttest averages of all groups in the academic achievement test.

Table 6. Academic Achievement Adjusted Post-test Averages of All Groups

		$\overline{X}$	sd
D1	Post-test	20.08	1.38
D2	Post-test	17.49	1.42
K	Post-test	12.94	1.26

Adjusted Pre-Test Mean Score= 4.34.

The adjusted post-test mean scores of the groups according to their academic achievement test scores are given in Table 6. Accordingly, the mean of experimental group 1 was 20.08, the mean of experimental group 2 was 17.49, and the mean of the control group was 12.94. It is seen that there is a difference between the adjusted post-test averages of the groups. The significance of this difference between the groups was analyzed by ANCOVA and the results are given in Table 7.

Table 7. All Groups Academic Achievement Pretest-posttest ANCOVA Results

Source of Variance	**Sum of Squares**	**sd**	**Mean Squares**	**F**	**p**	**η2**
Pre-test	322.407	1	322.407	11.470	0.002	0.211
Group	**418.670**	**2**	**209.335**	**7.448**	**0.002**	**0.257**
Error	1208.628	43	28.108			
Total	14745.000	47				

According to Table 7, there was a significant difference between the groups in academic achievement post-test scores [F(2,43) =7.448, p=0.002<0.05]. This proves that the learning models applied to the groups affected academic achievement. When the effect size of the significant difference between the groups is examined, it can be said that the effect of the applied teaching model on the difference between the academic achievement of the groups is large ($\eta^2 = 0.257 > 0.14$). Table 8 shows between which groups the academic achievement post-test scores differed.

Table 8. Academic Achievement Pre-test-post-test ANCOVA Results Comparison of the Difference between Groups

$\underline{x}_1$	$\underline{x}_2$	$\underline{x}_1$-$\underline{x}_2$	**Sd**	**p**
Experiment Group 1	Experiment Group 2	2,59	1,97	0,587
Experiment Group 1	Control Group	7,14	1,89	0,001*
Experiment Group 2	Control Group	4,55	1,91	0,044*

When Table 8 is examined, it is seen that there is no significant difference in the academic achievement post-test scores of the experimental groups (p=0.587>0.05), but there is a significant difference between experimental group 1 and the control group (p=0.001<0.05) and there is a significant difference between experimental group 2 and the control group (p=0.044<0.05). Although there was no significant difference between the experimental groups, the fact that there was a significant difference between them and the control group proves that teaching with the flipped classroom model increases success more than teaching in accordance with the education program.

Descriptive statistics of the 21st century skills scale pretest-posttest data obtained in the study are given in Table 9. According to these results, 21st century skills increased in the experimental groups and decreased in the control group. The highest increase in 21st century skills was observed in the experimental group 2. The findings of one-way analysis of covariance (ANCOVA), in which the corrected data were compared according to the pre-test scores of the 3 groups participating in the study, were shared.

Table 9. 21st Century Skills Scale Pretest-posttest Mean and Standard Deviation Values

Group	N	Pre-test	Standard Deviation	Post-test	Standard Deviation
Experimental Group 1	15	109.73	21.76	136.80	6.45
Experimental Group 2	14	106.86	18.06	140.43	7.28
Control Group	18	122.78	14.12	110.78	17.57

According to Table 9, it is seen that there is a difference between the mean 21st century skills pre-test scores of the groups (D1= 109.73, D2=106.86, K=122.78). Since there was a difference between the groups, one-way covariance analysis was performed to analyze the level of relationship by equalizing the groups.

It is seen that there is a difference between the groups' 21st century skills post-test mean scores (D1= 136.80, D2=140.43, K=110.78). Table 10 shows the adjusted post-test averages of all groups on the 21st century skills scale.

Table 10. Adjusted 21st Century Skills Posttest Mean Scores of All Groups

		$\bar{X}$	sd
D1	Post-test	136.69	2.38
D2	Post-test	141.04	2.47
K	Post-test	122.40	2.17

Adjusted Pretest Score Mean = 109.28.

The post-test mean scores of the groups corrected according to the 21st century skills scale scores are given in Table 10. Accordingly, the mean of experimental group 1 was 139.69, the mean of experimental group 2 was 141.04, and the mean of the control group was 122.40. It is seen that the adjusted post-test averages of the groups are different. The significance of this difference between the groups was analyzed by ANCOVA and the results are given in Table 11.

Table 11. All Groups 21st Century Skills Scale Pretest Posttest ANCOVA Results

Source of Variance	Sum of Squares	sd	Mean Squares	F	p	η2
Pre-test	1021.399	1	1021.399	12.067	0.001	0.219
Group	**3101.909**	**2**	**1550.955**	**18.324**	**0.000**	**0.460***
Error	3639.541	43	84.640			
Total	832796.000	47				

According to Table 11, there was a significant difference between the groups in 21st century skills post-test scores [F(2,43) =18.324, p=0.000<0.05]. This proves that the learning models applied to the groups affected the 21st century skills of the students.

When the effect size of the significant difference between the groups is examined, it can be said that the effect of the teaching model applied on the difference between the 21st century skills of the groups is large

($\eta 2=0.460>0.14$). Table 12 shows between which groups the 21st century skills post-test scores differed.

Table 12. 21st Century Skills Scale Pretest-posttest ANCOVA Results Comparison of the Difference between Groups

$\underline{x}_1$	$\underline{x}_2$	$\underline{x}_1$-$\underline{x}_2$	sd	p
Experiment Group 1	Experiment Group 2	-4,35	3,43	0,632
Experiment Group 1	Control Group	14,29	3,22	0,000
Experiment Group 2	Control Group	18,63	3,29	0,000

When Table 12 is examined, it is seen that there is no significant difference in the 21st century skills post-test scores of the experimental groups ($p=0.632>0.05$), but there is a significant difference between experimental group 1 and the control group ($p=0.000<0.05$) and there is a significant difference between experimental group 2 and the control group ($p=0.000<0.05$). Although there was no significant difference between the experimental groups, the fact that there was a significant difference between them and the control group proves that teaching with the flipped classroom model improves students' 21st century skills compared to teaching in accordance with the education program.

When the ANCOVA findings of the 21st century skills scale sub-dimensions are analyzed, it is seen that similar results were obtained. The comparison of 21st century skills sub-dimensions pretest-posttest ANCOVA results of the difference between groups is shown in Table 13.

Table 13. 21st Century Skills Sub-dimensions Pretest-posttest ANCOVA Results Comparison of the Difference between Groups

	$\underline{x}_1$	$\underline{x}_2$	$\underline{x}_1$-$\underline{x}_2$	sd	p
Cognitive Sub-dimension	Experiment Group 1	Experiment Group 2	-1,45	1,39	0,912
	Experiment Group 1	Control Group	9,38	1,34	0,000*
	Experiment Group 2	Control Group	10,83	1,39	0,000*
Affective Sub-dimension	Experiment Group 1	Experiment Group 2	-2,07	1,82	0,787
	Experiment Group 1	Control Group	8,65	1,74	0,000*
	Experiment Group 2	Control Group	10,72	1,82	0,000*
Sociocultural Sub-dimension	Experiment Group 1	Experiment Group 2	-0,58	1,74	1,000
	Experiment Group 1	Control Group	10,64	1,75	0,000*
	Experiment Group 2	Control Group	11,21	1,78	0,000*

When Table 13 is examined, it is seen that there is no significant difference in the post-test scores of the sub-dimensions of the 21st century skills scale of the experimental groups, but there is a significant difference between experimental group 1 and the control group, and there is a significant difference between experimental group 2 and the control group. Although there is no significant difference between the experimental groups, the fact that there is a significant difference between them and the control group shows that teaching with the flipped classroom model is more effective on students' 21st century skills in cognitive, affective and sociocultural terms than

teaching in accordance with the education program.

Discussion and Conclusion

When the academic achievement test findings of the study are examined, it is seen that the groups in which the flipped classroom model was applied were more successful. In the Natural Sciences Curriculum, it is recommended that the 5 topics included in the Systems in Our Body unit should be given in 24 lesson hours. This intensity in the curriculum causes students to learn the subjects superficially. With the flipped classroom model, students can learn the subject at home at their own learning pace and learn the subjects well with the activities in the classroom because their readiness for the lesson is high. With the flipped classroom model, students can watch the videos as many times as they want before the lesson, pause and take notes, identify the parts they do not understand despite the repetition and ask the teacher during the lesson. They continue to learn through qualified activities in the lesson. The realization of activities in the lesson enables the teacher to identify students' incomplete or incorrect learning and to intervene immediately. In traditional approaches, incorrect learning can be reinforced with homework. When the teacher does not have the opportunity to evaluate each student's answers in detail during post-assignment checks, the wrong learning can become permanent. For these reasons, the flipped classroom model can be said to increase academic achievement more than traditional approaches. In other studies conducted in the literature, it was observed that the flipped classroom model was more successful than the current program in increasing academic achievement in Science course (Karaaslan, 2023; Çelebi, 2023; González-Gómez et al., 2016; Elian & Hamaidi, 2018). Considering these studies, it can be said that the flipped classroom model is an effective method to increase students' academic achievement.

Another result of the study was that there was no significant difference between the groups in which the flipped classroom model was applied, but there was a significant difference between the groups in which the flipped classroom model was applied and the group in which the model appropriate to the education model was applied in favor of the groups in which the flipped classroom model was applied. When the 21st century skills scale sub-dimensions scores were examined, similar developments were observed in favor of the experimental groups. This shows that teaching with the flipped classroom model improves students' cognitive skills such as managing, structuring, using and problem solving; affective skills such as self-worth, self-identity, self-responsibility and self-management; and sociocultural skills such as social membership, social sensitivity, social performance and socialization.

The flipped classroom model is a model that requires students to be able to use technology outside the classroom, to control their own learning, and to solve the problems they encounter on their own; and to cooperate, think critically, solve problems, and learn by doing and experiencing in the classroom. For this reason, while the model provides learning, it also develops 21st century skills. As seen in the study, the 21st century skills of the students who learned the subject outside the classroom and participated in the activities in the lesson developed more than the students who learned the subject in the classroom and did the homework at home. In other studies conducted in the literature, it was observed that the flipped classroom model was more successful in increasing 21st century skills than the current program (Demirel, 2023; Çelebi, 2023; Chang & Hwang, 2018). Considering these studies

in the literature, it can be said that the flipped classroom model is a very effective method to increase students' 21st century skills. By applying the flipped classroom model in different learning areas at different grade levels, the effects of the model on science teaching can be examined.

References

Arslanhan, A., Bakırcı, H., & Altunova, N. (2022). The opinions of science teachers on the flipped learning model. *Journal of Computer and Education Research, 10*(19), 26–49. https://doi.org/10.18009/jcer.1017574

Ashiyan, Z., & Salehi, H. (2016). Impact of WhatsApp on learning and retention of collocation knowledge among Iranian EFL learners. *Advances in Language and Literary Studies, 7*(5), 112–127.

Bektaş Esen, E. (2022). *Evaluation of the development of 21st-century skills in the instruction of the 7th-grade force and energy unit through the flipped classroom model* (Doctoral dissertation, Trabzon University). Yükseköğretim Kurulu Ulusal Tez Merkezi. https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=sG74OPgx3OjhP8yZWZzGCg&no=M8d-Ew2dQ_bCQIXjWrdNUQ

Bolat, A., & Karamustafaoğlu, S. (2019). Development of an achievement test for the "Systems in Our Body" unit: Validity and reliability. *Gazi Journal of Educational Sciences, 5*(2), 131–159.

Boyraz, S. (2014). *Evaluation of the implementation of flipped education in English language teaching* (Master's thesis, Afyon Kocatepe University, Institute of Social Sciences).

Butt, A. (2014). Student views on the use of a flipped classroom approach: Evidence from Australia. *Business Education & Accreditation, 6*(1), 33.

Chang, S.-C., & Hwang, G.-J. (2018). Effects of an augmented reality-based flipped learning guiding approach on students' scientific project performance and perceptions. *Computers & Education, 125*, 226–239.

Çakır, E. (2017). *The effect of flipped classroom practices on 7th-grade students' academic achievement, mental risk-taking and computational thinking skills in science course* (Master's thesis, Ondokuz Mayıs University, Institute of Educational Sciences, Samsun, Turkey).

Çelebi, Ö. (2023). *The effectiveness of uninterrupted flipped learning model on student achievement and student and parent opinions regarding the process* (Doctoral dissertation, Ordu University, Institute of Science).

Demir, E. (2018). *The effect of flipped classroom application on environmental awareness in the 5th grade science course human and environment unit* (Master's thesis, Kastamonu University, Institute of Science).

Demirel, H. (2023). *The effect of different teaching methods in the 8th-grade science course processed with the flipped classroom model on students' 21st-century skills* (Master's thesis, Ordu University, Institute of Science).

Devrim, A. (2023). *The effect of flipped learning model applied in the force and energy unit on middle school students' academic achievement, learning responsibilities, and opinions* (Master's thesis, Kafkas University, Institute of Science).

Dixon, K., & Wendt, J. L. (2021). Science motivation and achievement among minority urban high school students: An examination of the flipped classroom model. *Journal of Science Education and Technology, 30*(5), 642–657.

Elian, S. A., & Hamaidi, D. A. (2018). The effect of using flipped classroom strategy on the academic achievement

of fourth grade students in Jordan. *International Journal of Higher Education, 7*(6), 110–121.

González-Gómez, D., Jeong, J. S., Airado Rodríguez, D., & Cañada-Cañada, F. (2016). Performance and perception in the flipped learning model: An initial approach to evaluate the effectiveness of a new teaching methodology in a general science classroom. *Journal of Science Education and Technology, 25*, 450–459.

Göğebakan Yıldız, D., & Kıyıcı, G. (2016). The effect of the flipped classroom model on pre-service teachers' achievement, metacognitive awareness and epistemological beliefs. *Manisa Celal Bayar University Journal of Social Sciences, 14*(3), 0–0. https://doi.org/10.18026/cbusos.70886

Griffiths, S., Campbell, C., & McDonald, C. V. (2021). "A problem shared is a problem halved": Supporting early career science teachers' implementation of flipped learning. *Issues in Educational Research, 31*(2), 495–512.

Gürdal, B. (2018). *Teachers' opinions about the 6th-grade science curriculum and its applications updated in 2018* (Unpublished master's thesis, Marmara University, Istanbul).

Hwang, G. J., Chang, S. C., Song, Y., & Hsieh, M. C. (2021). Powering up flipped learning: An online learning environment with a concept map-guided problem-posing strategy. *Journal of Computer Assisted Learning, 37*(2), 429–445.

Kang, M., Kim, B., Kim, B., & You, H. (2012). Developing an instrument to measure 21st-century skills for elementary students. *The Korean Journal of Educational Methodology Studies, 25*(2).

Karaaslan, Z. E. (2023). *An investigation of the flipped classroom model implemented with active learning-based activities in science course* (Doctoral dissertation, Hacettepe University). Yükseköğretim Kurulu Ulusal Tez Merkezi.

Karaismailoğlu, F. (2022). *The effect of 3D modeling within the framework of flipped classroom model on pre-service science teachers' spatial ability and academic achievement* (Master's thesis, Marmara University, Institute of Educational Sciences, Department of Science Education).

Karakaş, M. M. (2015). *Measuring 21st-century skill levels of 8th-grade middle school students towards science* (Unpublished Master's thesis, Eskişehir Osmangazi University, Institute of Educational Sciences).

Katauhi, R. C., Widodo, W., & Sari, D. A. P. (2022). Implementation of the science e-module based on guided inquiry with the flipped classroom strategy to improve students' science process skills. *Jurnal Pijar MIPA, 17*(5), 657–665.

Katz, Y. J. (2002). Attitudes affecting college students' preferences for distance learning. *Journal of Computer Assisted Learning, 18*(1), 2–9. https://doi.org/10.1046/j.0266-4909.2001.00202.x

Kaya, M., & Yıldırım, F. S. (2022). The effect of the flipped classroom model on understanding and access to the nature of science by students. *The Turkish Online Journal of Educational Technology, 21*(1), 145–156. https://files.eric.ed.gov/fulltext/EJ1338136.pdf

Kılıç, K. (2023). *An implementation of flipped classroom model supported by Education Information Network (EBA): The unit of sound and its properties* (Master's thesis, Van Yüzüncü Yıl University, Institute of Educational Sciences).

Korkmaz, H., & Kaptan, F. (2001). Project-based learning approach in science education. *Hacettepe University Journal of Education, 20*(20).

Manresa, M. (2018). Adolescents' reading habits: The effect of school activities on reading practices. In *Youth*

Reading (pp. 123–136). Routledge.

McLaughlin, J. E., White, P. J., Khanova, J., & Yuriev, E. (2016). Flipped classroom implementation: A case report of two higher education institutions in the United States and Australia. *Computers in the Schools, 33*(1), 24–37.

Ministry of National Education (MEB). (2018). *Science course curriculum* (Primary and Secondary School Grades 3, 4, 5, 6, 7, and 8). Retrieved from http://mufredat.meb.gov.tr/ProgramDetay.aspx?PID=325

Nacaroğlu, O. (2020). *The effect of the flipped learning model on gifted students' achievements and self-regulation skills in the matter and change unit* (Master's thesis, Erciyes University, Institute of Educational Sciences, Turkey).

Ocak, G. (2019). *Scientific research methods in education (in Turkish).* Pegem Akademi Publishing.

Oppong, E., Quansah, F., & Boachie, S. (2021). Improving pre-service science teachers' performance in nomenclature of aliphatic hydrocarbons using flipped classroom instruction. *Science Education International, 33*(1), 102–111.

Özbay, Ö., & Sarıca, R. (2019). Trends in studies conducted on flipped classrooms: A systematic literature review. *Ahi Evran University Journal of Social Sciences Institute, 5*(2), 332–348.

Öztürk, Ö. T. (2023). Examination of 21st Century Skills and Technological Competences of Students of Fine Arts Faculty. *International Journal of Education in Mathematics, Science and Technology*, *11*(1), 115-132.

Seren, S., & Veli, E. (2018). Comparison of the inclusion levels of STEM education in science curricula changed as of 2005. *STEAM Education Journal, 1*(1), 24–47.

Söndür, D. (2020). *The effect of the flipped learning model supported by STEM activities on various variables* (Doctoral dissertation, Erciyes University, Institute of Educational Sciences, Turkey).

Staker, H., & Horn, M. B. (2012). *Classifying K–12 blended learning*. CA: Innosight Institute.

Stratton, E., Chitiyo, G., Mathende, A. M., & Davis, K. M. (2020). Evaluating flipped versus face-to-face classrooms in middle school on science achievement and student perceptions. *Contemporary Educational Technology, 11*(1), 131–142.

Tekin, D. (2020). *Teaching of the units of fundamental laws of chemistry, chemical calculations, and mole concept with the constructivist-based flipped classroom model* (Unpublished master's thesis, Marmara University, Istanbul).

Trentin, G. (1997). Telematics and online teacher training: The Polaris Project. *Journal of Computer Assisted Learning, 13,* 261–270. https://doi.org/10.1046/j.1365-2729.1997.00029.x

Turan Yılmaz, A. (2023). *The effect of flipped learning on 7th grade middle school students' academic achievement in work and energy topic and their opinions about the model* (Unpublished Master's thesis, Balıkesir University, Institute of Science).

Turan, Z., & Goktas, Y. (2016). The flipped classroom: Instructional efficiency and impact on achievement and cognitive load levels. *Journal of e-Learning and Knowledge Society, 12*(4).

Türnüklü, A. (2001). Using different research techniques together to answer the same research question in the field of educational science. *Education and Science, 26*(120). Retrieved from http://213.14.10.181/index.php/EB/article/view/5242/1404

Uçaş, Ü. G. (2023). *An investigation of the effect of the gamified flipped classroom model on primary school*

students' critical thinking tendencies, problem-solving skills, and science learning motivation (Master's thesis, Mersin University). Yükseköğretim Kurulu Ulusal Tez Merkezi. https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=FKgTBLhg_WcARDMobHaMrQ&no=nZBc96qYlD0HsDycy-Q2-A

Uksuzoğlu, T. (2023). *The effect of flipped classroom applications in science education on students' motivation, misconceptions, achievement, and scientific process skills* (Master's thesis, Akdeniz University, Institute of Educational Sciences).

Ünal, S., Çoştu, B., & Karataş, F. Ö. (2004). A general overview of curriculum development studies in science education in Turkey. *Gazi University Journal of Gazi Education Faculty, 24*(2).

Ünlütürk, A. Ö. (2022). *Examination of the effectiveness of out-of-school science education structured with flipped learning in terms of various variables* (Master's thesis, Süleyman Demirel University, Institute of Science, Department of Electronics and Computer Education).

Ünlütürk, A. Ö., & Bakioğlu, B. (2023). The implementation of flipped learning in out-of-school science education by students. *Kocaeli University Journal of Education, 6*(1), 124–140. https://doi.org/10.33400/kuje.1225945

Verim, S. (2022). *The effect of teaching the pressure unit in science course through flipped learning method on students' achievement and attitudes* (Master's thesis, Atatürk University, Institute of Educational Sciences, Department of Physics Education).

Yanardağ, H. (2021). *The effect of flipped classroom applications on academic achievement, attitude, and learning retention of 8th-grade students in the teaching of the Seasons and Climate unit* (Master's thesis, Dicle University, Institute of Educational Sciences).

Yurtlu, S. (2018). *The effect of flipped classroom model in science education on students' achievement and opinions* (Master's thesis, Muş Alparslan University, Institute of Science, Department of Science Education).

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