



MIDDLE SCHOOL STUDENTS' EXPERIENCES AND PERCEPTIONS ABOUT FLIPPED CLASSROOM APPLICATIONS USED IN GEOMETRY LESSONS

Nuray ÇAKIROĞLU, Mutlu PIŞKİN TUNÇ

Abstract: The purpose of the study was to investigate the experiences and perceptions of middle school students about the flipped classroom applications used in geometry lessons. The research was designed as a case study. Data were collected through field notes, focus group interviews, and semi-structured interviews. The sample consisted of 26 eighth-grade students studying in a state middle school in Turkey. Within the scope of the flipped classroom, lecture videos and summaries, multimedia activities, and exercises were sent to the students through the Education Information Network (EIN) lesson module. The results indicated that students could control their learning at their pace and the lesson module were generally comprehensible. Moreover, the in-class activities enabled students to learn mathematics in a meaningful and in-depth manner. There was enough time for the application and implementation of classroom tasks. Furthermore, students learned better by getting support from their friends in the group, the interaction between student-student and student-teacher improved, and they were actively involved in the lessons. Additionally, students' bias towards mathematics decreased.

Key words: Flipped classroom, hybrid educational models, education information network, mathematics education.

1. Introduction

It becomes inevitable to modify to human needs in today's world due to the developing technologies, scientific studies, and growing population. Unfortunately, utilizing traditional models and strategies in education systems does not manage to satisfy such needs effectively (Aydın, 2016; Bilyalova, Salimova, & Zelenina, 2019). Traditional learning has been found to limit students, teachers, the variety of classroom environment, current materials, and techniques (Kharat, Joshi, Badadhe, Jejurikar, & Dharmadhikari, 2015). Further, it is known that in the traditional education system, there is a lack of time for classroom tasks due to excessive lesson contents (Külekçi, 2013). In the traditional education system, there are also negative comments such that homework may cause tiredness among students, it is difficult to check whether students' study efficiently or not (Kapıkıran & Kıran, 1999) and homework are done in an atmosphere in which students cannot ask their questions to the teachers (Talbert, 2012). Prensky (2001) emphasized that it was meaningless to educate today's students growing with technology in the same way as previous generations. Moreover, it is difficult to keep up with the times if technological opportunities are not integrated into the educational field (Ally, 2009; Bilyalova et al., 2019). Drucker (1994) stated that the biggest change with technology will be in the structure, content, meaning and importance of the information for societies. In today's world, digital technology is not only a tool, but also a way of life that opens new possibilities, such as studying at any time that is convenient for you and continuing your education (Bilyalova et al., 2019). In this sense, while the digital revolution transforms societies, it restructures education systems and eliminates certain controversial doctrines (Toffler, 1996). Moreover, this transformation brings about a radical paradigm change in global learning systems, bringing to light the necessity of questioning and updating the designed learning and teaching environments, teacher and student roles, and educational tools used (Kuhn, 2003; Prashar, 2015). In this context, by targeting to bring a different dimension to the traditional education system, it becomes increasingly significant to integrate flipped classroom

Received May 2021.

Cite as: Nuray Çakiroğlu, N, Pişkin Tunç, M. (2022). Middle School Students' Experiences and Perceptions about Flipped Classroom Applications Used in Geometry Lessons, 15(2), 26-42, <https://doi.org/10.24193/adn.15.2.3>

model, regarded as an interchange between homework and lecture, into education (Abeysekera & Dawson, 2014).

Covid-19 virus, which arose in China in December 2019 and has prevailed all over the world since then, has not only affected the healthcare field but also the educational field. In order to decelerate infection speed and spread of Covid-19 virus, to reduce the deaths that may occur, and to gain time for treatment studies, face to face education was suspended in many countries around the world, or hybrid educational models in which face-to-face education and distance education were carried out together began to be used (Yamamoto & Altun, 2020). In this context, it becomes more and more substantial to apply most appropriately face-to-face training and online learning opportunities together through different models such as flipped classroom model (OECD, 2020). Flipped classroom model allows students to practice and collaborate more in the classroom, and it eliminates the “knowledge transfer” role of the teacher in traditional education by replacing the place and the time of lecture with homework (Abeysekera & Dawson, 2014). With this model, since students learn the subject at home, more time is allocated for individual and group studies, problem-solving activities, and exercises in the classroom (Seaman & Gaines, 2013). Further, conducted studies showed that when the students took part in their learning processes, not only their success and learning performances increased but also their interests in peer learning processes (Huang, Fan, Hu, & Feng, 2020; Akey, 2006; Fredricks, 2011; Marzano, 2013).

When the previous studies were examined, it was determined that the students could not understand or misunderstand some geometric concepts because geometric concepts are abstract, contain assumptions and the properties of the concepts are difficult to visualize in mind (Olkun, Çelebi, Fidan, Engin, & Gökgün, 2014). Furthermore, studies revealed that many formulas, properties of geometric shapes, and rules were memorized to students in geometry teaching, therefore students could not realize the relationship between the concepts in geometry and the functional aspect of geometry (Olkun & Aydoğdu, 2003). Yurniwati and Utomo (2020) aimed to design a learning model to help students develop their higher order thinking skills in geometry. It was a literature review study focused on relevant articles and books. The sources were examined to develop a practical learning model. The findings indicated that problem-based learning in a flipped classroom model improved students' higher order thinking skill. Additionally, the flipped classroom model allowed students to improve their self-directed learning and collaboration. Correspondingly, Bregmann & Sams (2012) stated that with flipped classroom applications, more time could be devoted to in-class activities and problem-solving, and the necessary environment was created for students to think, ask questions, and make comparisons. According to a recent comprehensive meta-analysis by Strelan, Osborne and Palmer (2020) flipped classroom model had a moderately positive effect on student performance. Regardless of discipline, the flipped classroom was found to be more effective than traditional teaching in this meta-analysis. The flipped classroom model can only be implemented effectively if teachers carefully plan their teaching materials both in-class and out-of-class. However, there has been little emphasis on how to design in-class and out-of-class sessions in the flipped classroom model and students' experiences in the in-class and out-of-class sessions. Moreover, most of the research on the flipped classroom model were performed in disciplines other than geometry teaching and with students in secondary or higher education. In this context, the aim of this study was to examine the experiences and perceptions of the students regarding the flipped classroom applications applied in the 8th-grade geometry class.

2. Flipped Classroom Model

Flipped classroom is described as devoting more time for material usage in classroom by moving lecturing process out of classroom through videos, that is, the shifting between in-class training and homework (Bregmann & Sams, 2012; Gaughan, 2014). According to Mok (2014), flipped classroom model means to take the teaching, in which students are inactive, out of classroom through videos and to spend classroom hours with a learning process in which students are active. Similarly, Jacot, Noren and Berge (2014) regarded flipped classroom as performing of a narrative education out-of-class and performing of the activities in classroom under the guidance of the teacher. On the other hand, Lage, Platt, & Treglia (2000) described it to be a perspective in which lecturing takes place out of classroom

via videos or other resources in the light of a notion that the learning responsibility belongs to learners and active learning is carried out through classroom activities. The flipped classroom model enables students to learn without time and place limitations. In addition, it provides the opportunity to get ready for the activities to be done in the classroom by building their own knowledge outside the school. It is also aimed to eliminate note-taking monotony of the student in classroom and to get full efficiency from teachers in applications (Toto & Nguyen, 2009). The flipped classroom model allows students to do more problem-solving activities individually or with a group on subjects that they explore on their own in a classroom setting (Yurniwati & Utomo, 2020). Moreover, it allows concentrating on issues that many students face in the self-learning process and gives opportunity to a teacher to give one-on-one attention to each learner (Seaman & Gaines, 2013). The advantages of flipped classroom model for both teachers and learners can be sorted as follows:

- ✓ It enables students to attend the lessons even if they could not go to school because of various reasons such as social occasions or illness (Bregmann & Sams, 2012; Johnson, 2013; Talbert, 2012).
- ✓ It eliminates unnecessary time consumption for the subjects that students can learn easily on their own and instead of this, they can repeat the subjects that they hardly learn as many times as they need (Enfield, 2013; Morgan, 2014).
- ✓ It provides students with an opportunity to take responsibility and to gain self-knowledge. It also enables students to gain a skill through which they can apply knowledge that they learned to real life conditions (Enfield, 2013; Fulton, 2012; Talbert, 2012).
- ✓ Independent of the place and time, it helps students to learn in accordance with their individual learning pace during the non-class period (Bregmann & Sams, 2012; Bishop & Verleger, 2013; Davies, Dean, & Ball, 2013).
- ✓ Flipped classroom model, based on constructivist learning approach, increases students' participation and interests to the course by means of student-centred learning (Aksoy, 2020; Çevikbaş, 2018; Fulton, 2012; Huang et al., 2020; Herreid & Schiller, 2013; Özdemir, 2016; Talan & Gülseçen, 2019; Tekin, 2018).
- ✓ It facilitates classroom management, as it offers one to one or small group study opportunities to teachers (Abirami & Kiruthiga, 2018; Bregmann & Sams, 2012).
- ✓ It contributes to develop and efficient and creative time management in classroom and to increase communication between teacher- student and student- student (Bregmann & Sams, 2012; Fulton, 2012; Tekin, 2018).
- ✓ It helps teachers to do more activities instead of teaching something in classroom and therefore they can focus on students' learning processes (Rutkowski & Moscinska, 2013).
- ✓ By offering learning experience, peer learning and teacher guidance, it makes possible to run active learning and individual learning together (Bishop & Verleger, 2013).
- ✓ It leads students to present their knowledge and skills during the activities conducted in classroom (Foust, 2012).
- ✓ Students do their homework in the classroom so that teachers can easily recognize students' learning difficulties and their learning styles (Fulton, 2012).

There are also some disadvantages of flipped classroom model besides its advantages. One of its common disadvantages may be regarded as the lack of technological devices that are needed for its application and technological faults (Aksoy, 2020; Arslan, 2020; Güç, 2017; Long, Logan, Cummins, & Waugh, 2016; Nielsen, 2012; Özdemir M. Ç., 2019) Another disadvantage of this model is to give extra responsibility to the students (Arnold, 2014; Özdemir M. Ç., 2019; Güç, 2017). This disadvantage shows itself in the possible inconsistency between students' learning habits and the learning style of flipped classroom embedded technology. That is, in contrast to those preferring to keep their own learning under control, other students may need extra assistance as they cannot manage

their own time and studies (Arnold, 2014). To sum up, when the previous studies were investigated, it could be understood that its advantages predominated over its disadvantages.

In this context, the purpose of the study was to investigate the experiences and perceptions of the students regarding flipped classroom applications applied in 8th-grade geometry class. The research problem was: “What are the students’ experiences and perceptions related to flipped classroom applications used in the teaching of “Triangles” and “Congruence and Similarity” concepts?”

3. Method

3. 1. Research Design and Procedure

A case study design was used in this study that aimed to investigate the experiences and perceptions of the middle school students regarding flipped classroom applications applied in the 8th-grade geometry class. In the case study designs researchers work through and examine thoroughly one or several cases in a certain limited time by using different data collection tools (visual or audial materials, report, document, observation, interview) and collect in-depth information and describe a situation by revealing themes (Creswell & Poth, 2016).

Based on the literature review, it was decided to send lecture videos, multimedia activities and exercises that were suitable for learning outcomes within the context of flipped classroom on EİN-Educational Information Network. EİN is an online social education platform designed in Turkey to use effective materials via technological devices during the education period and it contains proper, reliable, and checked e-contents that are eligible for different learning grades (Ministry of National Education [MNE], 2020). Besides the rich content and visual materials of EİN; it is very useful for research because it enables to follow up students’ participation in the studies from the study reports. Moreover, the education platform allows students to follow the homework and exercises sent by the researcher instantly on the calendar, to do the work on time, to work on any subject at any time and to continue learning both at school and outside of school.

“Triangles Readiness Test” was applied to students at the beginning of the week on which application would start. The test was prepared by using the questions in the statewide exams at the middle school level in Turkey. Firstly, all the mathematics questions, between the years 1998-2018, were reviewed. Secondly, the questions belonging to the “Geometry” and “Measurement” learning areas were determined. Thirdly, from the 56 questions determined, 20 multiple-choice questions including the concepts that form the basis of the “Triangles” and “Congruence and Similarity” sub-learning areas were selected. Angles, polygons, and area were all included in this test. 40 minutes was allowed for students to complete the test. This test was only conducted to create the groups and to determine the students who participate the semi-structured interviews. Five heterogeneous groups were created consisting of 4 quintets and 1 sextet according to the results of readiness test performed. These groups worked together in all studies performed throughout the application. Six students from different groups and levels were chosen according to the readiness levels and to their ability to reflect their opinions clear and intelligibly. Individual semi-structured interviews were conducted with these six students before and after the study. All the students involved in the research group benefited from flipped classroom applications and the resources on EİN lesson module. The members of the research groups did not change and worked together in all activities performed throughout the application. The study process was determined as 27 lessons that were normally allocated for “Triangles” and “Congruence and Similarity” contents in the curriculum. During the six-week application period, group meetings were held with all students in the study groups in the last lesson of each week. In these meetings, focus group interviews were conducted with the five research groups separately.

3. 2. Participants

The sample of the study consisted of 8th-grade middle school students studying in a state middle school where one of the researchers was a mathematics teacher. Twenty-six students totally took part

in the study; 16 of them were female and 10 of them were male. These students participated in the research based on voluntariness with convenience sampling method which is one of the purposeful sampling methods. In convenience sampling method, nearby and accessible participants are chosen in order to accelerate and ease the study (Yıldırım & Şimşek, 2018). Instead of their names, students were coded as S1, S2 before the study according to the classroom list. Six students who would be invited to the interviews were chosen by means of maximum variation sampling according to their 'Triangles Readiness Test' scores and voluntary basis. According to the scores of the readiness test, S8 and S12 stood for good; S3 and S7 stood for average; S16 and S21 stood for weak students. In the study, while students' experiences were obtained from observations of the five heterogeneous groups consisted of 26 students; students' opinions were obtained from semi-structured interviews conducted with the six students and focus group interviews conducted with all the students. The heterogeneous groups created and the groups including students with whom semi-structured interviews were performed are shown on Table 1.

Table 1. Groups formed according to Triangles Readiness Test

Group Number	Students in the groups	Students interviewed
Group 1	S6, S9, S12 , S17, S19	S12
Group 2	S5, S8 , S10, S14, S21 , S25,	S8, S21
Group 3	S2, S3 , S18, S23, S26	S3
Group 4	S4, S13, S16 , S20, S24	S16
Group 5	S1, S7 , S11, S15, S22	S7

3. 3. Data Collection Tools

3.3.1. Observations

During the application, observations were done in the classroom to figure out students' experiences with flipped classroom applications. Throughout six weeks, one of the researchers taking part as a teacher in every stage of the process observed all the students involved in working group for 27 lesson hours. The researcher took field notes after each lesson. The researcher tried to reveal the difficulties encountered during the application and the effectiveness of the teaching with the notes she took. During the application, concepts thought in the lesson, definitions, rules, explanations, important points, students' questions, and unclear points were recorded with notes by the researcher. This field notes helped researchers to find out general situation of the classroom atmosphere.

3.3.2. Interviews

Throughout six weeks, focus group interviews were performed with all the students taking part in the research groups at the last lesson of each week. Each of the five research groups was interviewed separately. Researcher asked students '*What do you think about the lesson of this week?*' during the interviews and requested students to evaluate the teaching process of the related week. The interviews lasted between 10 and 15 minutes. Students' answers were recorded. Additionally, two semi-structured interviews, as one pre-research interview and one post-research interview, were conducted with the six students (S12, S8, S21, S3, S16, S7) to determine students' opinions. The questions in the interview forms were given special attention to ensure that they were clear and instruction-free. Until implementing flipped classroom applications, pre-research interviews were performed to determine the general opinions of the students. During the pre-research interview, students were asked how they prepared for targeted subjects at home before coming to math class, as well as which sources, they used. The interviews were about 10 minutes long. Post-research interviews were conducted after "Triangles" and "Congruence and Similarity" subjects had been taught via flipped classroom applications. The questions in the post-research interview were mostly aimed to reveal students' perceptions about flipped classroom applications. In the post-research interview, students were asked

what they think about the flipped classroom applications, what the advantages and disadvantages of the applications were about out-of-class and in-class processes, and how they were feeling during the flipped classroom application. The interviews lasted between about 20 and 25 minutes. All the interviews were held in a quiet place to enable students to express themselves comfortably. Short notes were taken, and interviews were recorded to make the data collected from interviews more reliable.

3. 4. The Process of Flipped Classroom Instruction

Within the research, a detailed plan related to activities and studies carried out with working group during the process was prepared. It was preferred to conduct out-of-class activities, which were the part of flipped classroom applications performed at home, on EIN module. Activities performed weekly out of class were sent to students via EIN lesson module. These activities are given on Table 2. Students completed videos, multimedia activities, exercises, summaries, and quizzes sent via EIN lesson module before each lesson.

Table 2. Assignments sent to students via EIN lesson module

	<i>Content</i>	<i>Type</i>
Week 1	Angle bisector of a triangle	Lecture video
	Median of a triangle	Lecture video
	Height of a triangle	Lecture video
	Drawing the height of a triangle	Activity
	Examining the angle bisector, median and height of a triangle	Activity
	Angle bisector, median and height of a triangle	Exercise
	Angle bisector, median and height of a triangle	Summary
	Angle bisector, median and height of a triangle	Quiz – 10 questions
Week 2	Triangle Inequality	Lecture video
	Triangle Inequality	Activity
Week 3	The relationship between angles and sides of a triangle	Lecture video
	Determining the relationship between angles and sides of a triangle	Activity
Week 4	Drawing a triangle	Lecture video
	The triangle inequality theorem and drawing a triangle	Exercise
	The triangle inequality theorem and drawing a triangle	Quiz – 10 questions
	The triangle inequality theorem and drawing a triangle	Summary
Week 5	Pythagorean theorem	Lecture video
	Proof of the Pythagorean theorem	Activity
	Finding the distance between two points in the coordinate plane	Lecture video
	Right-angled triangle and Pythagorean theorem	Summary
	Right-angled triangle and Pythagorean theorem	Exercise
	Right-angled triangle and Pythagorean theorem	Quiz – 10 questions
	Congruent polygons and triangles	Lecture video
	Finding congruent polygons and triangles	Activity
Week 6	Similar polygons	Lecture video
	Similarity in triangles	Lecture video

	Finding similar triangles and polygons	Activity
	Congruence and similarity	Exercise
	Congruence and similarity	Summary
	Congruence and similarity	Quiz – 10 questions

Worksheets and activity papers were developed for students who would arrive at school after completing their assignments at home. Every week, at the start of the class, students were asked questions about the concepts covered that week in order to remind them about what they learned at home and to correct any gaps in their knowledge. Activity papers were also used. Activity papers were designed to help students determine how well they learned the learning outcomes in flipped classroom applications and to correct any skipped or mislearned content. They were used to allow students to take an active role in the classroom, engage with one another and their teachers, and construct the knowledge they had learned. Additionally, worksheets were designed to reinforce what students learned out-of-class and in-class processes. They were made up of open-ended questions in order to better observe how students apply their knowledge. Literature and course books provided by MNE to students were taken as references when the activity papers and worksheets were prepared (Böge & Akıllı, 2019; Serçifeli & Atmaz, 2019; Şataf, 2009). Activity papers and worksheets prepared by the researchers were put into final form by conferring on two mathematics teachers. The in-class activities are given on Table 3.

Table 3. *The in-class activities*

	Activity	Time
Week 1	Drawings of angle bisector, median, and height of various triangles were performed in the activity paper.	One lesson hour
	The worksheets about angle bisector, median and height of a triangle were distributed, and students were asked to work in groups to answer the questions.	One lesson hour
Week 2	The groups were given sticks of various lengths and asked to build the triangles on the "Building Triangles" activity paper and discuss which triangles they were able to form and which they were unable to form.	Two lesson hours
	"Triangle Inequality" worksheets were distributed to each student and they were asked to answer the questions individually, and to get support from their groupmates if they had any difficulties.	Three lesson hours
Week 3	Protractors and rulers were distributed to the students individually and asked to measure the angles and sides of the various triangles given in the activity paper.	Two lesson hours
	The worksheets about the relationship between angles and sides of a triangle were distributed to each student and they were asked to answer the questions individually, and to get support from their groupmates if they had any difficulties.	Three lesson hours
Week 4	Compasses, rulers, and protractors were distributed to the students individually and asked to draw the triangles given the measurements in the activity paper.	Four lesson hours
	The students were asked to create a concept map to summarize the subject of "Drawing a Triangle".	One lesson hour

Week 5	The activity papers about proofs of The Pythagorean Theorem (Euclid's Proof, Bhaskara's Proof, Garfield's Proof) were performed in groups.	Two lesson hours
	The worksheets about "The Pythagorean Theorem" were distributed to each student and they were asked to answer the questions individually, and to get support from their groupmates if they had any difficulties.	One lesson hour
	"Congruent triangles" and "Congruent polygons" worksheets were answered in groups.	Two lesson hours
Week 6	Tangram sets were distributed to the students individually and ask to perform the tasks about similar polygons.	Two lesson hours
	The activity papers about similar triangles were performed in groups.	Two lesson hours
	The worksheets about "Congruence and Similarity" were distributed to each student and they were asked to answer the questions individually, and to get support from their groupmates if they had any difficulties.	One lesson hour

3. 5. Data Analysis

In the current study, the data obtained from observations of the researcher, focus group interviews and semi-structured interviews were analyzed by utilizing content analysis method. The primary goal of content analysis is to identify patterns and relationships that can help in the clarification of the data collected. (Patton, 2002; Yıldırım & Şimşek, 2018). At first, audio recordings of interviews were transcribed into written documents. Then, data obtained during the in-class process (observations of researcher, focus group interviews) and semi-structured interviews were read and coded repeatedly, and themes were obtained within the framework of flipped classroom applications. Afterwards, the relationships and differences between the themes obtained by classification were determined. Themes with similar meanings were combined and tried to get clearer results. Finally, the data obtained were interpreted and explained. The Figure 1 includes the master coding list used in the data analysis. In qualitative research, it is critical to maintain credibility (internal validity) (Merriam, 2015). Researchers critically questioned themselves and the research process and checked whether the findings and results they obtained reflected the reality (Yıldırım & Şimşek 2018). It was intended to compare, check, and approve the findings obtained using multiple data collection methods and instruments (observations of researcher, focus group and semi-structured interviews). In addition, some of the data obtained from the research were analyzed by a mathematics teacher as the second coder. Whether the data were consistent among the second coder and the researchers was examined. Rich and detailed definitions made to increase the level of transferability of the research findings to different situations (Merriam, 2015). Furthermore, the research group and data collection process were explained in detail. Additionally, research findings were expressed clearly and in detail, supported by direct statements.

4. Results

According to the analysis of data, experiences and perceptions of the middle school students regarding the flipped classroom model applied in the geometry class were classified under some major categories and subcategories. The participants' experiences and perceptions are summarized for a clear explanation (See Figure 1).

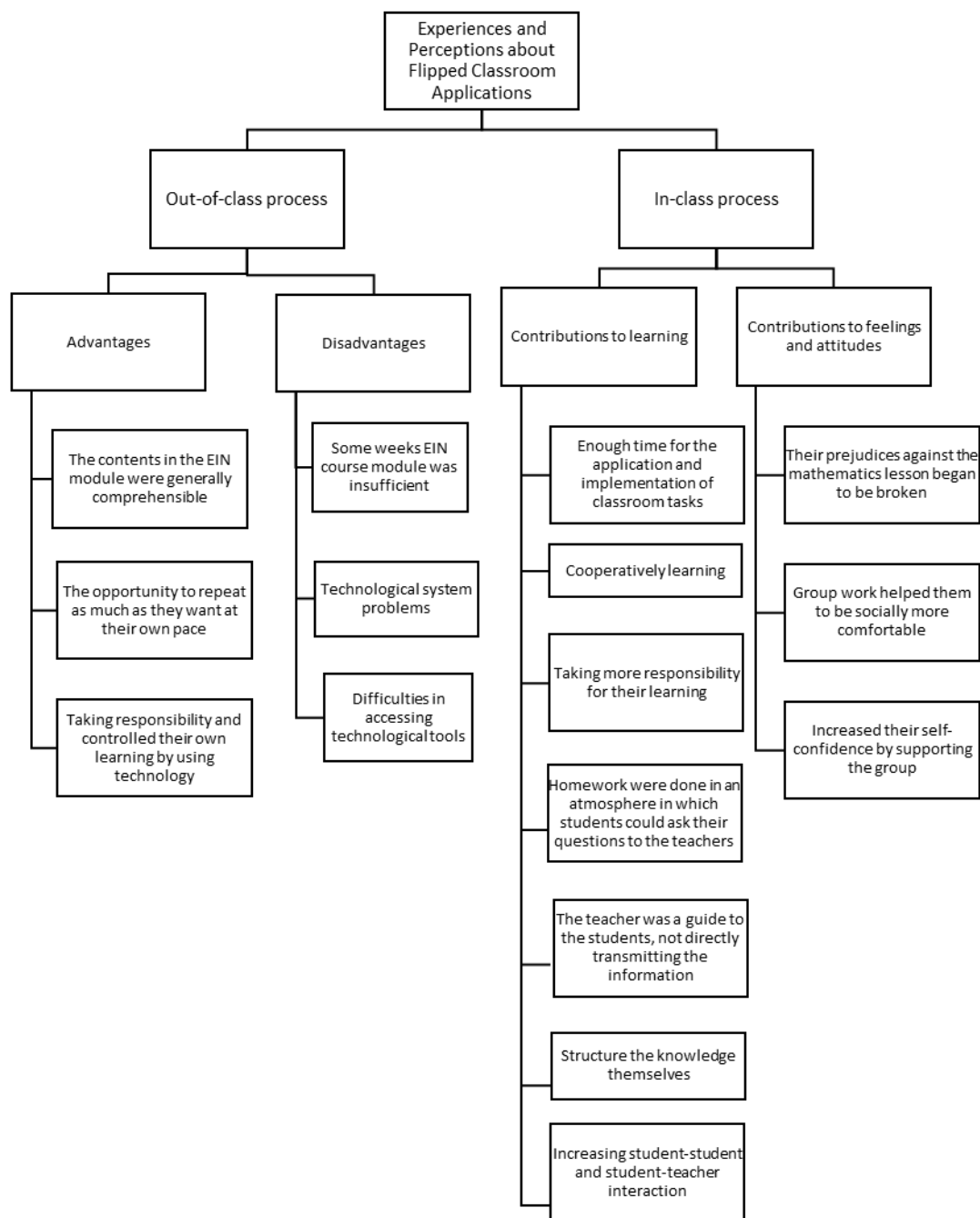


Figure 1. A summary for middle school students' experiences and perceptions about the flipped classroom model

4. 1. Findings Regarding Middle School Students' Experiences and Perceptions about Out-Of-Class Process

4.1.1. Advantages of The Flipped Classroom Model

From the first week to the last week of the flipped classroom applications, all students completed the lecture videos, activities, exercises, summaries, and quizzes sent to them via EIN (except the similar polygons lecture video). From the answers given by the students to the questions, which were asked at the beginning of the lesson to remind students what they learned at home and correct their incomplete learning, it could be interpreted that the contents in the EIN module were generally comprehensible. In other words, the students got ready for the lesson and understood the subject. For instance, in the focus group interview S8 said: "I carefully watch the videos in EIN and take notes so that I can answer the

questions you ask when starting the lesson. This is the first time I get ready for math class.” It was noticed that the assignments sent to the students via the lesson module were generally sufficient for the students to comprehend the subject. The active participation of students in the activities and practices in the classroom also supports this claim. Moreover, the statements of the students in the post-research interviews were in the same direction. For example, S3 stated: “The subject we will learn is already explained in EIN in a way that we can understand. In this way, I was able to reinforce it more quickly when I returned to school.” In the out-of-class process of flipped classroom applications, students had the opportunity to repeat as many times as they wanted at any time and place. In the post-research interview, all the students mentioned this advantage of flipped classroom applications. To illustrate, S7 said: “I was able to listen to the subject whenever I wanted from the lesson module, there were several videos, and I could understand the subjects well.” In a similar way, in the focus group interview S11 stated: “It is better for me to learn the subject from the lesson module. I stop where I do not understand and listen again. When the subject was taught in class, we did not have such a chance.” The lesson module enabled them to repeat the subject as much as they want at their own pace before they came to school.

In the sixth week, the lecture video for "Similar Polygons" could not be completed due to technological system problems, although students tried many times. However, many of the students stated that they watched videos about "Similar polygons" on YouTube in order not to get behind in the lesson. For example, in the post-research interview S8 said: “When I could not watch the similarity video on EIN, I watched it on YouTube. I did not want to get behind in the activities we did in the classroom.” This situation revealed that in the flipped classroom applications, students took responsibility and controlled their own learning by using technology. On the other hand, in the pre-research interview, most of the students stated that they did not make any preparations regarding the subject they would learn before coming to the classroom. Students commonly reported that they used textbooks, test books, and the YouTube platform to complete or repeat their incomplete learning after learning the subject at school. Similarly, S3 expressed: “No, I'm not getting ready for the class. I look at lecture books after studying the topic in school, and I occasionally watch lecture videos on YouTube.”

4.1.2. Disadvantages of The Flipped Classroom Model

However, in some weeks, it was seen that the videos and activities in the EIN lesson module were insufficient to fully comprehend the subject. For example, in the second week, although the students knew the rules about the triangle inequality, they struggled to apply the procedures in the triangle inequality activity in the classroom. To illustrate, in the focus group interview S10 stated: "There were more exercises in EIN about the angle bisector, median and height of a triangle. There are only two for this topic, I watched but did not quite understand. I could understand it when we did in class." In addition, there were technological problems in some weeks. For example, in the sixth week, the lecture video for "Similar Polygons" could not be completed due to technological system problems, although students tried many times. This situation could be seen as a disadvantage of flipped classroom applications due to technological problems. In addition, some students stated that they had difficulty in carrying out the assignments given in the lesson module because they did not have computers at home, or their internet access was limited. For example, in the focus group meeting S5 stated: "I do my work in EIN by using the cell phone, but it is difficult for me because the screen is small." It could be said that one of the disadvantages of the flipped classroom model was the difficulties in accessing technological tools.

4. 2. Findings Regarding Middle School Students' Experiences and Perceptions about In-Class Process

4.2.1. Contributions of The Flipped Classroom Model to Learning Process

While designing the activities in the classroom, activities allowed students to discover the rules about the subject themselves were tried to be prepared. Students, who came prepared for the subjects with the help of the EIN lesson module, had the opportunity to practice with activities in the classroom. Since students learned the subject at home with flipped classroom model, the time allocated for activities and practices in the classroom was more than the traditional method. For instance, the

activities in the third and fourth weeks generally include drawing and constructing triangles using compasses, rulers and protractors. It was observed that the students had difficulties in using these drawing tools. Although the mathematics curriculum includes activities related to construction of geometric shapes, it was understood from the students' expressions that teachers did not give much time for construction activities in their lessons. For instance, in the focus group interview of the third week, S7 said; "We never used to draw using compasses and rulers before. I did not know how to use compasses, I learned through these activities." and S9 stated; "We had teachers who told us to buy compasses, rulers and protractors before, but we did not use them. I had a lot of fun drawing with them." One of the reasons for this situation may be the loss of time while drawing, and therefore the concerns of teachers about not able to finish all of the topics in the curriculum. However, in the flipped classroom, there was enough time for the application and implementation of classroom tasks. In this way, many activities were done with students about triangle drawing. In other words, it was seen that the time allocated for activities to be carried out in the classroom was much due to the students learning the subject at home. Similarly, in the focus group interview of another week, S23 stated; "In the past, only the subjects were taught in the classroom. Now we do everything ourselves in the class. We do both activities and solve questions. There is enough time for all." Correspondingly, in the post-research interview S16 said: "We always thought math was as difficult, but I learned best by doing it, seeing it, and not hurrying. We can even say that I taught myself." In the activities within the scope of flipped classroom model, the teacher was a guide to the students, not directly transmitting the information. This situation supported students' meaningful and permanent learning. For example, in the post-research interview, S3 said; "When I cannot solve a problem, it is better for me that you give clues rather than solve it. In this way, I try to solve the problem myself, and I never forget how it is solved." Furthermore, the in-class activities enabled students to learn mathematics in a meaningful and in-depth manner by encouraging them to structure the knowledge themselves. In a similar manner, in the post-research interview S12 expressed: "We memorized math formulas before, but there was evidence in the activities. Why does a squared plus b squared equal c squared in a right-angled triangle? We showed this by proving. Therefore, we do not need to memorize something."

The data analysis revealed that students learned better by getting support from their friends in the group. For instance, in the focus group interview S20 stated; "I would not ask anyone where I did not understand before. Now, I can ask my friends and sometimes I understand better when they tell." It was noticed that the activities and practices carried out as group work encouraged students to take more responsibility for their learning and learned cooperatively. In addition, it was noticed that they asked questions to their groupmates before their teachers when they could not do during the activity and solved problems by helping each other. In this case, it could be said that the flipped classroom applications increased student-student interaction. For example, in the focus group interview S13 said; "It is fun to draw, but sometimes I do not know how to draw. When I could not draw, I got help from my friends and you. The lessons are going well, and I can ask every question I want." Flipped classroom practices not only increased student-student interaction but also increased student-teacher interaction. Because, in this model, the teacher was a guide in implementing the activities, not transmitting the information. Additionally, in the flipped classroom applications, homework was done in an atmosphere in which students can ask their questions to the teachers.

4.2.2. Contributions of The Flipped Classroom Model to Students' Feelings and Attitudes

In all the activities carried out in the classroom, group work, which is one of the most suitable teaching methods for the flipped classroom model, was applied. In this way, it was observed that students with low mathematics achievement increased their self-confidence by supporting the group and made more effort to participate in the activities. To illustrate, in the post-research interview S7 said; "Before, I could not ask my friends things I did not understand; now I am easily asking. They also ask me, and I like it very much when I can answer. I wish we did group work in other lessons." In addition, the students mentioned that they were satisfied with the activities and practices carried out in the classroom with group work. Moreover, students stated that group work helped them to be socially more comfortable in the classroom.

In the first weeks, it was observed that the students were anxious because the flipped classroom model was a new method for students and their prejudices about mathematics lessons had been ongoing for

years. In the following weeks, it was seen that the students were very interested in the activities and applications in the classroom, thus their prejudices against the mathematics lesson began to be broken. It was observed that the students who were prepared for the lesson were more interested in the lesson. Moreover, the considerable number of activities and practices carried out in the classroom and the active participation of students in this process changed their negative thoughts towards mathematics lesson and increased their interest in the lesson. The expressions of S5 and S12 support the claims. For instance, in the focus group interview S5 stated; "I was bored when the teacher lectured on the board, I did not want to listen. Now, I did it all myself in this lesson. The lesson was very good." and in the post-research interview S12 said; "I had a lot of fun. I never liked math class before. I wish we always do activities like this." As seen in the quotes even the students who stated that they did not like the mathematics lesson participated in the activities with great enthusiasm. For example, in the focus group interview S6 expressed; "Before, I could not follow the lesson at all. I was very bored, the teacher was telling and solving questions on the board, but now I am participating." and in the post-research interview S3 said; "I have been following the studies from EIN at the weekend, wondering what we will do this week. The lessons are very fun. I never thought I would wait for the math class to come." Moreover, it was observed that students, who came ready and willing to the lesson, actively participated in the lesson, and the fear of doing mistakes and not able to do decreased in the following weeks. Furthermore, it was noticed that the students could easily express themselves and participate in the activities. For instance, S7 said; "It was the first time I taught math with fun and understanding. I was also surprised that I was able to do it." The researcher also noticed this situation during the activities carried out in the classroom.

5. Discussion

The purpose of the study was to investigate the experiences and perceptions of the middle school students about the flipped classroom applications used in the teaching of "Triangles" and "Congruence and Similarity" contents. Within the scope of flipped classroom applications, the students came to the school by learning the subjects outside the classroom through the EIN lesson module. It was concluded that students could take responsibility for their own learning since they could repeat as many times as they want wherever they want. Bregmann & Sams (2012) stated that one of the important advantages of the flipped classroom model was the opportunity to stop, undo and repeat. Similarly, Güç (2017) stated that students would be more successful when they could feel cognitively and physically ready, and when they could plan their study according to their individual pace. Moreover, studies emphasized that it was essential for students to be able to control their individual studies and learning by taking notes outside of the classroom (Bregmann & Sams, 2012; Honeycutt, 2016; Yurniwati & Utomo, 2020).

According to the findings, the students generally had positive views towards the flipped classroom model. Moreover, students defined the flipped classroom model as an enjoyable method that increased the permanence of learning and facilitated learning. In a similar way, it was seen that the flipped classroom activities supported students' meaningful and permanent learning. Studies in the literature indicated that flipped classroom practices increased the permanence of learning (Güç, 2017; Özdemir, 2016), facilitated learning (Huang et al., 2020; Mok, 2014; Strelan et al., 2020; Turan & Göktaş, 2015), and these practices were enjoyable for students (Fulton, 2012; Güç, 2017; Tekin, 2018). Similarly, there were many studies in the literature in which students had positive opinions about the flipped classroom model (Bulut, 2019; Davies et al., 2013; Findlay-Thompson & Mombourquette, 2014; Murphree, 2014; Musib, 2014; Pierce & Fox, 2012; Roach, 2014). Contrary to these results, Johnson & Renner (2012), in their study comparing the flipped classroom model with the traditional method, argued that students had negative views about the flipped classroom model. In a similar way, in the first weeks of the current study, it was observed that the students were anxious. The reason for this might be that the flipped classroom practice was a new method for students and their prejudices about mathematics lessons had been ongoing for years. But, in the following weeks, it was seen that the students were very interested in the activities and applications in the classroom, thus their prejudices against the mathematics lesson began to be broken.

In addition, the results of the study indicated that since the students came ready for the lesson, the time allocated for the problem-solving activities and practices in the lesson was sufficient, and accordingly, the participation and interest of the students in the lesson increased. Similarly, Seaman & Gaines (2013) argued that with flipped classroom model, since students learned the subject at home, more time was allocated for individual and group studies, problem-solving activities, and exercises in the classroom. Furthermore, results showed that the flipped classroom applications increased student-student interaction and student-teacher interaction. The reason might be that the activities and practices carried out as group work encouraged students to ask questions to groupmates and the teacher, helped them to be socially more comfortable, and learned cooperatively. Correspondingly, Abeysekera and Dawson (2014) suggested that flipped classroom model allowed students to practice and collaborate more in the classroom, and it eliminated the “knowledge transfer” role of the teacher in traditional education by replacing the place and the time of lecture with homework. Moreover, the flipped classroom model transformed students to primary actors in the classroom, as well as emphasized “learning as the center”, and had beneficial effects on teaching (Huang et al., 2020). On the other hand, the results of the study showed that the disadvantages of the flipped classroom model were technological problems caused by the EİN lesson module and the problems students experience while logging into the system from their phone or tablet. Similarly, Arslan (2020) observed that internet access and network connection were difficulties for students in the flipped classroom model. Moreover, in some weeks, students criticized the insufficient content presented in the EİN lesson module. Similar results about disadvantages of the flipped classroom applications were obtained by the research studies (Çakır, 2017; Güç, 2017; Turan, 2015).

In conclusion, the findings of this study revealed that the flipped-classroom applications in geometry instruction had various advantages, despite some disadvantages in the out-of-class process. Moreover, the findings indicated that the flipped classroom applications had noticeable contributions to students' learnings, motivation, and attitudes during the in-class process. Regarding the positive outcomes of the flipped classroom model on students' experiences and perceptions, it could be suggested that the model should be used and popularized by other teachers in mathematics lessons. It is important to note that the flipped classroom model can only be implemented effectively if teachers carefully plan their teaching materials both in-class and out-of-class processes. This research is supposed to be a good example of how flipped-classroom model can be used in-class and out-of-class processes of geometry instruction.

References

- Abeysekera, L., & Dawson, P. (2014). Motivation and cognitive load in the flipped classroom: definition, rationale and a call for research. *Higher Education Research & Development*, 34(1), 1-14. DOI: 10.1080 / 07294360.2014.934336
- Abirami, A. M., & Kiruthiga, P. (2018). Collaborative learning tools for data structures. *Journal of Engineering Education Transformations*, 31(3), 79-83.
- Akey, T. M. (2006). *School Context, student attitudes and behavior and academic achievement: An exploratory analysis*. Retrieved from <http://www.projectored.uevora.pt/documentos/LICE.pdf>
- Aksoy, İ. (2020). *Flipped classroom applications in secondary science teaching*. (Unpublished master's thesis). Kastamonu: Kastamonu University Graduate School of Naturel and Applied Sciences.
- Ally, M. (2009). *Mobile learning: transforming the delivery of education and training*. Canada: Athabasca University.
- Arnold, G. (2014). The flipped classroom teaching model and its use for information literacy instruction. *Communications in Information Literacy*, 8(1), 7-22. DOI: 10.7548 / cil.v8i1.260
- Arslan, A. (2020). A systematic review on flipped learning in teaching English as a foreign or second language. *Journal of Language and Linguistic Studies*, 16(2), 775-797, doi: 10.17263/ jlls.759300.

- Aydın, G. (2016). *The investigation of the effect of flipped classroom model on undergraduate students' attitude, self-efficacy and academic achievement towards programming* (Unpublished master's thesis). İzmir: Dokuz Eylül University, Graduate School Of Educational Sciences.
- Bilyalova, A. A., Salimova, D. A., & Zelenina, T. I. (2019). Digital transformation in education. *International Conference on Integrated Science*, 78, 265–276.
- Bishop, J. L., & Verleger, M. A. (2013). The flipped classroom: A survey of the research. *ASEE National Conference Proceedings*, 30(9), 1-18.
- Böge, H., & Akıllı, R. (2019). *Middle schools and Imam Hatip middle schools 8th grade mathematics textbook*. Ankara: MEB Publishers.
- Bregmann, J., & Sams, A. (2012). *Flip your classroom: Reach every student in every class every day*. Alexandria: VA: International Society For Technology in Education; ASCD.
- Bulut, R. (2019). *Investigation of the use of the flipped classroom model in teaching the ratio-proportion* (Unpublished master's thesis). Erzincan: Erzincan Binali Yildirim University Institute of Natural and Applied Sciences.
- Creswell, J. W., & Poth, C. N. (2016). *Qualitative inquiry and research design: Choosing among five approaches*. Sage Publications.
- Çakır, E. (2017). *The effect of flipped classroom on 7th grade students' academic achievement, cognitive risk taking skills and computational thinking skills in science education classroom* (Unpublished master's thesis). Samsun: On Dokuz Mayıs University, Graduate School Of Educational Sciences.
- Çevikbaş, M. (2018). *Investigation of the student engagement process in a mathematics class based on flipped classroom practices*. (Unpublished doctoral dissertation). Ankara: Gazi University Graduate School of Educational Sciences.
- Davies, R. S., Dean, D. L., & Ball, N. (2013). Flipping the classroom and instructional technology integration in a college-level information systems spreadsheet course. *Educational Technology Research and Development*, 61(4), 563-580. DOI: 10.1007 / S11423-013-9305-6
- Drucker, P. F. (1994). *Post Capitalist Society*. (B. Çorakçı, Trans.) İstanbul: İnkılap Publishers.
- Enfield, J. (2013). Looking at the impact of the flipped classroom model of instruction on undergraduate multimedia students at CSUN. *TechTrends*, 57(6), 14-27. DOI: 10.1007/s11528-013-0698-1
- Findlay-Thompson, S., & Mombourquette, P. (2014). Evaluation of a flipped classroom in an undergraduate business course. *Business Education & Accreditation*, 1(6), 63-70. DOI: 10.1080/2331186X.2019.1638147
- Foust, T. (2012). Special guest article: A tip of the hat to the flip of the class. *Illinois Music Educator*, 73(2), 100.
- Fredricks, J. A. (2011). Engagement in school and out-of-school contexts: A multidimensional view of engagement. *Theory into Practice*, 50(4), 327-335. DOI: 10.1080/00405841.2011.607401
- Fulton, K. (2012). Upside down and inside out: Flip your classroom to improve student learning. *Learning and Leading with Technology*, 39(8), 12-17.
- Gaughan, J. E. (2014). The flipped classroom in world history. *The History Teacher*, 47(2), 221-244.
- Güç, F. (2017). *The effect of the flipped classroom practice on the rational numbers and operations with rational numbers* (Unpublished master's thesis). Amasya: Amasya University Graduate School of Natural and Applied Sciences.
- Herreid, C. F., & Schiller, N. A. (2013). Case studies and the flipped classroom. *Journal of College Science Teaching*, 42(5), 62-67.

- Honeycutt, B. (2016). *Ready to flip: Three ways to hold students accountable for preclass work*. Retrieved from Faculty Focus: <https://www.facultyfocus.com/articles/blended-flipped-learning/ready-to-flip-three-ways-to-hold-students-accountable-for-pre-class-work/>
- Huang, L. J., Fan, E., Hu, K. L., & Feng, S. (2020). Research and practice of flipped classroom in data structure. *Journal of Computers*, 31(5), 302-309.
- Jacot, M. T., Noren, J., & Berge, Z. L. (2014). The flipped classroom in training and development: Fad or the future? *Performance Improvement*, 59(3), 23-28. DOI: 10.1002 / pfi.21438
- Johnson, G. B. (2013). *Student perceptions of the flipped classroom* (Unpublished master's thesis). Okanagan: The University of British Columbia Graduate School of Educational Technology.
- Johnson, L. W., & Renner, J. D. (2012). *Effects of the flipped classroom model on a secondary computer applications course: Student and teacher perceptions, questions and student achievement*. (Unpublished doctoral dissertation). University of Louisville.
- Kapıkıran, Ş., & Kıran, H. (1999). The effect of the homework on the student's academic succes. *Pamukkale University Journal of Education*, 5, 54-60.
- Kharat, A. G., Joshi, R. S., Badadhe, A. M., Jejurikar, S. S., & Dharmadhikari, N. P. (2015). Flipped classroom for developing higher order thinking skills. *Journal of Engineering Education Transformations*, 116-121. DOI: 10.16920/ijerit/2015/v0i0/59541
- Kuhn, D. (2003). Understanding and valuing knowing as developmental goals. *Liberal Education*, 89(3), 16-21.
- Külekçi, E. (2013). An assesment of teachers' views about multigrade classes applications within the context of 4+4+4 education system. *Journal of Research in Education and Teaching*, 2(2), 369-377.
- Lage, M. J., Platt, G., & Treglia, M. (2000). Inverting the classroom: A gateway to creating an inclusive learning environment. *The Journal of Economic Education*, 31(1), 30-43. DOI: 10.1080 / 00220480009596759.
- Long, T., Logan, J., Cummins, J., & Waugh, M. (2016). Students' and instructor's attitudes and receptions of the viability of using a flipped classroom instructional model in a technology-enabled active learning (TEAL) Classroom. *Journal of Teaching and Learning with Technology*, 5(1), 46-58. DOI: 10.14434/jotlt.v5n1.18879
- Marzano, R. (2013). *Art and science of teaching/ask yourself: Are students engaged*. Retrieved from <http://www.ascd.org/publications/educational-leadership/mar13/vol70/num06/Ask-Yourself@-Are-Students-Engaged%C2%A2.aspx>
- Ministry of National Education [MNE]. (2020). *Fatih project*. Retrieved from <http://fatihprojesi.meb.gov.tr/about.html>.
- Mok, H. N. (2014). Teaching tip: The flipped classroom. *Journal of Information Systems Education*, 25(1), 7-11.
- Morgan, H. (2014). Focus on technology: Flip your classroom to increase academic achievement. *Childhood Education*, 90(3), 239-241. DOI: 10.1080/00094056.2014.912076
- Murphree, D. S. (2014). "Writing wasn't really stressed, accurate historical analysis was stressed": Student perceptions of inclass writing in the inverted, general education, university history survey course. *History Teacher*, 47(2), 209-219.
- Musib, M. K. (2014). Student perceptions of the impact of using the flipped classroom approach for an introductory-level multidisciplinary module. *CDTL Brief*, 17(2), 15-20.
- Nielsen, L. (2012). Five reasons I'm not flipping over the flipped classroom. *Technology & Learning*, 32(10), 46-46.
- OECD. (2020). *Education responses to COVID-19: Embracing digital learning and online collaboration*. Retrieved from OECD Policy Responses to Coronavirus:

<https://www.oecd.org/coronavirus/policy-responses/education-responses-to-covid-19-embracing-digital-learning-and-online-collaboration-d75eb0e8/>

Olkun, S., & Aydoğdu, T. (2003). What is the Third International Mathematics and Science Research (TIMSS)? Questions what? Sample geometry questions and activities. *Elementary Education Online*, 2(1), 28-35.

Olkun, S., Çelebi, Ö., Fidan, E., Engin, Ö., & Gökğün, C. (2014). The meaning of unit square and area formula for Turkish students. *Hacettepe University Journal of Education*, 29(1), 180-195.

Özdemir, A. (2016). *Flipped classroom model practice focused on blended learning in secondary mathematics education* (Unpublished doctoral dissertation). Ankara: Gazi University Graduate School of Educational Sciences.

Özdemir, M. Ç. (2019). *The use of flipped classroom in geometry teaching investigation of the effect of the mathematics teacher candidates on the attitudes of geometry* (Unpublished master's thesis). Bayburt: Bayburt University Graduate Education Institute.

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

Pierce, R., & Fox, J. (2012). Vodcasts and active-learning exercises in a "Flipped Classroom" model of a renal pharmacotherapy module. *American Journal of Pharmaceutical Education*, 76(10), 1-5. DOI: 10.5688 / ajpe7610196

Prashar, A. (2015). Assessing the flipped classroom in operations management: A pilot study. *Journal of Education for Business*, 90(3), 126-138. DOI: 10.1080 / 08832323.2015.1007904

Prensky, M. (2001). Digital natives, digital immigrants part 1. *On The Horizon*, 9(5), 1-6. DOI: 10.1108 / 10748120110424816

Roach, T. (2014). Student perceptions toward flipped learning: New methods to increase interaction and active learning in economics. *International Review of Economics Education*, 17, 74-84. DOI: 10.1016 / j.iree.2014.08.003

Rutkowski, J., & Moscinska, K. (2013). Self-Directed learning and flip teaching: Electric circuit theory case study. *41st SEFI Conference*. Leuven, Belgium.

Seaman, G., & Gaines, N. (2013). Leveraging digital learning systems to flip classroom instruction. *Journal of Modern Teacher Quarterly*, 1, 25-27.

Serçifeli, Z., & Atmaz, D. (2019). *Middle schools and Imam Hatip middle schools 8th grade mathematics textbook*. Ankara: Kök-e Publishers .

Strelan, P., Osborn, A., & Palmer, E. (2020). The flipped classroom: A meta-analysis of effects on student performance across disciplines and education levels. *Educational Research Review*, 30, 100314.

Şataf, H. A. (2009). *Effect of computer-assisted mathematics teaching on achievement and attitude of 8th graders in transformation geometry and triangles sub-learning areas (Isparta Sample)*. (Unpublished master's thesis). Sakarya: Sakarya University Institute of Social Sciences.

Talan, T., & Gülseçen, S. (2019). An analysis of students' views on flipped classroom. *Journal of Higher Education*, 9(3), 353-368.

Talbert, R. (2012). Inverted classroom. *Colleagues*, 9(1).

Tekin, O. (2018). *Flipped classroom in high school mathematics: A mixed design study* (Unpublished doctoral dissertation). Tokat: Tokat Gaziosmanpaşa University Graduate School of Educational Sciences.

Toffler, A. (1996). *Future Shock*. (S. Sargut, Trans.) İstanbul: Altın Kitaplar Publisher.

Toto, R., & Nguyen, D. H. (2009). Flipping the work design in an industrial engineering course. *ASEE/IEEE Frontiers in Education Conference*. San Antonio: TX.

Turan, Z. (2015). *The evaluation of flipped classroom method and examination of its effects on academic achievement, cognitive load and motivation* (Unpublished doctoral dissertation). Erzurum: Atatürk University Graduate School of Educational Sciences.

Turan, Z., & Göktaş, Y. (2015). A new approach in higher education: The students' views on flipped classroom method. *Journal of Higher Education and Science*, 5(2), 156-167. DOI: 10.5961/jhes.2015.118

Yamamoto, Y., & Altun, D. (2020). The Coronavirus and the rising of online education. *Journal of University Research*, 3(1), 25-34. DOI: 10.32329/uad.711110

Yıldırım, A., & Şimşek, H. (2018). *Qualitative research methods in social sciences*. Ankara: Seçkin Publishers.

Yurniwati, Y., & Utomo, E. (2020). Problem-based learning flipped classroom design for developing higher-order thinking skills during the COVID-19 pandemic in geometry domain. *Journal of Physics: Conference Series*, 1663(1). DOI:10.1088/1742-6596/1663/1/012057

Authors

Nuray ÇAKIROĞLU, Ministry of National Education, Karabük (Turkey). E-mail: cakiroglunuraay@gmail.com

Mutlu PİŞKİN TUNÇ, Zonguldak Bülent Ecevit University, Faculty of Education, Department of Mathematics and Science Education, Zonguldak (Turkey). E-mail: mutlupiskin@gmail.com

Acknowledgement

This article was based on the master's thesis of the first author, written under the supervision of the second author.