Article

The Effectiveness of a Technology-Enhanced Flipped Science Classroom

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Baris Sezer[1]

Abstract

This study examined the effect on the learning and motivation of students of a flipped classroom environment enriched with technology. A mixed research design using a pretest or posttest experimental model, combined with qualitative data, was conducted in a public middle school in Turkey for 2 weeks (three class hours) within a science course. Participants consisted of two groups of sixth-grade students. A variety of electronic materials to support a flipped classroom environment was distributed to students in the experimental group 3 days before the class. Before the normal class hour, the basic outline of the subject was discussed with the students, problem situations were created and solutions suggested, issues that were not understood were focused on, and, most importantly, student–teacher interaction was carried out at the highest level. It was determined that the flipped classroom yielded both greater academic achievement and greater motivation compared with the control group.

Keywords

flipped classroom, science class, educational technology, motivation, academic achievement

[1]Department of Medical Education and Informatics, Hacettepe University, Ankara, Turkey

Corresponding Author:
Baris Sezer, Faculty of Medicine, Department of Medical Education and Informatics, Hacettepe University, Altindag, 06100 Ankara, Turkey.
Email: barissezer13@hotmail.com

The vision of the Science and Technology Education Program, prepared by the Turkish Ministry of Education, is to raise all students as literate in science and technology, no matter what their individual differences are. In the introduction to the Basic Science Course Textbook of the Turkish Ministry of Education, it is stated that all topics are covered in five steps. These are (a) arousing curiosity, (b) encouraging discovery, (c) supporting the findings discovered, (d) providing more detail, and (e) performing self-assessment. However, most studies conducted in Turkey show that traditional education has not been abandoned and that students are continuing their passive learning under the leadership and control of the teacher (Akpınar & Gezer, 2010). This situation has very serious consequences for Turkey, which lags far behind the international average in science, mathematics, and reading comprehension in studies such as PISA (The Programme for International Student Assessment) and TIMSS (Trends in International Mathematics and Science Study).

The greater emphasis on affective and psychomotor skills in the post-2006 education program in comparison to their emphasis in previous program goals and behavior is seen as a significant change, because assigning importance only to cognitive skills in educational environments does not lead to an adequate level of success (Seah & Bishop, 2000). Many studies (Alsop & Watts, 2000; Duit & Treagust, 1998, 2003; Lee & Brophy, 1996; Meredith, Fortner, & Mullins, 1997; Thompson & Mintzes, 2002; Weaver, 1998; as cited in Tosun, Senocak, & Ozeken, 2013) state that affective area skills are also important in students becoming successful. Affective skills consist of many factors such as interest, attitude, motivation, values, beliefs, and self-efficacy. These factors make an important contribution to uncovering the knowledge and skills of students. Motivation, which is one of these factors, is recognized as an important element in students' success (Freedman, 1997; Lee & Brophy, 1996). While Martin and Briggs (1986) have defined motivation as a structure, including all internal and external conditions affecting the awakening, sustaining, and control of behavior, Keller (1987) has defined motivation as the degree of effort or work put in by someone to reach a goal or to avoid something, depending on the importance of the behavior of the individuals and their control.

Education technology can be defined as a process that is used to enrich all stages of education and make the work of those involved in education easier. It takes its essence from education theory and research, aims to enable the highest level of learning in individuals, and is focused on the planning, application, evaluation, and restructuring of education according to the results of evaluations. When developments in the field of education are reviewed, it can be seen that these developments are toward new technological systems, learning–teaching processes, educational environments, developments in the education workforce and relevant developments, and new approaches toward program regulation methods (Namlu, 1995). When viewed from this perspective,

it is of great importance for a variety of teaching methods that validity be investigated in an integrated manner with technology.

As previously mentioned, with a traditional approach, it seems very difficult to increase students' academic achievements above standards and to increase their motivation. When viewed from this perspective, it is an accepted fact that there is a need for a more modern and effective learning–teaching method that assigns responsibility to the student, that encourages individual learning, that makes the teacher more of a guide than a leader. The current deficiencies in these areas make it necessary for technologists to take responsibility and work on new ideas, products, and methods that will help develop educational goals and stimulate ideas by sharing their findings. This change has led to the emergence of new approaches to teaching and learning and has raised the question of the use of the new teaching strategy of the flipped classroom. The flipped classroom environment, with the aid of a variety of materials, gives students access to the subjects they will study that are suitable for self-study and offers the opportunity for individual or group problem-solving activities in the classroom.

Education technology has the mission to design, manage, implement, and evaluate technological resources and processes to facilitate learning. As this mission statement suggests, blending technology with effective methods for facilitating student learning and conducting studies in more attractive learning environments is one of the areas of/interest for education technologists (Alpar, Batdal, & Avcı, 2007). Studies of methods especially suited to the philosophy of creating a more efficient and effective learning environment for students in the constructive paradigm and researching their effectiveness seems important (Aslan & Aydın, 2016). The flipped classroom environment, which has been the subject of many studies in recent years, is one of these methods. This environment allows students access, with the aid of a variety of materials, to the subjects they will study that are suitable for self-study and offers the opportunity for individual or group problem-solving activities in the classroom. In short, this system, which gives students the ability to focus on problems encountered during individual learning, is defined as the switching of homework and classroom. Various recent studies (Baepler, Walker, & Driessen, 2014; Gannod, Burge & Helmick, 2008; Hung, 2015; McGivney-Burelle & Xue, 2013; Moravec, Williams, Aguilar-Roca, & O'Dowd, 2010; Strayer, 2012; Talbert, 2012; Tune, Sturek, & Basile, 2013; Wetterlund, 2009; Zownorega, 2013) have determined that this classroom environment is effective for learning. The present study, which was carried out to examine whether it is feasible in Turkey, researches the following basic questions:

- Is there a significant difference in the academic achievement levels of sixth-grade students taught in a flipped classroom environment in comparison with students taught with traditional methods?

- Is there a significant difference between the motivation levels of sixth-grade students taught in a flipped classroom environment and those of students taught with traditional methods?
- What are the opinions and thoughts of sixth graders taught in a flipped classroom environment?

Theoretical Background

The field of educational technology focuses on improving learning and performance. These concepts are important in the public service sector, the private sector, health, the military, and other areas (Reigeluth & Duffy, 2007). When looking at this subject from an educational perspective, the integration of learning with developing technology has been the subject of many studies (Gulbahar, 2007; Howie & Blignaut, 2009; Kaya & Usluel, 2011; Rogers, 2002; Wang, 2009), both nationally (Turkey) and internationally. While a wide variety of definitions have been made, at the most basic level, integrating technology with education is described as a permanent and sustainable process that contributes to student learning (Belland, 2009).

The integration of technology with education covers the learning environment, conditions, circumstances, resources, and so on that are effective in learner development. In a student-centered learning environment, teachers attempt to address the interests and strengths or weaknesses of students based upon their previous experiences and prior knowledge. This approach to building knowledge is based upon the paradigm of building new knowledge upon previous knowledge (the constructivist paradigm). In the knowledge-centered learning environment, teachers prefer the traditional method for the acquisition of knowledge by students. Applying new knowledge to a given situation or someone else is a gain in information. Careful analysis is required for teachers to answer the questions of what students must know and do and what position they must take at the end of a subject or course. The efficient and effective use of technology plays a strong role in the delivery of this response.

Technology, science, and the continuing changes in these two areas also have an impact on education. The continuing changes in the system mark the importance of the use of technology in all aspects of education. Undoubtedly, the education system should be sensitive to changes related to technology, and these changes should be incorporated into the system. In this context, various paradigm changes have occurred. Technology-related changes have led to the emergence of new approaches to teaching and learning and have raised the question of the use of a new teaching strategy: the flipped classroom. Having first been used at Miami University due to the abundance of homework (Lage, Platt, & Treglia, 2000), the flipped classroom environment allows students to use

a variety of materials, to access the subjects they will study that are suitable for self-study, and to take advantage of the opportunity for individual or group problem-solving activities in the classroom. In short, this system, which gives students the ability to focus on the problems encountered during individual learning, is defined as the switching of homework and classroom (Verleger & Bishop, 2013). In contrast to the usual practice, students learn the content of the course material under their own supervision and then discuss and practice what they have learned under the supervision of a teacher in class. This system of education, which provides students with the opportunity to access desired information at any time and place using video recordings, and which has the potential to assist in individual learning, is a teaching–learning method where students are given the opportunity to focus on individual or group problem-solving activities and which allows the teacher the opportunity to become actively involved with each student (Seaman & Gaines, 2013). The flipped classroom model was mentioned in the literature from 2000s onwards, but became popular in recent years, and started to be implemented at almost all levels of education (elementary, secondary, and tertiary).

The main difference between the traditional teaching method and the flipped classroom method is the transformation of classroom instruction. In the flipped classroom method, the teacher shares a video of the lesson with the students prior to class, students come to class prepared, having watched the video, and during the class, the teacher assumes a supportive and advisory role, which results in effective learning. In the traditional method, on the other hand, learning takes place during the class, as the teacher delivers a lecture and provides support, and students do their homework after the class. The flipped classroom environment is implemented in the following manner: (a) the time spent outside class preparing the student for the activities in class, (b) teachers evaluating the lesson preparation carried out by the students, (c) the opportunity for collaborative and problem-based learning among students instead of simple listening and taking notes in the classroom environment, and (d) offering students the opportunity to practice theoretical knowledge with the presence of a teacher and an opportunity for instant feedback (McGivney-Burelle & Xue, 2013).

When considering educational technology in terms of the principal objectives of support for learning goals, the primary objective is integrating technological resources in education in the most appropriate way. Viewed from the perspective of the flipped classroom environment, some of the opportunities provided by technology (opportunity for repetition, drawing attention, motivation, etc.) can be said to make this classroom environment more attractive. Seaman and Gaines (2013) argue that careful analysis and use of technology can contribute significantly to making the flipped classroom environment effective, efficient, and attractive. However, one must not create a situation of inequality of opportunity

for the students. While some students today are raised in households with the most advanced technology, unfortunately some students have access to computers and the Internet only in the classroom environment. This situation is undoubtedly an indirect factor affecting the success of the flipped classroom environment. When considering this from another perspective, it is difficult to keep track of whether students have really fulfilled their tasks, assignments, and responsibilities before class. Furthermore, students whose individual learning skills are not high may have difficulty. However, all these situations that seem to be disadvantages can easily be alleviated with systematized preclass analysis. A review of the literature shows that the problems most commonly encountered when using this method include the students coming to class unprepared (Rotellar & Cain, 2016; Veeramani, Madhugiri, & Chand, 2015), a lack of motivation on the part of students (Kim, Kim, Khera, & Getman, 2014; Milman, 2012), the failure to use the correct materials (McLaughlin et al., 2014; Ramar, Hale, & Dankbar, 2015), and technical problems (Goldberg, 2014; See & Conry, 2014). Chen, Wang, Kinshuk, and Chen (2014) argues that facilitating the process of getting used to the flipped classroom method should be taken into consideration as students would be used to being taught using the traditional method.

The flipped classroom method has achieved widespread adoption, particularly at college level (Asef-Vaziri, 2015; Zappe, Leicht, Messner, Litzinger, & Lee, 2009). However, conducting studies on the feasibility and impact of this method at lower levels could contribute to the adoption of the flipped classroom method.

The studies to date indicate a need to determine the effects of the flipped classroom method on efficient, effective, and attractive learning environments; and while these effects are tested, several variables must be controlled for. The effects on students of different cultures must be determined, and options for different learning environments must be compared. However, if we consider that a tablet computer is to be distributed to all students and teachers as part of the Fatih Project, which is currently underway in Turkey with completion planned for 2019 and which has the integration of technology into education as its goal, the feasibility of the classroom system being defined in this study can contribute to the success of the Fatih Project. Thus, it is important to study new, modern approaches and methods where technologies can be used effectively. This study was planned and implemented to examine the effect on academic achievement and motivation of students in their science class, the subject matter of which was the fight against germs, and to contribute to the meeting of these requirements. In this context, the general objective of this research was to determine the effect of the application of the flipped classroom method in the science course and to determine whether it had an effect on the academic achievement and motivation of students.

Table 1. Pretest and Posttest Experimental Design With Control Group.

Group	Pretest	Experimental procedure	Posttest
G1[a]	T1,[c] M1[d]	Operation with flipped classroom	T2,[c] M2[d]
G2[b]	T1,[c] M1[d]	Operation with traditional education	T2,[c] M2[d]

[a]G_1: Classroom flipped experimental group subjected to the method. [b]G_2: The control group where traditional education methods were used. [c]T_1 and T_2: Achievement test related to "Fight against germs." [d]M_1 and M_2: Motivation scale related to the science course.

Method

Research Design

In this study, a mixed research pattern using a pretest/posttest experimental design combined with qualitative data (follow-up questions) was used. This research aimed to support study results achieved through an experimental process making use of qualitative data and supported by the perceptions and opinions of students. The design of the study is set out in Table 1:

The research reported here, which had as its aim to study the effect of the flipped classroom method on the academic achievements and motivation of students regarding their science class, applied appropriate processes to the experimental group, using techniques and materials suited to the flipped classroom method; the control group used the traditional curriculum and applications. Focus group interviews were conducted with students in the experimental group, the data obtained from three open-ended questions in a structured form, evaluated in the context of this study.

Study Group

The study described here took place during the second semester of the 2013 to 2014 academic year, over a period of 2 weeks (for a total of 3 hours). The participants were sixth-grade students studying in two separate classes (with 35 students in the experimental group and 33 in the control group). The achievement and motivation pretest was applied to seven classes of sixth graders who were currently under the supervision of the science teacher.

When we consider that students cannot be isolated from their motivating factors where cognitive processes are concerned, the studies that have been conducted have underscored the requirement that the education they receive must reflect their motivating factors as well as their cognitive processes (Anderman & Young, 1994; Lee & Brophy, 1996; Pintrich, Marx & Boyle, 1993). There are also studies (Anderman & Midgley, 1997; George, 2006; Urdan & Midgley, 2003; Wigfield & Wentzel, 2007) that indicate that students' motivation toward

learning generally affects their success, directly or indirectly. Accordingly, the effect of the flipped classroom method on student motivation as well as academic achievement was studied. In this context, the scale developed by Dede and Yaman (2008) was used to determine students' level of motivation toward their science courses. Before the groups were assigned, the difference in motivation between these two groups that related to science class and their academic achievement was determined with pretests. Following the analysis of the two groups, it was determined that there was no significant difference between these two averages ($p > .05$) in terms of motivation and academic achievement variables for the two groups. Accordingly, in terms of pretest scores, it can be said that the groups have equivalent levels of academic achievement and motivation. The results of these pretests are given in tabular form in the following section.

Of the 35 students in the experimental group, 20 (57%) were male, while 15 (43%) were female. The average age of the female students in this group was 12.17, while for the male students, it was 11.92. Of the 33 students in the control group, there were 16 female (49%) and 17 (51%) male students. The average age of the female students in the control group was 12.28, while for the male students, it was 12.08. The general science achievement for the students in the experimental and control groups was around 6 to 6.5 on a 10-point scale, and the information that their achievement levels are close to each other was obtained from the course teacher.

Data Collection Tools

The data collection tools used in the study were an achievement test used as a pretest and posttest, a motivation scale used to measure the motivation toward science class, and the structured survey used to obtain the students' views regarding the flipped classroom environment. These tools are discussed briefly in the following subsections.

Achievement test. The achievement test used as the pretest and the posttest was developed by the researchers and two science subject experts. First, 25 four-choice multiple choice questions were prepared following the analysis of the subtitles of the subject *fight against germs* in the sixth-grade science class. The two experts were consulted to determine content validity, and five questions were revised following the determination that they would be difficult for sixth-grade students. Before the beginning of the study, the final version of the test was applied as a pilot study to three classes outside of the experimental and control groups. Following the removal of two questions that reduced the reliability of the test and whose discriminant validity was under 0.20, the test took its final shape, consisting of 23 multiple-choice questions. The reliability coefficient calculated with the KR-20 (Kuder Richardson) formula for the pretest was .83 and for the posttest was .88.

Motivation scale. To determine the motivation of the students in the study group toward the science course, a 23-item scale measuring motivation toward science learning was used that was developed by Dede and Yaman (2008). This is a five-dimension scale that includes ''Motivation Towards Research,'' ''Performance-Oriented Motivation,'' ''Communication Oriented Motivation,'' ''Motivation Towards Cooperative Work,'' and ''Motivation Towards Participation.'' The Cronbach's α internal consistency coefficient of the scale was calculated at .80. While the lowest possible score from the scale is 23, the highest score is 115. The high scores obtained from this scale show that motivation toward science was high among these students.

Structured interview form. Along with the three open-ended questions used to determine the perceptions and opinions of student participants toward the class and the flipped classroom environment, interviews were also conducted with students in the experimental group.

Experimental Procedures and Materials Used

Both quantitative and qualitative data collection techniques were used in this study. The study was conducted at a public secondary school in Turkey, as indicated earlier, and the experimental and control group classes were taught by the same instructor.

Before the experimental process was started, the requirements of the students in the experimental group were analyzed, and the students without computers or Internet connections at home were determined; a total of four students did not have an Internet connection. To avoid fostering unequal opportunity, the computer labs at the school were kept open during specific hours for these students, and at the same time, the students were given compact discs containing all the material on the website and digital media (see below). Materials were distributed to students 3 days prior to the normal course hour where the subject of the fight against germs was to be covered. Some of the materials prepared and shared with the students are as follows: When the e-materials mentioned earlier were being prepared, an expert opinion was sought in terms of content compliance. (Figure 1 shows a main page of e-material creation program. E-book category was prepared by selecting from this program. The sample picture in Figure 2 shows a PowerPoint presentation slide presenting the information that the human body fights germs every day, and the body has three different layers of protection. Figure 3 shows a screenshot of the user video about germs. Figure 4 shows a screenshot of the introduction page of the prepared e-book, featuring information on how to advance pages and run sound files.) The PowerPoint presentation, which is the basic material of the study (for a total of 25 slides), is the asynchronous teaching material that students could study individually. This material was a presentation that was recorded as if the material were being

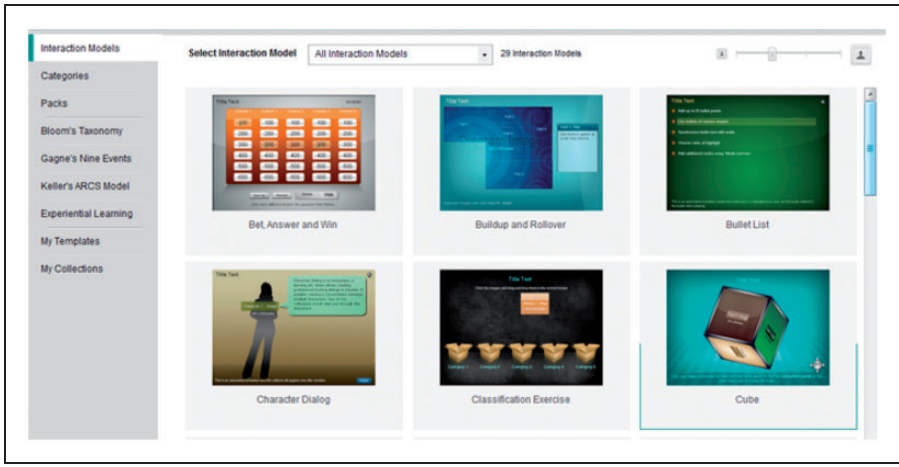

Figure 1. Screenshot of the program that makes up the interactive learning material.

Figure 2. The video format PowerPoint presentation with voice-over prepared by the researcher.

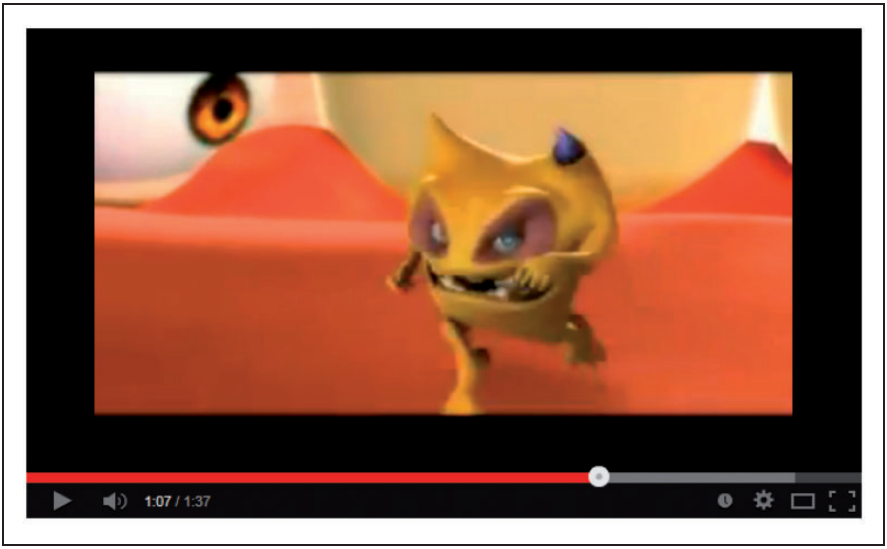

Figure 3. A sample video with the theme of the fight against germs.

Figure 4. E-book prepared on the subject.

taught in a normal classroom environment, including all audio and operations. This presentation was prepared with the aim of covering all the learning objectives relating to the fight against germs. The presentation is in video format and includes the basic information describing the subject, links to various helpful documents, supporting videos, visuals, exercises, and practical knowledge.

The materials prepared other than the video presentation were intended to reinforce the main subject and enabled students to assess themselves. For example, an online test containing multiple-choice, true or false, and fill-in-the-blanks question sets was prepared and included in the materials given to the students. This test material consisted of 25 questions in total. When the students completed these 25 questions, their scores and any sub-subjects they needed to repeat were given as feedback, and they were directed with hyperlinks to the relevant subject.

These self-assessment materials were distributed to the students 3 days prior to the normal class hour (as website links and in CD format) to enable the students to study them before class. In the classroom, the problems previously prepared by the researchers on the fight against germs subject were studied, students having difficulty with individual learning were identified and supported, and collaborative work was conducted on subjects that students did not understand. Those students whose level of awareness and individual learning capacity was at a lower level were divided into groups of three that included other students and given the opportunity to collaborate in solving problems. In the total of three class hours, techniques such as discussion, finding solutions to problem situations, reinforcing of subject material with other prepared material, and brainstorming were covered. In the control group, which used the traditional teaching method, the materials (textual books, PowerPoint presentations, and various videos) previously used in regular classes were provided. The teacher presented videos/presentations previously prepared, using the computer in the classroom, and held a class discussion with the students in the remaining time.

Data Analysis

Data analysis was performed on the achievement and motivation tests before and after the pretests and posttests for both groups. Information related to the flipped classroom environment gathered using the interview form that covered the qualitative data of the study was coded under three themes, using content analysis. In the analysis of the data, frequency (f) values, percent (%) values, and analysis of variance (ANOVA) statistical techniques were used.

Findings

This part of the study presents our findings on whether the flipped classroom environment has an effect on the academic achievement and motivation of

students in science class and the views of the relevant students on this classroom environment. The results are given in subsections.

Findings Achieved According to the Academic Achievement Variable

This part of the study presents findings on whether the flipped classroom environment had an effect on the academic achievement of students in science class. Table 2 reports the pretest and posttest mean scores and standard deviations for the academic achievement test.

As Table 2 shows, the experimental group students, who were taught using the flipped classroom method, received a mean score of 13.11 for academic achievement prior to the experiment and 18.02 after the experiment. Control group students, on the other hand, who were taught using the traditional teaching method, received mean scores of 12.54 and 15.45, respectively. This shows that levels of academic achievement have increased among both the experimental group students, who were taught using the flipped classroom method, and control group students, who were taught using the traditional teaching method. To examine whether the change observed in the mean score of the experimental group is significantly different from the change in the mean score of the control group, the pretest and posttest scores of the two groups were analyzed using a two-way repeated measures ANOVA, and results are reported in Table 3.

Table 3 shows that overall academic achievement pretest and posttest scores of the experimental and control groups significantly differ from each other, $F(1,\ 66) = 12.782;\ p < .05;\ \eta_p^2 = .16$. This finding indicates that the academic achievement scores of the students in the experimental and control groups differed from each other, without making a distinction whether the scores came from the pretest or the posttest.

Pretest and posttest mean scores for academic achievement significantly differed from each other, $F(1, 66) = 101.578; p < .05; \eta_p^2 = .60$. This finding indicates that the teaching method used, without making a distinction between whether they were in the experimental group or in the control group, changed their levels of academic achievement.

Table 2. Pretest and Posttest Mean Scores and Standard Deviations for the Academic Achievement Test.

	Pretest			Posttest		
Groups	*N*	$\overline{X}$	*SD*	*N*	$\overline{X}$	*SD*
Experimental	35	13.11	2.08	35	18.02	3.25
Control	33	12.54	1.85	33	15.45	2.18

Table 3. Results of the Variance Analysis of the Academic Achievement Test Scores of Experimental and Control Group Participants.

Source	Sum of squares	*df*	Mean square	*F*	*p*	Partial eta squared (η_p^2)
Between groups	517,03	67				
Group (Experimental/ Control)	**83,887**	**1**	**83,887**	**12,782**	**.000**	**.16**
Error (between)	433,143	66	6,563			
Within groups	891,676	68				
Measurement (Pretest–Posttest)	**519,794**	**1**	**519,794**	**101,578**	**.000**	**.60**
Group × Measurement	**34.147**	**1**	**34.147**	**6,673**	**.012**	**.09**
Error (within)	337,735	66	5,117			
Total	1408,706	135				

Results of the analysis reported in Table 3 show that the pretest and posttest academic achievement test scores of the experimental and control group students, who were taught using two different teaching methods, significantly differed from each other; that is to say, the interaction effect of the repeated measures factors on different treatment groups (experimental and control) was found to be significant, $F(1, 66) = 6.673$; $p < .05$; $\eta_p^2 = .09$. This finding indicates that the flipped classroom method and the traditional teaching method improve the students' academic achievement at different levels. In other words, the academic achievement scores of the experimental and control group students varied according to the method and one consequence of the treatment was that the groups had different levels of academic achievement.

Partial eta squared was calculated as a measure of effect size. Also known as effect size, the eta-squared statistic shows the proportion of total variance in the dependent variable explained by the independent variable or the factor (Büyüköztürk, 2007). Eta squared (η^2) values around .01 are interpreted as small effect size, values around .06 are interpreted as moderate effect size, and values around .14 are interpreted as large effect size (Cohen, 1988). An examination of the partial eta squared, which indicates effect size, shows that the variance in the experiment mostly resulted from measurements ($\eta_p^2 = .60$). In other words, the eta squared value obtained ($\eta_p^2 = .60$) shows that the flipped classroom method had a large affect on students' academic achievement levels. An overall assessment of the findings indicates that the differences observed in students' levels of academic achievement were mainly a result of the student-centered and technology-oriented approach of flipped classroom method. The flipped classroom method generated a larger increase in academic achievement

scores in the posttest, indicating that flipped classroom is more effective in improving students' academic achievement levels compared with the traditional method.

Findings on Motivation Variables

This part of the study presents findings on whether the flipped classroom environment had an effect on the motivation of students in science class. Table 4 reports the pretest and posttest mean scores and standard deviations for the Motivation scale.

As Table 4 shows, the experimental group students, who were taught using the flipped classroom method, received a mean score of 79.28 for motivation prior to the experiment and 92.20 after the experiment. Control group students, on the other hand, who were taught using the traditional teaching method, received mean scores of 78.90 and 84.09, respectively. This shows that levels of motivation have increased among both the experimental group students, who were taught using the flipped classroom method, and control group students, who were taught using the traditional teaching method. To examine whether the change observed in the mean score of the experimental group is significantly different from the change in the mean score of the control group, the pretest and posttest scores of the two groups were analyzed using a two-way repeated measures ANOVA, and results are reported in Table 5.

Table 5 shows that overall motivation pretest and posttest scores of the experimental and control groups significantly differ from each other, $F(1, 66) = 7062.524$; $p < .05$; $\eta_p^2 = .06$. This finding indicates that the motivation scores of the students in the experimental and control groups differed from each other, without making a distinction whether the scores came from the pretest or the posttest.

Pretest and posttest mean scores for motivation significantly differed from each other, $F(1, 66) = 107.163$; $p < .05$; $\eta_p^2 = .61$. This finding indicates that the teaching method used, without making a distinction between whether they were in the experimental group or in the control group, changed their levels of motivation.

Table 4. Pretest and Posttest Mean Scores and Standard Deviations for the Motivation Scale.

	Pretest			Posttest		
Groups	*N*	$\overline{X}$	*SD*	*N*	$\overline{X}$	*SD*
Experimental	35	79.28	8.19	35	92.20	9.62
Control	33	78.90	8.96	33	84.09	8.98

Table 5. Results of the Variance Analysis of the Motivation Scale Scores of Experimental and Control Group Participants.

Source	Sum of squares	*df*	Mean square	*F*	*p*	Partial eta squared (η_p^2)
Between groups	9490,904	67				
Group (Experimental/ Control)	**611,533**	**1**	**611,533**	**4.545**	**.003**	**.06**
Error (between)	8879,371	66	134,536			
Within groups	5001,688	68				
Measurement (Pretest–Posttest)	2781,078	**1**	**2781,078**	**107,163**	**.000**	**.61**
Group × Measurement	**507,784**	**1**	**507,784**	**19,566**	**.000**	**.22**
Error (within)	1712,826	66	25,952			
Total	11203,73	135				

Results of the analysis reported in Table 5 shows that the pretest and posttest motivation scale scores of the experimental and control group students, who were taught using two different teaching methods, significantly differed from each other; that is to say, the interaction effect of the repeated measures factors on different treatment groups (experimental and control) was found to be significant, $F(1, 66) = 19.566$; $p < .05$; $\eta_p^2 = .22$. This finding indicates that the flipped classroom method and the traditional teaching method improve the students' motivation at different levels. In other words, the motivation scores of the experimental and control group students varied according to the method and one consequence of the treatment was that the groups had different levels of motivation.

An examination of the partial eta squared, which indicates effect size, shows that the variance in the experiment mostly resulted from measurements ($\eta_p^2 = .61$). In other words, the eta squared value obtained ($\eta_p^2 = .61$) shows that the flipped classroom method had a large affect on students' motivation levels. An overall assessment of the findings indicates that the differences observed in students' levels of motivation were mainly a result of the student-centered and technology-oriented approach of flipped classroom method. The flipped classroom method generated a larger increase in motivation scores in the posttest, indicating that flipped classroom is more effective in improving students' motivation levels compared with the traditional method.

Findings Related to the Structured Focus Group Interview

Following the experimental procedure, a structured interview was conducted on the students in the experimental group to obtain their views regarding the flipped

Table 6. Student Opinions Related to the Flipped Classroom Environment.

Theme category	*F*	Examples of student opinion
Motivational	11	It seemed different doing homework first. But it was good because I had the opportunity to ask my teacher anything that stuck in my mind during class. I wish it was always like this (Student 1). Science is one of my favorite subjects. My teacher gave me a CD and I studied well. I liked studying on my own more. Because I was able to rewind the video for the part I didn't understand and listen again. I repeated it in class too (Student 2).
Instructive	8	I studied myself, and I asked my mom and dad and during class my teacher gave us problems and I got a chance to repeat. Now to live healthier I can fight germs more easily (Student 3). The video was great fun. I took a break where I liked. I continued the next day. I solved all of the questions my teacher prepared. In class, we just discussed problems with friends (Student 4).
Interesting	6	We always did the homework later. Now our teacher gave it first. I got help from my mom and dad too. They were very surprised too. They told me what I should ask and I asked my teacher in class (Student 5). I always do my homework on time. Now my teacher gave the course topics in advance. I studied them all every day. I went to class having already learned. I shared the ones that confused me with my friends and everyone learned something from each other (Student 6).

classroom. After brainstorming with students by the instructor on the use of the flipped classroom method, a structured form consisting of three questions was distributed to the students, and the results were subjected to content analysis. In Table 6, the data obtained from the answers of the content analysis are given in themes.

Table 6 shows that the flipped classroom environment is perceived positively by students and that they have stated the opinion that this situation increases motivation and is instructive and interesting. This situation can be interpreted as having a positive effect on the perception that homework or taking responsibility is not well liked.

Discussion, Conclusion, and Recommendations

In this study, the effectiveness of the technology-enhanced flipped classroom environment was investigated in middle school students. As part of the scope of the study, the education practice, which was detailed in the previous sections, took place in four primary stages. These are (a) preparation of electronic

materials, (b) identification of students without computers or Internet access to take measures to prevent unequal opportunity, (c) distributing the material to the students before the class, and (d) discussion of parts of the course that are not understood, ensuring reinforcement of the subject by creating various problem situations and supporting students who have difficulty in learning. While preparing material for study, care was taken for the diversity of examples by considering the age of the target audience and the main topics on the agenda for health problems. As the target audience consists of middle school students, the materials were enriched with playful content and cartoons.

When looking at the results of the research, we determined that the flipped classroom applied to the experimental group yielded both better academic achievement levels and enhanced motivation toward the lesson in comparison with the traditional teaching method applied to the control group. On the other hand, the students in the experimental group reported in the focus group session that this classroom environment was more fun than the traditional classroom environment and that it was more educational and more inspiring. A number of studies in the literature (Baepler, Walker, & Driessen, 2014; Gannod, Burge, & Helmick, 2008; McGivney-Burelle & Xue, 2013; Moravec et al., 2010; Strayer, 2012; Talbert, 2012; Tune et al., 2013; Zownorega, 2013) report findings that parallel the findings of the present study. Some of these studies, conducted in various courses at different levels of education, are briefly reviewed in the following.

Zownorega (2013) studied the traditional teaching method in a mechanically based physics class in 2011 to 2012 and the flipped classroom method in 2012 to 2013. When the end-of-term exam results were taken into account, the students in the flipped classroom environment were found to have finished the term with higher scores than those of students receiving traditional education. Moreover, it has been reported that this classroom environment has also positively affected the students' motivation.

In a study at Franklin University where two different groups of students were taught with the traditional environment and flipped classroom environment, it was found that the group in the flipped classroom environment showed higher levels of success than those in the traditionally educated group. In addition, in a flipped classroom applied for a term in an ''Introduction to Computer Science'' course, it has been observed that students with a short computer history were able to develop their talents with this system and gain a high level of technical skills (Talbert, 2012).

Wetterlund (2009) created an electronic art museum using photos and various online applications to develop the knowledge of archaeology of the students. A study where the art museum and schoolteachers took part together was meant for students, so that they could learn the material used in art museums, to interpret art with reading–viewing–listening activities, and to develop their classification skills with a flipped classroom system.

Strayer (2012) investigated the effect of a flipped classroom environment on the academic achievement of high school students in mathematics and English classes. For this, 3-, 5-, and 7-minute videos were prepared for each course and shared with students, and these videos were discussed in class. The study determined that negative attitudes of students toward homework changed and that the period of time during lectures usually used for explaining the subject was used for consolidating the course. The percentage of students failing in English classes dropped from 19% to 13% and from 50% in mathematics to 44%.

Gannod, Burge, and Helmick (2008) have reported that the flipped classroom application used in a university software course to develop programming abilities was successful and that students had advanced in application development and taking responsibility. A flipped classroom applied in an ''Introduction to Biology'' course at the University of California was found to increase exam results by 21% with prerecorded videos being watched by students outside of the class and being followed by interactive exercises (Moravec et al., 2010).

These studies show that the flipped classroom method affects learning in different courses/levels of education. However, several studies (Davies, Dean, & Ball, 2013; Findlay-Thompson & Mombourquette, 2014; Johnson & Renner, 2012; McLaughlin et al., 2014) report, to the contrary, that the flipped classroom method does not have an effect on learning. It could be argued that the discrepant results reported in the literature result from the differences in the way the flipped classroom method was implemented. There is no doubt that many factors (the quality of the materials used, technical issues, and failure to manage the process effectively) can hamper the implementation of the flipped classroom method (Jeavons, Flecknoe, Davies, & White, 2013; Johnson, 2013; Phillips & Trainor, 2014). This indicates that good planning is imperative when it comes to course design and course materials for flipped learning.

In the present study to support the quantitative (experimental) findings of the research, the views of the students in the flipped classroom environment were obtained concerning the method and process. The data obtained from the students show that the use of this method in general had a positive effect on student perceptions of the science course. The situation in which the students were most satisfied was their discovering a teaching method where they took an active role in the determining the basis of the science course. When the results of the experimental procedure and the views of the students are evaluated together, it can be said that the flipped procedure has enabled the students to use science knowledge (from the fight against germs as their subject) in many problems in their daily lives, that it has enabled them to be individuals with an active role, and that being able to repeat certain material without a time limit has given them motivation and increased their academic achievement.

As part of ongoing Fatih Project, expected to be completed by 2019, in Turkey, a tablet computer will be distributed to all students and teachers and all classrooms will have an interactive board. Following this project, where distribution is continuing rapidly at the high school level and beginning operation in all levels of education, moving away from traditional teaching methods toward various more creative methods that will have a positive effect on students' learning is an important phenomenon. From this perspective, it is hoped that the flipped classroom environment supported by this technology will contribute positively to the outcome of this project and will improve students' learning. These studies on classroom environment are limited in number, and it is an issue not much explored in the literature on Turkey. In this context, it can be said that further research is needed on the cultural and educational validity of this method in Turkey.

In light of the results of this study, the following recommendations are made for researchers and operators:

- The preparation of the various electronic resources required for the application of the flipped classroom environment and the motivation of students is a very difficult job in the already busy professional life of teachers. From this perspective, it is expected that support from the private sector and distribution of a variety of educational materials to schools can increase the applicability and success of this method.
- The Fatih Project, which will soon be completed at all educational institutions, will result in each student having a tablet computer. This situation must be converted to an opportunity to positively influence students' learning and go beyond the tablets' just being used in the classroom environment to being used before the class, as in the flipped classroom environment, and create cognitive and affective awareness.
- Information should be given to teachers at every level through in-service training in what the flipped classroom environment is and how it can be applied. At the same time, information should be given to teacher candidates at preservice levels in educational faculties.
- In terms of generalization of the results, the effect on courses and students of different levels should be investigated.
- Researchers creating various educational materials and investigating the effects of these materials will contribute to both the applicability of the method and learning in students.

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Author Biography

Baris Sezer is a research assistant at department of Medical Education and Informatics, Faculty of Medicine, Hacettepe University, Ankara, Turkey. He earned his PhD degree from Ankara University in 2016. His research interests are instructional design, technology integration, technological leadership, and electronic performance support systems.