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Effects of the Flipped Learning Model on Primary School 4th Grade Students' Learning of Geometry

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Abstract

This study analyses the effects of applying the flipped learning model on 4th grade students' geometric thinking levels and their feelings about the course as well as their more general thoughts on the model. This experimental study involved 42 students, with 21 assigned to the experimental group and 21 to the control group. Students in the experimental group were taught geometry with the flipped learning model in line with the curriculum while the control group was taught with a more traditional approach, applying the activities included in the relevant textbook. This research was conducted over the course of 5 weeks. Quantitative and qualitative research methods were used together in the research. The quantitative data of the study were collected using the Three-Dimensional Reasoning Test and the Attitude Towards Mathematics Activities Scale, while the qualitative data were collected through semi-structured interview questions and math diaries. Significant differences were found between the students' three-dimensional reasoning test post-scores at the end of the study, with scores being higher among students of the experimental group. Differences between the pre-test and post-test scores of the experimental group in terms of their attitudes towards mathematics activities were also significant, as were the differences for the control group. Additionally, information about students' opinions on the model was presented.

Keywords

1. Flipped learning model
2. Geometry thinking levels
3. Student opinions

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INTRODUCTION

Societies are constantly influenced by scientific and technological developments and changes. Educational systems should similarly adapt in line with such changes so as to be able to follow the ongoing innovations and developments within society (Kırmızıoğlu & Adıgüzel, 2019). Educators who are capable of using the possibilities provided by technology can provide their students with opportunities to configure knowledge and make knowledge more retainable by creating better learning environments (Bolat, 2016). Students of today are expected to experience learning, assume responsibility for their own learning outcomes, communicate successfully with the world in which they live, and place themselves at the centre of learning (Kırmızıoğlu & Adıgüzel, 2019). Changes stemming from students' characteristics and expectations causing changes in traditional class approaches, in which teachers take control and students remain passive subjects. Learning approaches that value learning outside of the classroom as well as in-class learning have particularly started to attract attention in recent years (Karadeniz, 2015). Flipped learning is one of these approaches.

The flipped learning model was initially suggested by Lage, Platt, and Teglia in the early 2000s. It was subsequently developed by Bergman and Sams and began gaining widespread implementation (Soliman, 2016). This learning model is a pedagogical approach that has been receiving interest at various levels of education and in a diverse range of disciplines. It is popularly used from primary school to the university level because it has the potential to promote active learning and students' participation (Bond, 2020). It is a model with the power to change learning environments and it incorporates a combination of face-to-face activities and learning opportunities facilitated by technological applications (Hayırsever & Orhan, 2018). In its broadest definition, the flipped learning is described as the reversal of the lecture process and homework (Çakır & Yaman, 2018). While the implementation of the model differs across classrooms, the basic underlying principle is the creation of learning structures and situations in which students encounter course materials in a more independent and individual manner. In traditional classrooms, students are introduced to new course materials in the classroom setting, but with flipped learning, their first encounters occur outside the classroom and are facilitated by technology in an online setting (Murphy, Chang & Suaray, 2016).

In the teaching processes applied in traditional classrooms, students read their textbooks and complete their homework outside of school, and they listen to the lectures of their teachers during school hours. In flipped learning, however, students learn most or all of the content outside the classroom. In-class teaching is performed through collaborative learning under the teacher's guidance (McBride, 2015). Students access instructional materials outside the classroom within the framework of this model. Students are expected to study those resources and do the assignments and activities on their own; they then join classroom discussions with that preparation completed. Instruction during class hours is conducted through activities with a student-centered approach (Bergman & Sams, 2012). Gaining basic knowledge outside of school allows learners to enjoy more learning opportunities and supports them in strengthening their higher-level thinking skills through in-class discussions, activities, and problem-solving processes (Hayırsever & Orhan, 2018). Teachers take on the role of guides in the classroom throughout these steps. They can give instant feedback by monitoring students' work more closely. They also gain more opportunities to correct students' misconceptions. Thus, they take on new and important roles in such classrooms compared to traditional school settings (Carter, Carter & Foss, 2018).

A considerable part of the flipped learning model is based on the application of digital technologies. Students can use the provided materials to prepare for lessons whenever they wish (Muir & Geiger, 2016). Lessons are presented by means of specifically prepared online videos in this model (Carter et al., 2018). Online videos are easy to use with learning and teaching approaches that are suitable for technology integration (Şahin, Cavlazoğlu & Zeytuncu, 2015). For example, the practicability, portability, and internet accessibility of digital technologies and young people's predisposition to using such devices provide opportunities for technology-assisted learning in mathematics classes (Borba et al., 2016). Technological equipment with which students are familiar and which is easy to use and easy to carry should be chosen. Many educators prefer Khan Academy videos for this reason, but platforms such as YouTube EDU also offer well-prepared video content (McBride, 2015). Resources such as EBA and Okulistik in Turkey provide students with rich content. Teachers wishing to have more control over the content can also manage the process by using videos they prepare themselves (Naccarato & Karakok, 2015).

Studies have indicated that using the flipped learning model in mathematics classes contributes in positive ways to students' learning. Akçayır and Akçayır (2018), for instance, noted that previous research on the flipped learning model has largely been concerned with academic achievement, that positive results have been obtained, and that this approach can support students' learning. The model also has positive effects on students' participation in mathematics classes. Students who come to class having already done their preparation are able to make more effort and experience more interest in the course (Çevikbaş, 2018; Kalafat, 2019; Kaya, 2018; Yurtlu, 2018). The study conducted by Kalafat (2019) demonstrated that students who came to the classroom after such preparation moved more rapidly through the stages of knowledge and comprehension described in Bloom's taxonomy. Another positive effect of the model is that it supports students in learning at their own pace (Arslan, 2021; Bulut, 2019). In addition, it was also found that the model made positive contributions to students' self-confidence, self-regulation, and self-efficacy skills (Arslan, 2021; Hwang & Lai, 2017; Kaya, 2018; Lai & Hwang, 2016). Students benefit from ample opportunities to ask more questions, to comment on the subject, and to discuss the subject with their peers when flipped learning is applied (Clark, 2015; Kalafat, 2019). Studies have also found that a sense of responsibility was cultivated among students with the application of this model and that students gained a sense of cooperation and belonging in group settings (Bolatlı, 2018; Yurtlu, 2018). Learning the lessons in advance through videos allows the teacher to spend more time on classroom activities. In this way, teachers also gain more opportunities to answer students' questions and give feedback (Akçayır & Akçayır, 2018; Çevikbaş, 2018; Wei et al., 2020). In addition, it was determined that disciplinary problems decreased in classrooms where the flipped learning model was used (Çevikbaş, 2018). The model promotes students' communication with both the teacher and their classmates and contributes to the willingness to adopt the idea of helping each other (Bolatlı, 2018; Çevikbaş, 2018; Lo & Hew, 2017). In turn, helping each other and learning by asking questions benefits both advanced and less advanced students (McBride, 2015). Studies have also confirmed the ability of the flipped learning model to increase student-teacher interactions, help teachers use in-class time more efficiently, support the appropriate use of materials (Bergmann & Sams, 2012), and make positive contributions to students' attitudes towards mathematics and their participation in class (Clark, 2015; Güç, 2017; Kaya, 2018). Similarly, it was previously demonstrated that teaching and learning processes conducted using technology developed students' mathematical skills and made it easy to teach mathematical concepts (Kaya, 2018; Özdemir, 2016).

Students and teachers may encounter negative aspects as well as the aforementioned benefits when the flipped learning model is implemented. One of the greatest disadvantages of this model lies in the potential for technological deficiencies and inadequacies (Arslan, 2021; Kalafat, 2019; Zengin, 2017). Students who lack access to adequate technology or are unable to use such devices and programs effectively are influenced in negative ways throughout the implementation process (Akçayır & Akçayır, 2018). Students with technological inadequacies and problems in accessing the internet have difficulties in watching videos (Aydın, 2020). Another challenge for students with this model lies in the fact that they cannot ask real-time questions while watching the videos. Having no teachers beside them while watching videos and having no immediate feedback poses problems in subjects that students do not understand (Arslan, 2021). Long videos may also influence students in negative ways (Aydın, 2020; Talbert, 2012). Therefore, materials prepared for the implementation of this model should be of high quality and must be suitable for the level of the students (Sahin et al., 2015). A study conducted by Bulut (2019) demonstrated that students with higher levels of achievement participated less in class with this model and that extra work should be done to support students who dislike group work. The fact that students may have difficulties in adapting to the model should also be taken into consideration (Arslan, 2021). Conflicting personality types during group work and the continual presence of close friends in the same groups may affect the process in negative ways (Bolatlı, 2018). Another major disadvantage of the model is that it increases the work load for both students and teachers (Akçayır & Akçayır, 2018). Preparing activities for flipped learning requires teachers to devote extra time to their preparations. Therefore, this model requires teachers to always be organized and prepared (Bolatlı, 2018; Sahin et al., 2015). If classrooms are too crowded, teachers must respond to the questions of more students, which makes it more difficult for them to manage the flipped learning process (Çevikbaş, 2018). Finally, students who are accustomed to traditional methods may show resistance to the application of this model (Sahin et al., 2015).

Aim of the Research

The limited volume of relevant research reported in the literature to date is noteworthy despite the existence of studies analysing the learning domain of geometry (Bhagat, Chang & Chang, 2016; Çakıroğlu, 2020; Hwang & Lai, 2017; Lai & Hwang, 2016; Leo & Hew, 2017; Kaya, 2018; Özdemir, Aydın & Demir, 2020; Weinhandl et al., 2020). Within this limited body of literature, the study conducted by Akçayır and Akçayır (2018) highlighted that previous studies concerning flipped learning have generally been conducted in settings of higher education and that the number of studies at the level of primary education remains insufficient. The latter point has been confirmed by other researchers, as well (Gökdaş & Gürsoy, 2018; Hwang & Lai, 2017; Kahramanoğlu & Şenel, 2018; Lai & Hwang, 2016). Muir (2017) argued that more extensive research is necessary to demonstrate the precise effects of applying the flipped learning model. Taking these studies as a starting point, it was assumed that analysing the effects of using a flipped learning application in the teaching of geometry to students in the 4th grade would yield significant findings for the literature.

This research was accordingly planned with the aim of analysing the effects of using flipped learning to teach a 4th-grade geometry course on the students' geometric thinking levels and their attitudes towards the course, as well as making it possible to examine their views of the model. Within the framework of these goals, the following research questions were pursued:

1. Are significant differences observed in the comparison of pre-test and post-test scores measuring geometric thinking between students in the experimental and control groups?

2. Are significant differences observed in the comparison of pre-test and post-test scores measuring attitudes towards geometry between students in the experimental and control groups?

3. What views do the students hold regarding the application of the flipped learning model in a geometry course?

METHOD

This was an experimental study. The qualitative and quantitative data collection tools have been used together. In experimental studies, the data being collected are intended to be observed under the control of a researcher to allow for an understanding of cause-and-effect relationships. There are always comparisons in experimental studies (Karasar, 2005).

Participants

4th students from a primary school affiliated with the Ministry of National Education in a district of Bitlis province in Eastern Anatolia constituted the participants of this study. The research was undertaken in the second semester of the 2021-2022 school year. The sample for the study is selected using simple random sampling. The school at which the research was conducted had two 4th-grade classes. Thus, one of these two classes served as the experimental group while the other class was taken as the control group. The experimental group comprised 21 students, including 10 (45%) girls and 11 (55%) boys. The control group similarly comprised 21 students, 9 (40%) of whom were girls and 12 (60%) of whom were boys. Thus, the research was conducted with the participation of 42 students in total. All students included in the experimental group confirmed that they had access to at least one relevant technological device at home, such as computers, tablets, smart phones, and USB flash drives. Having access to these materials has enabled students to participate in extracurricular activities.

Data Collection Tools

Four unique tools for data collection were applied in this study. The first was the Three-Dimensional Reasoning Test (TDRT). This test was designed by Akkurt-Denizli (2016) in order to evaluate the three-dimensional geometric thinking levels of students in the 1st through 4th grades. It consists of a total of 45 questions intended to measure the components of students' geometric thinking together with relevant sub-items. The questions in the test are intended to measure the student's ability to recognise three-dimensional objects (4 questions), notice and compare the features of three-dimensional objects (18 questions), establish associations between two-dimensional and three-dimensional objects (4 questions), recognise three-dimensional structures containing equivalent objects (8 questions), and calculate areas and volumes of three-dimensional objects (11 questions). The Cronbach's alpha internal consistency coefficient for the whole test was .87, while it ranged between .65 and .78 for the sub-components. This value was calculated as .81 for this research. Students were permitted approximately 40 minutes to answer the test questions. Their answers were scored with the assignment of 1 point for correct and 0 points for incorrect replies.

The second tool applied in the process of data collection was the Attitudes Towards Mathematics Activities Scale (ATMAS). This scale was developed by Ocak and Sönmez (2010) to describe primary school students' attitudes towards mathematics activities. It is composed of 19 items, including 10 positive statements and 9 negative statements, within 3 factors. The factor of trust has 9 items, the factor of interest has 5 items, and the factor of independence has 5 items. Scoring is performed with a 5-point Likert-type scale, allowing for replies that range between "I absolutely agree" and "I absolutely disagree". The negative items of the scale are scored in a manner that is the opposite of the scoring for positive items. Students were given approximately 20 minutes to answer the questions of this scale. The Cronbach's alpha internal consistency coefficient was .91 for the whole scale and .72, .64, and .72 for the factors of the scale, respectively. This value was calculated as .84 for this research.

The third tool for data collection was the application of semi-structured interview questions. These questions were prepared to obtain the students' views of the flipped learning model. They were prepared with careful consideration of the study's specific research questions, the relevant literature, and the theoretical framework. Special care was taken to ensure that the finalised questions would be clear and understandable enough to avoid any misunderstandings. Expert opinions were obtained from two lecturers, one from the area of educational sciences and the other from the area of mathematics, to verify the reliability and validity of the questions. Necessary modifications were made to the questions in accordance with the obtained opinions of these experts and then a pilot application was performed with two students. Some of the interview questions asked in the course of the semi-structured interviews were as follows: *"What is the difference between learning about geometry subjects with the flipped learning model and learning them in the other way?" "Did you encounter any difficulties while watching the class videos? If so, what were they? Could you please describe them?" "What do you think you enjoyed most while learning about geometry subjects with the flipped learning model? Could you please explain?"* Interviews were conducted with 10 students chosen from the experimental group after the implementation of the flipped learning approach had ended. These students were selected because it had been observed that they did not hesitate to express their thoughts clearly, took part in the implementation process, and were able to state their thoughts clearly and in an understandable way. All selected students consented to be interviewed on a voluntary basis. Special care was taken in choosing students with different levels of academic achievement (i.e., low, medium, and high). The interviews, which lasted approximately 10-12 minutes, were recorded after permission was received from both the students and their parents.

Participants were also asked to keep diaries throughout the implementation process to record their feelings and thoughts. Mathematics diaries were used in assessing what students had learnt, what they have not learnt, and their thoughts about a course (Toptaş, 2020). The participating students were thus asked to record their views, feelings, and thoughts about the material taught to them and the ways of teaching at the end of each class session throughout the research. In order to increase the validity and reliability of the research, it was aimed to collect diversified and in-depth data by using more than one data collection tool. In addition to expert opinion, direct quotes were also included.

Data Analysis

SPSS was used in analysing the quantitative data obtained in this study. Prior to the process of data analysis, skewness and kurtosis were evaluated to identify whether the data were normally distributed or not. Based on the obtained kurtosis value and the number of participants being smaller than 50, Shapiro-Wilk values were also examined. Among the students of the experimental group, the scores for the TDRT pre-test [$\boldsymbol{skewness}\text{:}\boldsymbol{.708}$; $\boldsymbol{kurtosis}\text{:}\boldsymbol{-.238}$; $\boldsymbol{p > 0}$] and post-test [$\boldsymbol{skewness}\text{:}\boldsymbol{.013}$; $\boldsymbol{kurtosis}\text{:}\boldsymbol{-1.447}$; $\boldsymbol{p > 0}$] conformed with normal distribution, as did the post-test scores of the control group [$\boldsymbol{skewness}\text{:}\boldsymbol{.693}$; $\boldsymbol{kurtosis}\text{:}\boldsymbol{-.479}$; $\boldsymbol{p > 0}$]. However, the pre-test scores of the control group did not reflect a normal distribution [$\boldsymbol{skewness}\text{:}\boldsymbol{1.589}$; $\boldsymbol{kurtosis}\text{:}\boldsymbol{-1.663}$; $\boldsymbol{p < 0}$]. ATMAS pre-test scores were found to be normally distributed for both the experimental group [$\boldsymbol{skewness}\text{:}\boldsymbol{-.503}$; $\boldsymbol{kurtosis}\text{:}\boldsymbol{-.977}$; $\boldsymbol{p > 0}$] and the control group [$\boldsymbol{skewness}\text{:}\boldsymbol{-.147}$; $\boldsymbol{kurtosis}\text{:}\boldsymbol{-.199}$; $\boldsymbol{p > 0}$], while the post-test scores of both the experimental group [$\boldsymbol{skewness}\text{:}\boldsymbol{-1.239}$; $\boldsymbol{kurtosis}\text{:}\boldsymbol{1.022}$; $\boldsymbol{p < 0}$] and the control group [$\boldsymbol{skewness}\text{:}\boldsymbol{.830}$; $\boldsymbol{kurtosis}\text{:}\boldsymbol{-1.789}$; $\boldsymbol{p < 0}$] did not conform with the trends of normally distributed data. Skewness and kurtosis values between -1 and +1 indicate a normal distribution (George & Mallery, 2001). The Wilcoxon signed-rank test was selected as a relevant non-parametric approach for the analysis of data without normal distribution and the independent-samples t-test was utilised for the normally distributed data. Qualitative data, on the other hand, were subjected to content analysis, which was performed separately by two different researchers. Those researchers subsequently came together to discuss their coding. Differences between the coders were discussed until a consensus could be reached.

Implementation Process

The research lasted for 5 weeks. Both groups were given instruction in line with the gains in the learning domain of geometry described in the 4th-grade mathematics curriculum of 2018 within the appropriate amount of time as described by the curriculum. The students of the experimental group were taught with the flipped learning method, while those of the control group were taught on the basis of activities available in the relevant mathematics textbook. Class videos from the free Okulistik (https://www.okulistik.com) interactive platform were used in implementing the flipped learning model. Prior to the beginning of the model's application, the students were informed about the flow of the lessons and what they should do before coming to class. In addition, a meeting was held with their parents a week before the research process began and they were informed of the forthcoming application and expectations were explained to them. Their assistance was requested in relation to students' participation in classes after watching the videos. A WhatsApp group was established for the parents of the students in the experimental group, making it possible for the students to access class videos easily. Students who requested it were also given the videos on a USB memory stick. The parents were informed about the videos every week via WhatsApp and were asked to monitor their children to ensure that they watched the videos. In the classroom, however, activities were conducted. Therefore, activities and worksheets were prepared regularly for use in the classroom by the researcher in line with the relevant gains in the geometry learning domain while considering the students' levels. The activities in the classroom were designed to be completed as group work. The researcher took special care in including students with high, low, and medium levels of achievement in each group while forming the groups for these activities.

Ethical Authorizations of the Research

Research approval was obtained from the ethics committee of Yozgat Bozok University Ethics Commission dated 12.11.2021 and numbered 27/08.

FINDINGS

Findings from Quantitative Findings

Findings for the Three-Dimensional Reasoning Test (TDRT)

The first question addressed in the present study was whether any differences of statistical significance existed between the TDRT pre-test and post-test scores obtained by the participants in the experimental group, who were taught with the flipped learning method, and those of the control group, who were taught with a traditional approach using the activities included in the relevant textbook. The data obtained from the TDRT administered to both groups of students before and after the implementation were analysed by applying the Wilcoxon signed-rank test. The findings of that analysis are provided in Table 1.

Table 1. Results of the Wilcoxon Signed-Rank Test for TDRT Pre-Test and Post-Test Scores of the Experimental and Control Groups

	Post-test/Pre-test	n	Rank averages	Rank totals	z	P
Experimental	Negative rank	0	.00	.00	-3.827	.00
	Positive rank	21	10.00	190.00		
	Equal	0				
Control	Negative rank	1	1.00	1.00	-3.985	.00
	Positive rank	20	11.50	230.00		
	Equal	0				

An examination of Table 1 makes it clear that differences of statistical significance existed between the pre-test and post-test scores of the students from the experimental group, who were taught according to the flipped learning model [$\boldsymbol{z = -3.827; p < .05}$]. Statistically significant differences were similarly observed between the post-test and pre-test scores of the students in the control group, who were taught with a traditional approach that utilised the activities provided in the relevant textbook [$\boldsymbol{z = -3.985; p < .05}$]. The differences in the scores of both groups were found to have positive ranks; in other words, in both cases, the differences were in favour of the post-test. Both teaching according to the flipped learning model and teaching in line with the activities in the textbook can be said to have affected the development of the students' geometric thinking levels in positive ways.

The post-test scores of the experimental and control groups show a normal distribution. The correlation between the TDRT post-test scores of the students in the experimental group and the control group was analysed by applying the t-test and the findings are presented in Table 2.

Table 2. Results of T-Test Comparisons of TDRT Post-Test Scores of the Experimental and Control Groups

	N	$\bar{X}$	S	sd	T	P
Experimental	21	29.09	2.23	40	1.84	0.00
Control	21	23.48	2.07			

As confirmed by the data presented in Table 2, a significant difference existed between the TDRT post-test scores of the students in the experimental and control groups. More specifically, the difference was found to be in favour of the experimental group [$\boldsymbol{t_{(40)} = 1.84; p < .05}$]. The average post-test score ($\boldsymbol{\bar{X} = 29.09}$) achieved within the experimental group was higher than that achieved within the control group ($\boldsymbol{\bar{X} = 23.48}$) and this finding was of statistical significance. As a result, it can be said that the flipped learning model influences students' geometric thinking levels in positive ways.

Findings for the Attitudes towards Mathematics Activities Scale (ATMAS)

The second question pursued in the course of this research was whether any differences of statistical significance existed between the ATMAS pre-test and post-test scores obtained by the participants in the experimental group, who were taught with the flipped learning method, and those of the control group, who were taught with a traditional approach using the activities included in the relevant textbook. The data obtained from the ATMAS administered to both groups of students before and after the implementation were analysed by applying the Wilcoxon signed-rank test. The findings of that analysis are presented in Table 3.

Table 3. Results of the Wilcoxon Signed-Rank Test for ATMAS Pre-test and Post-test Scores of the Experimental and Control Groups

	Post-test/Pre-test	n	Rank averages	Rank totals	z	P
Experimental	Negative rank	3	16.33	49.00	-2.092	.03
	Positive rank	17	9.47	161.00		
	Equal	1				
Control	Negative rank	9	11.33	102.00	-0.470	.63
	Positive rank	12	10.75	129.00		
	Equal	0				

Accordingly, differences of statistical significance were seen to exist between the post-test and pre-test scores of the students in the experimental group who received instruction in line with the flipped learning model [$z = -2.092;\ p < .05$]. In contrast, no significant differences were found upon comparing the post-test and pre-test scores of the students in the control group who were taught in line with the activities presented in the relevant textbook [$z = -0.470;\ p > .05$]. Thus, it can be said that the application of the flipped learning model affects students' attitudes towards geometry activities in positive ways.

Findings from Qualitative Data

Semi-structured interviews were held with the students to address the third question posed by this study: *"What views do the students hold regarding the application of the flipped learning model in a geometry course?"* Findings obtained from the students' mathematics diaries were also evaluated with the same aim. The students' views of the model were divided into two categories as positive and negative views. Figure 1 presents the relevant information on the positive and negative views reported by the students regarding the model that was applied. All students from the experimental group stated that they watched the assigned videos regularly before joining the classes.

The participants stated that the most enjoyable part of learning geometry with the flipped learning model was the activities. They also said that there was more retention in their learning when they joined classes after watching the videos and that learning in this way made them more successful in their exams. The researcher similarly observed that they were ready for class and participated in class more actively when they had watched the videos. Furthermore, the students appreciated the fact that they could watch the videos whenever they wanted. Some of them also said they learnt the subjects in entertaining ways thanks to the application of this model. The videos provided students with visual richness. Finally, some students felt that group work had made noteworthy contributions to the quality of peer interaction and student-teacher interaction. Some examples of the students' positive views of the model are as follows:

Ayşen*: "Because there are videos, the content is retained in the mind longer. I was able to remember easily in exams. Seeing the objects concretely made classes more enjoyable"*

Burak: *"I was able to answer your questions when I came to class. It helped me in the exams. Doing the activities was very enjoyable"*

Ceyda: *"I had fun in all the activities. We learnt the [course subjects] in a different way"*

Derya: *"I noticed what I hadn't understood in the videos. I had the opportunity to ask you about them. I also think the videos helped in exams. They made my learning permanent"*

Derya: *"It was nice to pause and continue watching the videos when I wanted. We all had time to do the exercises and I liked it. We worked in groups in some activities. It was also nice because I like helping my friends and being helped by them"*

Ferit: *"We learn at home and we revise it in the classroom. In this way, learning is retained more in the mind"*

Ilgaz: *"I was learning something about the subject before classes and we had more time to do activities. I was able to answer your questions easily. I saw mirror symmetry for the first time and it made me feel excited. We got into groups and I liked it very much"*

The participants had negative and positive views of learning geometry with the flipped learning model. They wanted to learn via classroom lectures from their teacher even though they had learnt the topics from the videos in advance. They also claimed that they had difficulty taking notes while watching the videos. Other problems encountered in the process were difficulties stemming from technical problems, the impossibility of asking questions while watching the videos, and home environments that were not conducive to learning. One student reported difficulties in completing the activities. Some negative views expressed by the students are as follows:

Burak: *"I had difficulty doing some of the activities, and I didn't like the situation. I was the head of my group in group activities but I couldn't manage the group. The group work might have been better if they had listened to me"*

Burak: *"There were subjects I didn't understand while watching the videos on my mobile phone. I couldn't understand those parts because I couldn't ask questions. But I could ask questions about what I didn't understand when you taught us"*

Ceyda: *"It would have been better if you taught us first and then we watched the videos. I could have understood better that way"*

When the students were asked for their views regarding whether or not other courses should be taught according to the flipped learning model, seven students said they would not want that; they insisted that the teacher should teach first and then the videos should be watched. One student stated that the flipped learning model should also be used with other subjects of mathematics.

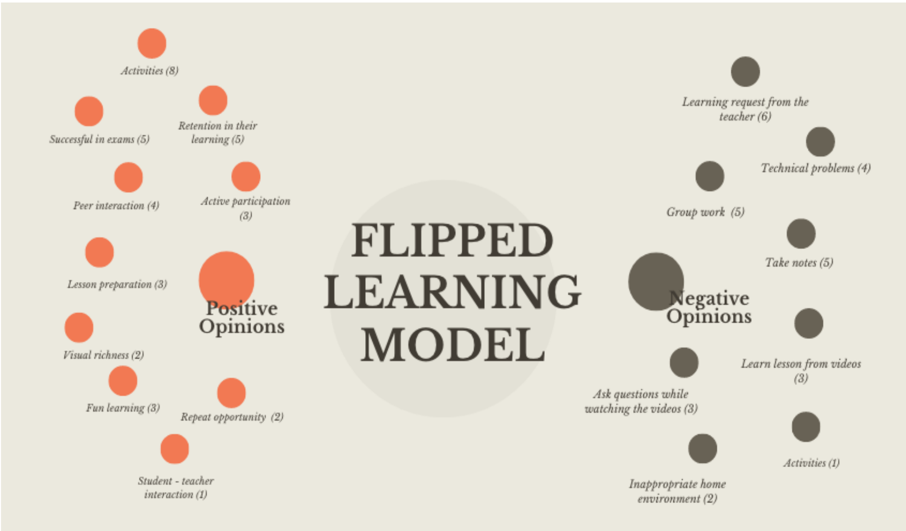

Figure 1. Students' views on the flipped learning model

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

In this study, it has been analysed the outcomes of an application of the flipped learning model in teaching a 4th-grade geometry course on the students' levels of geometric thinking and their attitudes towards the course as well as their more general views on the model. The findings obtained are described here in accordance with the specific research questions.

Considering the pre-test and post-test scores for the TDRT, differences of statistical significance were observed for both the experimental group and the control group. Upon examining the average TDRT post-test scores more closely, it was also found that the students of the experimental group who had been taught with the flipped learning model had a higher average score than the students of the control group who had been taught with a traditional approach using the activities included in the relevant textbook. Thus, geometry classes taught in line with the flipped learning model may be said to contribute in positive ways to the development of students' three-dimensional reasoning. In another study that employed the flipped learning model, Zengin (2017) concluded that the model increased students' understanding of double integrals and made retention possible. This was attributed to the fact that implementing flipped learning in the teaching of mathematics provided students with visual richness. Bhagat et al. (2016) claimed that they obtained evidence of the capacity of the model to support learning and teaching in mathematics classes. They also emphasised that the student-centred approach of the flipped learning model is more influential than traditional teacher-centred approaches. Kaya (2018) demonstrated that the flipped learning approach contributed to students' cognitive states as well as to their affective and behavioural states when it was implemented in mathematics classes.

This current study has also demonstrated the existence of a significant difference between the pre-test and post-test scores of students in the experimental group who were taught in accordance with the flipped learning model regarding their attitudes towards mathematics activities. On the other hand, no significant difference was observed in this regard between the pre-test and post-test scores of the students in the control group. As a result, it is possible to conclude that the application of this model positively affected attitudes towards mathematics activities among the students of the experimental group. The results obtained by Özdemir et al. (2020) similarly suggest that implementing flipped learning can positively affect students' attitudes towards geometry courses. Clark (2015) conducted a similar study with secondary school students and demonstrated that the flipped learning model influenced the students' attitudes towards mathematics in positive ways. However, in contrast to the results obtained in the present study, Güç (2017) reported that the flipped learning model influenced students' attitudes towards mathematics but that the observed differences did not reach the level of statistically significant changes. Türkoğlu (2021), in a similar vein, found that the application of this model did not have positive effects on students' attitudes towards a mathematics course. Gökdaş and Gürsoy (2018) conducted a similar study with primary school students and concluded that the flipped learning model did not have any effects on the students' motivation for the course. However, Yorgancı (2020) argued that the model was effective in increasing students' motivation.

It was found through interviews with the students of the experimental group that they generally had positive views on the flipped learning model. They found learning geometry with flipped learning to be entertaining. They said that they understood better, that they enjoyed the activities, and that they could actively participate in class when they attended after watching the assigned videos. Clark (2015) argued that students are engaged more in the teaching process with the flipped learning model compared to traditional teaching models and that they experience student-centred, entertaining, and high-quality teaching. In the present study, it was furthermore observed that the students were busier in the classroom and participated more actively. Interviews with the students revealed that they appreciated the visual richness offered by the assigned videos in this geometry course. Other previous studies that examined students' views in this regard found that the flipped learning model made positive contributions to their learning experiences. The students included in the study conducted by Çakıroğlu (2020), for instance, said that the flipped learning model was entertaining and helped them increase their ability to retain knowledge. Türkoğlu (2021) demonstrated that sharing videos with students to prepare them for their classes and the fact that students could watch those videos whenever and wherever they wanted were positive sides of this model. Özdemir et al. (2020) stated that an entertaining classroom environment was created through the implementation of this model and that the model appealed to students' audio and visual senses.

Students expressed negative views in addition to their positive thoughts about the flipped learning model. First and foremost, they wanted to learn from their teacher, not from videos. They insisted that teachers should present the subject first and then allow students to watch the videos afterwards. They also said that they could not ask about the things they did not understand while watching the videos and that they had difficulty taking notes during the videos. Kahramanoğlu and Şenel (2018) claimed that negative views such as these may specifically arise when students of younger ages who are not ready for innovative applications are taught with the flipped learning model because they may not be mature enough to take on the responsibility for learning in more independent learning environments. In the present study, some of the students also reported that they were challenged by technical problems or home environments not conducive to learning. In addition, some of them said that they did not enjoy the assigned group work. Türkoğlu (2021) similarly stated that one of the negative sides of applying this model was the possibility of technical problems.

Certain recommendations can be made for teachers and researchers who wish to use this model in primary school mathematics classrooms. Primary school students may not be fully prepared to take responsibility for their learning because they are still quite young. It is important that educators wishing to use this model in their classrooms cooperate effectively with their students' parents in managing the process efficiently. Some students in the present study said that they did not like working with each other in group work. Educators who plan to use this model are recommended to consider students' opinions while forming groups. Weinhandl et al. (2020) noted that there is no exact definition of the flipped learning model despite the great interest in this model and positive effects of this model demonstrated by various studies in the literature. It is also worth noting that relatively few studies of flipped learning have been conducted with the inclusion of primary school students. It is recommended that future studies analysing the effects of this model on the learning of primary school students be conducted with different mathematics subjects and variables.

Finally, this research has some limitations. It involved only a 5-week experimental process, which may not be practical for assessing students' attitudes towards mathematics within such a short period. Therefore, longer-term and larger-scale experimental studies are needed to evaluate students' geometric thinking levels and attitudes towards mathematics.

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