Original Article

Explorations to Overcome Socio-Economic Barriers in Learning and Thinking: A Flipped Classroom Study

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***Abstract**: The present study aims to examine the effect of the flipped classroom model on the academic achievement and critical-analytic thinking skills of students from different socio-economic backgrounds. For this purpose, two schools in the same province, attended by children from families with varying socio-economic levels, were included in the study. The study sample consisted of a total of 82 students: 30 from a secondary school with students from a low socio-economic background and 52 from another secondary school with students from a high socio-economic background in the 2021-2022 academic year. The study was designed based on the quasi-experimental design with pretest-posttest control groups. Experimental and control groups consisting of one class each, and four classes in total, were selected from the schools using the random assignment method. The total application period was 9 weeks while the duration of the experimental applications was 7 weeks (28 class hours). In the present study utilizing Edpuzzle, an online platform, interactive videos were developed in accordance with the learning outcomes of the course. Data were collected using the 25-item "Sun, Earth and Moon Achievement Test" applied to determine the learning levels of the students and the 72-item "Cornell Conditional Reasoning Test" applied to measure critical-analytic thinking skills. In conclusion, it was revealed that although there was no significant change in critical-analytic thinking skills, the flipped classroom model provided a significant increase in the academic achievement and critical-analytic thinking skills of students from both socio-economic backgrounds.*

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Introduction

THE rapid developments and changes in technology have had an impact on numerous fields including social, cultural, medical, and financial sectors, and have made major innovations and changes inevitable. Accordingly, the use of technology in education has expanded and emerging communication technology tools have become a new subject of study (Kahramanoğlu & Şenel, 2018). It has been observed that the use of these new technologies in education facilitates learning, increases the learning levels of students and can help them better understand and retain concepts by transforming education from a passive and reactive state to an interactive and more enjoyable one (Raja & Nagasubramani, 2018). Previous studies in this context have also demonstrated that the use of new technologies in education can make a positive contribution to the academic achievement of students (Aktaş, 2013; Oktay & Çakır, 2013). However, when educators insist on traditional education, it becomes highly difficult for students to acquire higher-order skills (Kara, 2008).

In traditional classrooms, students mainly follow the lecture and occasionally engage in brief discussions (Bergmann & Sams, 2012). In such classrooms, the teacher is usually at the center of an educational process that focuses on providing students with information through memorization (Alharthi, 2018). However, it is important not only to convey information but also to be able to distinguish what information is reliable, and it is necessary for children to possess critical thinking skills in order to do so (Lone, 2017). For this reason, critical-analytical thinking has become a necessity for children to access accurate information, particularly in today's world where the transfer of information is quite intense (Yaralı, 2020). This is because, in this century, it is a necessity to train individuals who can adapt to the various occupations of the present age and possess higher-order thinking skills (Ichsan et al., 2021). However, it is very difficult, particularly within the traditional education model, for a single teacher to adopt an individualized education approach in crowded student groups and to progress in line with the learning pace of students (Bergmann & Sams, 2012). For this reason, technology-integrated learning models should be included in the design of new education processes, considering the changing living conditions and the importance of the use of technology in education (Aydın, 2016). One of the models that are compatible with current technologies is the Flipped Classroom Model (FCM).

The FCM is a contemporary educational innovation that is viewed by many as a means to transform teaching and learning in the 21st century and beyond (Keengwe et al., 2014). This model establishes a framework that also enables students to receive a personalized form of education tailored to their individual needs (Bergmann & Sams, 2012). Although it is quite difficult to address the learning style of each student, the FCM adopts an instructional strategy that is relevant for a wide range of students (Lage et al., 2000). The starting point of the present study was the fact that despite the wide range of the FCM, no experimental study was found in the literature on the potential outcomes of this model in schools with different socio-economic levels. In this direction, the present study aims to examine the effect of the FCM on academic achievement, permanence, and critical-analytical thinking skills of students from different socio-economic backgrounds in the 5th-grade Science course unit “Sun, Earth and Moon”. In the study, answers will be sought to the following sub-problems:

Among the experimental and control group students in schools with low and high socio-economic levels.

(i) Is there a significant difference in terms of the post-test scores of the Sun, Earth and Moon Achievement Test?

(ii) Is there a significant difference in terms of the permanence scores of the Sun, Earth and Moon Achievement Test?

(iii) Is there a significant difference in terms of the post-test scores of Critical-Analytic thinking?

Theoretical background

The Flipped Classroom Model

The FCM was first implemented by Lage et al. (2000) in the Department of Economics at the University of Miami. Various concepts are used to refer to the FCM. These include inverted classrooms (Lage et al., 2000; Strayer, 2012), flipped classrooms (Bergmann & Sams, 2012; Bishop & Verleger, 2013; Enfield, 2013), inverted learning (Ram ŕez-Montoya & Hernandez, 2016), flipped learning (Seery, 2015), and “class at home, homework at school” (Demiralay & Karataş, 2014).

In essence, unlike the traditional model, the FCM refers to the implementation of classroom activities at home and home activities in the classroom (Bergmann & Sams, 2012). That is, in contrast to the widespread teaching approach, lectures and homework are swapped (Talbert, 2012) and time is completely restructured (Bergmann & Sams, 2012). While most of the class time in the traditional teaching model is allocated to activities such as lecture presentations or homework review, in classrooms where the FCM is employed, a short Q&A session is held prior to the lecture to check the information acquired by the students, and a significant portion of class time is devoted to critical-analytical thinking, problem-solving and application (Hayırsever & Orhan, 2018). In this model, lessons are carried out outside the classroom with pre-recorded videos, while active studies are carried out during class hours (Talbert, 2012).

The FCM establishes a student-centered teaching environment by ensuring active student participation (Özbay & Sarıca, 2019). Students are responsible for watching the videos, completing the exercises assigned in the videos, and asking appropriate questions. The teacher's role in the classroom is to manage and guide the process rather than conveying information to the students (Bergmann & Sams, 2012). In this sense, the model has replaced teacher-centered classes over time (Pierce & Fox, 2012).

Critical-Analytic Thinking and the FCM

Critical thinking is a process of analysis and evaluation to improve thinking (Paul & Elder, 2005). Analytical thinking is the process of breaking down a problem into parts and drawing meaning from these parts, explaining the functioning of a system, identifying the underlying reasons behind an event or the steps to solve a problem, comparing two or more situations, and evaluating and criticizing the properties of phenomena (Sternberg, 2002). Thus, this skill is referred to as critical, analytical, or critical-analytical thinking in the literature and is vital in understanding both daily life and science. This is because critical-analytical thinking is a type of logical and reflective thinking focused on making decisions regarding what to believe or what to do (Ennis, 1985). Acquiring this skill is the most favorable way to prepare the younger generation for a changing world (Marin, 2011).

Individuals with high levels of critical-analytical thinking can develop skills, abilities, and core values to help them succeed in life (Huong et al., 2018). Although the world has changed dramatically since the year 2000, students who practice critical-analytic thinking have been able to adapt to the changing landscape and have achieved exponentially greater success in higher education and the workplace compared to other students (Marin, 2011). Therefore, it is of great importance to design programs that can help students acquire critical-analytic thinking. Styers et al. (2018) stated that the implementation of active learning strategies in the flipped classroom can facilitate the acquisition of critical-analytic thinking skills. This is because when the learning environment is organized based on the traditional classroom model; students solve certain problems only when they "encounter" them. However, when the FCM is employed, students take turns answering questions, complete assignments, and maximize the knowledge they acquire by applying class outcomes to practical situations, and only in doing so can students' critical-analytic thinking skills gradually develop and reach higher levels (Huong et al., 2018).

There are previous studies examining the impact of the FCM on students' reading (Fulgueras & Bautısta, 2020) and listening comprehension skills (Etemadfar et al., 2020). Since there is a limited number of studies examining the effect of the FCM on critical-analytic thinking skills (DeRuisseau, 2016; Fulgueras & Bautısta 2020; Etemadfar et al., 2020; Putri et al., 2021), it is anticipated that the present study will make a significant contribution to the literature. However, it is also important to investigate what results this model will yield in schools with different socio-economic contexts.

Socio-Economic Level and the FCM

Income inequality in learning is one of the most significant issues today (OECD/UNICEF, 2021). Bradley & Crowny (2002) state that the socio-economic level of students' families is associated with cognitive and socio-emotional outcomes, and that its effects begin in utero and persist through adulthood, affecting the well-being of children on numerous levels. Previous studies also show that socio-economic status significantly affects children's success (Aslanargun et al., 2016; OECD, 2021).

In the study conducted by Tansel (2002) in Turkey, it was stated that the socio-economic level of families is effective in the academic achievement and participation processes of students. Kozikoğlu & Camuşcu (2019) stated that the socio-economic level of families affects the development of children's attitudes and skills as well as their readiness levels. Additionally, Çiftçi & Çağlar (2014) stated that higher socio-economic levels facilitate the learning process of students whereas the environmental and contextual characteristics of lower socio-economic levels do not sufficiently support the development of students. According to the OECD (2021), children from socio-economically disadvantaged families not only experience this disadvantage themselves, but also affect their peers. In other words, the more students from low socio-economic backgrounds in the classroom, the more the performance of students from high socio-economic backgrounds is affected, thus reducing class success. These studies reveal the importance and impact of socio-economic status on students' learning processes. Therefore, the importance of instructional designs that can alleviate the inequalities arising from socio-economic status increases even further.

It has been argued that only students from high socio-economic backgrounds can benefit from the FCM whereas students with low socio-economic status cannot do so without access to computers and reliable Internet (Horn, 2013). Based on the related literature, it can be stated that students with high socio-economic backgrounds are more prepared to learn with the FCM and that the opportunities provided by families (internet and technological tools) are effective in the development of positive attitudes (Kozikoğlu & Camuşcu, 2019). Turkey is among the OECD countries with the strongest correlation between academic achievement and socio-economic status (OECD, 2021). Turkey is also one of the countries with the highest

Gini Index, which is recognized as an indicator of income inequality among OECD countries (World Bank, 2019). This shows that Turkey is a suitable country for the examination and comparison of the success of students from low and high socio-economic backgrounds in FCM applications.

It is observed that there is a very limited number of studies examining the effect of the FCM on critical-analytic thinking skills, mostly at the level of secondary (Fulgueras & Bautısta, 2020; Sulisworo et al., 2019) and undergraduate (Andrini et al., 2019) education, with a particular deficiency in the field of science education. However, it is crucial to start teaching higher-order skills such as critical-analytic thinking as early as possible. Moreover, the majority of the studies on this model utilized Blackboard, while the Edpuzzle platform was employed in a very limited number of studies (Demirer & Aydın 2016; Özbay & Sarıca 2019). The present study will make an important contribution to the literature in terms of its unique aspects related to these deficiencies. Beyond these, the most significant feature that distinguishes the present study from others is its focus on students from families with different socio-economic levels. While the literature mostly focuses on students from families with middle and high socio-economic backgrounds, a limited number of studies examining the effect of the model on students from families with low socio-economic status (Yeoman, 2018) were also found. There are no studies in the literature on how the FCM yields results for students from families with different socio-economic levels within the same cultural structure. The present study is significant in terms of revealing the effects of the FCM in different contexts. Moreover, if the experimental application is successful, the study can serve as an important alternative in overcoming the disadvantages of students from families with lower socio-economic backgrounds.

Method

Design

In the present study, a quantitative quasi-experimental design with pretest-posttest control groups was employed. Johnson & Christensen (2012) stated that the quasi-experimental is suitable for cases where random assignment to groups cannot be made. While FCM was applied to the experimental groups in the study, the routine practice of the Ministry of National Education (MoNE) was not significantly intervened with in the control groups. Since the students in the experimental group were tasked with an additional project outside of class time, the students in the control group were given a project assignment that could be completed at approximately the same time.

Table 1. School Features.

Features of the Schools	LSELS	HSELS
General Features	The school building was demolished as it was an old structure and not resistant to earthquakes, and the school was moved to another school building in the same neighborhood. The building is used jointly by both schools. The school building has limited facilities. There is no space for social and cultural activities in particular.	The school building is a new structure and in a more central location. There are areas for social and cultural activities in the school building.
Environmental Features	The school is located in a suburb of the city center. There are small and very old buildings in the vicinity of the school. Consequently, people with very low income and education levels live in the area. The school is located in a neighborhood with a high crime rate.	The school is located in a central area of the province. It is situated in an environment where students with more advantageous residential and transportation opportunities reside. The school is located in a neighborhood with mostly civil servant families.
Parental Features	The parents have very low levels of income and education. Therefore, they are incapable of meeting the needs of their children. The number of parents convicted of one or more crimes is substantial.	Both the income and education levels of the parents are considerably higher compared to the other school. The majority of the students take private courses or lessons outside of school time.
Physical Equipment of Classrooms	All classrooms have internet access and interactive whiteboards. However, there is no science laboratory available. The classrooms are adequate in size for the number of students and receive sufficient light.	All classrooms have internet access and interactive whiteboards. There is a science laboratory present. The classrooms are adequate in size for the number of students and receive sufficient light.
Features of Application Teachers	The applications in both classes were conducted by the teacher of the course in this school. The teacher is a male Science teacher with 13 years of seniority.	The applications in both classes were conducted by the teacher of the course in this school. The teacher is a male Science teacher with 12 years of seniority.

Sample

The study was carried out in the 2021-2022 academic year in two different schools located in a city in Turkey, attended by students from low and high socio-economic backgrounds. A total of 82 5th-grade students, 30 from a low socio-economic level secondary school (LSELS) and 52 from a high socio-economic level secondary school (HSELS), constituted the sample of the study. The mean age of the students was 10 years. Since there were two classes in the HSELS taught by the volunteer teacher and only two classes in the LSELS, all of the 5th-grade students participated in the study. The experimental and control groups were determined through a draw of lots among the classes in the schools. **Table 1** shows the features of the schools.

Instruments

Two data collection tools were used in the present study. These are the "Sun, Earth and Moon Achievement Test" and the "Cornell Conditional Reasoning Test" of the "Cornell Critical Thinking Skills Test Series".

Sun, Earth and Moon Achievement Test

The Sun, Earth and Moon Achievement Test (SEMAT) was developed by Sontay & Karamustafaoğlu (2020) in accordance with the learning outcomes of this unit. When the item difficulty of the 25-item SEMAT was analyzed, six items were classified as easy while four items were difficult, and 15 items were moderate. The researchers calculated the mean item difficulty index of the test as 0.53 and the mean item distinctiveness index as 0.54. The KR-20 internal consistency coefficient of this achievement test was calculated as 0.83.

The Cornell Conditional Reasoning Test, Form X (CCRT-FX)

The Cornell Conditional Reasoning Test, Form X (CCT-FX) of the Cornell Critical Thinking Skills Test Series was used in the present study. This test was developed by Ennis & Millman (1985) to measure the critical thinking skills of 4th-14th grade students. The test was translated into Turkish by Mecit (2006).

CCT-FX was chosen as it objectively measures critical-analytical thinking and its content overlaps with aspects of inquiry-based learning. The test yields the sum of scores obtained from items measuring skills related to deduction, evaluation, observation, and examination of the reliability of statements by others, identification of assumptions, and discernment of meaning. The CCT-FX is a 72-item multiple-choice, general content-based test. Each question has three choices and one correct answer. Reliability coefficients obtained from various studies vary between 0.87 and 0.91 (Mecit, 2006).

Procedure

The application lasted for a total of 9 weeks in all classes, with an experimental application of 7 weeks (28 class hours) and the application of the pre-post tests. **Table 2** shows the application process in both groups. The applications in the experimental and control groups are presented under separate headings below.

Application Process in the Experimental Groups

Table 2. Application Process of the Study.

Week	Subject	Learning Outcome Numbers	Applications in the Experimental Group	Applications in the Control Group
1.	Introduction of the study, pretests		Briefings, preparations, and pre-test studies related to the study were conducted.	
2.	Structure and Characteristics of the Sun	F.5.1.1.1.	We Have No Gaps, True or False? Find the Right Path, Activity-1, Activity-11, Activity-30	Making a Sun Model, Home Activity
3.		F.5.1.1.2.	The Choice is Yours, Activity-3, Activity-8, Activity-14, Activity-17	Let's Watch, Learn, Evaluate Ourselves 1.1
4.	Structure and Characteristics of the Moon	F.5.1.2.1. F.5.1.2.2.	We Have No Gaps, Reach the Right Exit, Explaining with What I Have Learned, Activity-13, Activity-15, Activity-16, Activity-26, Activity-33	Is Life on the Moon Possible? Let's Evaluate Ourselves 1.2
5.	Movements and Phases of the Moon	F.5.1.3.1.	We Have No Gaps, True or False? Activity-4, Activity-5, Activity-10, Activity-12	The Moon's Rotation and Orbit, Did You Know?
6.		F.5.1.3.2.	The Choice is Yours, Draw the Moons, Exit the Space Map. Activity-7, Activity-20, Activity-27, Activity-29	Phases of the Moon, Classroom Activity, Let's Evaluate Ourselves 1.3
7. 8.	Movements of the Sun, Earth and Moon relative to each other	F.5.1.4.1.	We Have No Gaps, Reach the Right Exit, The Route of the Sun, My Light and Dark Side. Activity 24, Activity-28, Activity-41, Activity-44	The Sun, Earth and Moon Moving Together, Home Activity, Let's Watch and Learn, Assessment and Evaluation Activities
9.	Completion of the study and post-tests		Evaluation and post-test studies were conducted.	

The FCM application in both schools was carried out by the teachers of the course within the framework of the plan developed in the present study. The activities were selected from the textbooks prepared by the MoNE in accordance with the learning outcomes in the Science Curriculum (SC) (2018) and from the activities published on the MoNE Education Information Network (EIN) platform. All the necessary tools and materials for the activities were provided to both classes.

First, the teachers and students were informed about how the study would be conducted and how to use the Edpuzzle platform. In order to prevent any potential technical problems during the process, a class was created for each school on the Edpuzzle platform, and the teachers and students were assigned to these classes. One-on-one meetings were held with the parents of the students to inform them about the content and duration of the videos so that the students would not abuse the use of phones and tablets. Thus, the teachers were able to identify the students who did not watch the videos and to conduct one-on-one interviews with the students and their parents to en-

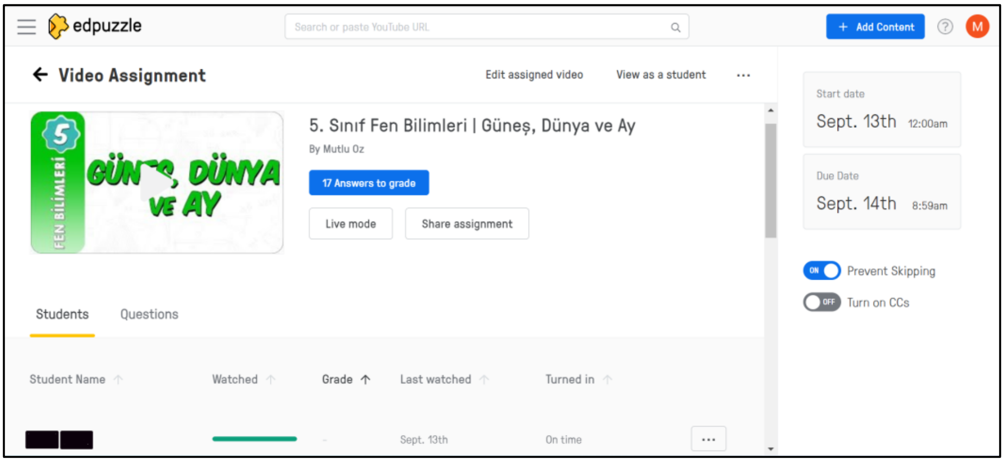

Figure 1. Video Content and Student Tracking Page.

sure that a more effective process. Moreover, one of the researchers registered as an administrator on Edpuzzle and closely monitored the application process and identified students who did not participate in the entirety of the application and excluded them from the sample.

In the study, the videos were prepared by one of the researchers. The aim here was to minimize uncontrollable variables that could affect the experimental implementation by using the same material in the experimental groups in both schools and ensuring that the process was carried out in the same way. The researcher worked in coordination with the teachers and uploaded the videos to the system in accordance with the learning outcomes.

The videos shared with the students were carefully picked from YouTube in accordance with the learning outcomes of the subjects and the developmental characteristics of the students. The videos were structured to be short (not exceeding 10 minutes), simple and comprehensible. Active student participation was censured by placing short pieces of information and various questions in the videos. Furthermore, by placing fast-forward and skip restrictions on the videos, it was aimed to ensure that the students watched the entire video without skipping the relevant questions and brief information. These structured videos were uploaded to Edpuzzle one day before each lesson with 2 videos per week. **Figure 1** shows a sample video content and student tracking page.

The students in the experimental group who came to school after watching the video related to the learning outcomes at home asked their teachers questions about the parts they did not understand nor had difficulties with in the first 10 minutes of the lesson. Then, the students performed the selected activities related to the learning outcomes in small groups. In this way, it was aimed to establish peer learning, which is another aspect of the FCM. At the end of the activity, the parts that the students had difficulties with were addressed through Q&A and debate methods, and the deficiencies in learning were tried to be eliminated by the teachers.

Application Process in the Control Groups

In order to ensure unity between the schools, the lessons in the control group were conducted in accordance with a course plan prepared jointly by the two teachers within the framework of the same plan based on SC (2018). The teachers developed this course plan using the textbooks published by the MoNE and the EIN platform, as was the case in the experimental group. Thanks to the course plan developed, the same application could be carried out in both schools in a controlled and planned manner. The activities and applications recommended in the textbook were carried out within the framework of this course outline in both schools. Tools, materials, and various documents required by the students during the application phase were provided to both schools. All activities were carried out by separating the students into small groups as in the experimental group. With group work, it was aimed to promote peer learning among the students, as was the case in the experimental group. Unlike the experimental group, this group was assigned project homework, which was followed up by the teachers.

Data Analysis

Preliminary Analyses of CCRT-FX and SEMAT

In both tests, the students' answers were checked against the answer key. Accordingly, the students' answers were coded as "1" if correct, and "0" if incorrect or blank, and the students' total scores were calculated. Since there are 25 questions in the SEMAT, the maximum total score possible for the students is 25. Since there are 72 questions in the Cornell Conditional Reasoning Test, the maximum total score is 72.

Statistical Analysis

FCM and socio-economic level are the independent variables of the study as the focus is on the impact of FCM on the learning and critical-analytic thinking of students from different socio-economic backgrounds. As seen in **Table 1**, since the socio-economic variable is a multidimensional variable in itself, it was decided that it would be more accurate to compare two different schools descriptively rather than statistically. In this direction, first, the effect of the FCM on the dependent variables (SEMAT and CCT-FX) in each school was determined. Then, the effects of the FCM in the two schools were compared in terms of dependent variables.

The independent samples t-test was used to determine whether there was a significant difference between the SEMAT and CCT-FX pre-test mean scores of the experimental and control groups. Since there was a significant difference between the groups, it was decided to use covariance analysis to determine the effect of the FCM on the dependent variables (Kline, 2009). ANCOVA was utilized since it provides the necessary prerequisites for parametric tests. The normality of data distribution for ANCOVA was determined based on skewness and kurtosis values. The homogeneity of variances was tested with the Levene's F test. The equality of the slopes of the intragroup regression lines was examined for each measurement. The Pearson correlation was used to test whether there was a significant relationship between the controlled covariates and the dependent variables for all measurements in which ANCOVA was applied. The power of the independent variable to explain the total variance in the dependent variables was determined by eta-squared (η^2). η^2 values at levels of 0.01, 0.06 and 0.14 were interpreted to indicate a small, medium, and large effect size (Cohen, 1988), respectively. The interpretation of the significance of the findings was based on a significance level of 0.05.

Findings

Findings on SEMAT

Before starting the FCM applications in both schools, it was examined whether there was a significant difference between the groups based on the achievement test. In the LSELS, the pre-test mean scores of the students in the experimental group ($X = 4.643$) were lower than the mean scores of the students in the control group ($X=7.000$). There is a statistically significant difference ($t(28) = 3.022$, $p < 0.05$) between the experimental and control groups based on the pre-test of SEMAT. Similarly, the score difference between the experimental group ($X = 7.542$) and the control group ($X = 10.321$) based on the pre-test of SEMAT in the HSELS is also statistically significant ($t(50) = 3.024$, $p < 0.05$). Since there was a significant difference between the groups in the pre-test in both schools, ANCOVA was performed by assigning the SEMAT pre-test as the covariate.

As shown in **Table 3**, although the pre-test mean score of the students in the LSELS was 2.357 points higher in favor of the control group, the adjusted mean after the FCM application was 3.529 points higher in favor of the experimental group. However, according to the ANCOVA results, there

Table 3. SEMAT Pre-test, Post-test, Adjusted Mean and ANCOVA Results of the Experimental and Control Groups in the LSELS and HSELS.

School	Group	N	Tests	Mean Achievement Score			F	p	η_p^2
				X	SD	Adj. X			
LSELS	*Exp.*	14	*Pre-test*	4.643	0.589	-	2.650	0.115	0.089
			Post-test	15,000	5.818	16.749			
	Cont.	16	*Pre-test*	7.000	0.516	-			
			Post-test	14,750	5.894	13.220			
HSELS	*Exp.*	24	*Pre-test*	7.542	2.963	-	8.421	0.006	0.147
			Post-test	18.625	3.449	19.490			
	Cont.	28	*Pre-test*	10.321	3.570	-			
			Post-test	16.571	5.3085	15.830			

Table 4. The SEMAT Pre-test, Permanence Test, Adjusted Mean and ANCOVA Results of the Experimental and Control Groups in the LSELS and HSELS.

School	Group	N	Tests	Mean Achievement Score			F	p	η_p^2
				X	SD	Adj. X			
LSELS	*Exp.*	14	Pre-test	4.643	0.589	-	2.822	0.105	0.095
			Perm.-test	13.143	6.262	15.028			
	Cont.	16	Pre-test	7.000	0.516	-			
			Perm.-test	13.125	5.512	11.476			
HSELS	*Exp.*	24	Pre-test	7.542	2.963	-	6.238	0.016	0.113
			Perm.-test	16.125	3.627	17.075			
	Cont.	28	Pre-test	10.321	3.570	-			
			Perm.-test	14.750	5.317	13.936			

is no statistically significant difference between the adjusted post-test mean scores of the students in the experimental and control groups based on their SEMAT pre-test scores ($F(1, 27) = 2.650$, $\eta_p^2 = 0.089$, $p = 0.115$, $p > 0.05$). Based on the partial eta-squared value, the FCM has a moderate effect on the SEMAT post-test scores in the LSELS and explains 8.9% of the variance. Although the SEMAT pre-test mean score of the students in the HSELS was 2.779 points higher in favor of the control group, there was a difference of 3.660 points in favor of the experimental group between the adjusted post-test mean scores after the application. Based on the ANCOVA results, there is a statistically significant difference between the post-test mean scores adjusted according to the SEMAT pre-test scores among the groups in the

HSELS ($F(1, 49) = 8.421$, $\eta_p^2 = 0.147$, $p = 0.006$, $p < 0.05$). According to the partial eta-squared value, the use of different applications between the groups has a high-level impact on the SEMAT post-test scores and explains 14.7% of the variance.

As shown in **Table 4**, there is a difference of 3.552 points between the permanence test scores of the experimental and control groups in the LSELS as adjusted for the SEMAT pre-test scores. On the other hand, according to the ANCOVA results, the difference between the scores of the students in the experimental and control groups is not statistically significant, $F(1, 27) = 2.822$, $\eta_p^2 = 0.095$, $p = 0.105$, $p > 0.05$. According to the partial eta-squared, the use of different applications between the groups has a moderate effect on SEMAT permanence scores and explains 9.5% of the variance.

Similarly, there is a difference of 3.139 points between the permanence test scores of the experimental and control groups in the HSELS adjusted for the SEMAT pre-test scores. As seen in **Table 4**, according to the ANCOVA results, there is a statistically significant difference between the adjusted SEMAT permanence test mean scores of the students in the experimental and control groups ($F(1, 49) = 6.238$, $\eta_p^2 =0.113$, $p = 0.016$, $p < 0.05$). The use of different applications between the groups has a moderate effect on the SEMAT permanence test scores and explains 11.3% of the variance.

Findings on CCRT-FX

According to CCRT-FX, the pre-test mean score of the experimental group students in the LSELS ($X = 25.857$) was lower than that of the control group students ($X = 30.563$). In the LSELS, there was a statistically significant difference between the experimental and control groups according to the pre-test of CCRT-FX, $t(28) = 2.302$, $p = 0.029$, $p < 0.05$. In the HSELS, unlike the LSELS, the pre-test mean scores of the students in the experimental ($X = 33.292$) and control groups ($X = 33.679$) were close to each other. Additionally, there was no statistically significant difference between the groups according to the pretest application of CCRT-FX, $t(50) = 0.136$, $p = 0.892$, $p > 0.05$. In the LSELS, it was decided to analyze covariance due to the presence of a significant difference between the CCRT-FX pretest scores of the experimental and control groups in the LSELS and the idea that some prior knowledge may affect critical-analytic thinking. Therefore, both the CCRT-FX pre-test and SEMAT pre-test were assigned as covariates in both schools. Below are some statistical data and ANCOVA results for CCRT-FX.

As shown in **Table 5**, the pre-test mean score of the LSELS experimental group students was 4.706 points lower than the control group. However, there was a difference of 3.336 points in favor of the experimental

Table 5. The SEMAT Pre-test, CCRT-FX Pre-test, Post-test, Adjusted Mean and ANCOVA Results of the Experimental and Control Groups in the LSELS and HSELS.

School	Group	N	Tests	Mean Achievement Score X	SD	Adj. X	F	p	η_p^2
LSELS	*Exp.*	14	SEMAT Pre-test	4.643	0.589	-	1.812	0.190	0.065
			Pre-test	25.857	4.881	-			
			Post-test	29.714	6.753	33.762			
	Cont.	16	SEMAT Pre-test	7.000	0.516	-			
			Pre-test	30.563	6.132	-			
			Post-test	33.625	8.196	30.426			
HSELS	*Exp.*	24	SEMAT Pre-test	7.542	2.963	-	0.622	0.434	0.013
			Pre-test	33.292	7.827	-			
			Post-test	38.583	4.442	38.620			
	Cont.	28	SEMAT Pre-test	10.321	3.570	-			
			Pre-test	33.679	11.882	-			
			Post-test	37.536	6.071	37.505			

group between the post-test mean scores adjusted after the application. According to the ANCOVA results, there was no statistically significant difference between the mean CCRT-FX post-test scores of the students in the LSELS experimental and control groups adjusted according to the SEMAT pre-test and CCRT-FX pre-test scores, $F(1, 26) = 1.812$, $\eta_p^2 = 0.065$, $p = 0.190$, $p > 0.05$. The use of different applications between the groups explains 6.5% of the variance in CCRT-FX post-test scores, which shows a moderate effect.

There is a difference of 0.39 points between the CCRT-FX Pre-test Scores of the HSELS experimental and control group students in favor of the control group. In the CCRT-FX post-test, according to the adjusted mean scores, there was a difference of 1.11 points between the groups in favor of the experimental group. This difference is not statistically significant, $F(1, 48) = 0.622$, $\eta_p^2 = 0.013$, $p = 0.434$, $p > 0.05$. **Table 5** shows that the use of different applications between the groups had a low-level impact on the CCRT-FX post-test scores and explained 1.3% of the variance.

Discussion

In the study, one of the variables focused on in the FCM applications in schools with low and high socio-economic status was academic achievement. Coincidentally, the group with low levels of academic achievement was the experimental group in both schools. The SEMAT pre-test score difference between the groups before the application was significant in favor of the control group in both schools. After the application, there was a significant difference between the experimental and control groups according to the SEMAT post-test and permanence tests in the HSELS (Tables 3 and 4). This finding is in line with numerous studies (Alamri, 2019; Ali et al. 2021; Bergmann & Sams, 2012; Çakır & Yaman, 2018; Davies et al. 2013; Ghanaat & Habibzadeh, 2021; Kansızoğlu & Cömert, 2021; MacKinnon, 2015; Ok, 2019; Pierce & Fox, 2012; Yıldız et al. 2016; Zhao et al. 2021).

In the LSELS, the experimental group scored higher in SEMAT, but this difference was not statistically significant (**Tables 3 and 4**). While there is a limited number of studies (Yeoman, 2018) reporting that FCM applications are unsuccessful compared to traditional teaching methods, there are also studies in the literature stating that the effect of the FCM on academic achievement is not significant (Al-Abdullatif, 2020; Cabı, 2018; Smallhorn, 2017; Yavuz & Karaman, 2021). According to the findings of the experimental group in the LSELS, there was an increase of 223.27% in the SEMAT post-test compared to the pre-test and an increase of 10.36 points in the mean score. According to the adjusted post-test mean scores, the difference between the experimental and control groups was 3.53. In the HSELS, there was a difference of 11.09 points and an increase of 147.08% between the pre-test and post-test mean scores of the students in the experimental group (**Table 3**). The difference between the post-test scores of the experimental and control groups according to the adjusted mean in the HSELS was 3.66 points. Similarly, the difference between the adjusted SEMAT permanence test scores of the experimental and control groups in the HSELS was 3.14, while this difference was 3.55 in the LSELS (**Table 4**). Although the score differences in both schools were very similar, there was a significant difference at a level of $p = 0.006$ in the HSELS and no difference in the LSELS according to the post-tests (**Table 3**). This can be explained by the sample size. Since the sample of the LSELS is approximately half the size of the sample of the HSELS, a significant difference could not be found here due to Type 1 error (Cohen, 1988). Based on this, it can be said that conducting lessons based on the FCM in both schools greatly impacts students' SEMAT post-test and permanence test scores and that this practice is highly effective in learning.

When the variable of socio-economic level was examined from the perspective of learning, many studies revealing the presence of a significant relationship between socio-economic level and academic achievement outside of the context of the FCM were found (Ahmar & Anwar, 2013;

Aslanargun et al. 2016; Azhar et al. 2014; Çömlekcioğulları, 2020; Lacour & Tissington, 2011; Sarıer, 2016; Yelgün & Karaman, 2015). However, no studies were found in the literature that investigated the impact of the FCM on schools with different socio-economic levels. With the exception of the study conducted by Yeoman (2018), most of the studies were conducted in schools with middle and upper socio-economic levels. Yeoman (2018) stated that although there was no statistically significant difference between the groups, the data favored the traditional classroom group rather than the FCM group. This study completely differs from the SEMAT findings in the LSELS. In the present study, one of the reasons why the FCM was successful among the LSELS students as much as the HSELS students despite many disadvantages may be the interest of the students. In fact, Arastaman (2009) found that children from families with high socio-economic status had a lower sense of commitment to school compared to children from families with low socio-economic status. In addition, the author stated that schools cannot be an interesting environment for these children who have much greater opportunities in their own homes. This study is supportive of our view.

According to Çiftçi & Çağlar (2014), the socio-economic level of the family affects the child's access to resources, tools, and equipment. In the present study, it was found that while the families in the HSELS are able to provide their children with a wide range of opportunities outside of school through private tutoring and special courses as well as hardware support such as Internet access, computers and resource books, the families in the LSELS may be unable to do so. However, Bergmann & Sams (2012) stated that teachers can overcome this situation by using their creativity when educational materials are not accessible to poor families. In this direction, the present study was able to minimize economic inequality by opting to use mobile phones, which are accessible to almost everyone, and students in low-income families were also able to access these educational materials. At the same time, due to the pandemic process, non-governmental organizations and the MoNE have carried out a significant amount of work on the acquisition of tablets and computers by disadvantaged children in remote education. It can be stated that this situation is also beneficial in FCM applications.

Another variable focused on in the applications of the FCM in schools with different socio-economic levels is critical-analytical thinking. Unlike the HSELS, there was a statistical difference between the CCRT-FX pre-test scores of the LSELS students in favor of the control group. The group with low academic success in the LSELS also had low CCRT-FX pre-test scores. However, there is no significant difference between the groups in the HSELS. This finding is in line with Bozkurt (2022) who found that students from families with low socio-economic status were had less success analyzing case-based science scenarios based on analytical thinking compared to those with middle and high socio-economic status.

According to the CCRT-FX post-test, it can be stated that results in favor of the experimental group were obtained although no significant difference was found between the experimental and control groups regarding the critical-analytic thinking skills of the students in both secondary schools based on the FCM. There are numerous studies in the literature reporting that the FCM has positive effects on the critical-analytic thinking skills of students (Andrini et al., 2019; Asmara et al., 2018; Baranovic 2013; Etemadfar et al, 2020; Kong, 2014; Nugraheni, Surjono & Aji, 2022; DeRuisseau, 2016; Sulisworo et al., 2019; Styers et al., 2018; Putri et al., 2021). However, in line with the present study, certain studies revealed that the model did not have a statistically significant effect on critical-analytic thinking (Fulgueras & Bautısta, 2020; Hantla, 2014; Saunders, 2014). The lack of a significant difference in the findings of the study may be attributed to the fact that the duration of the study was limited to seven weeks and longer-term applications are needed to significantly develop higher-order thinking skills such as critical-analytic thinking.

In the literature, no studies were found examining the effect of the FCM on the critical-analytic thinking levels of students from different socio-economic levels. Based on both the effect value and the difference between the adjusted mean scores according to the CCRT-FX post-test in both schools, it can be said that the FCM was more effective in terms of critical-analytic thinking in the LSELS (**Table 5**). Çakır (2016) found that parents in families with high socio-economic status asked more open-ended questions and talked to their children much more frequently compared to parents in families with low socio-economic status, thereby, children from families with high socio-economic status are introduced to high-level thinking by their parents before school. Keskin & Sezgin (2009) found that children from families with high socio-economic status had higher self-esteem and self-confidence. Based on these studies, the difference between the two schools suggests that the additional opportunities and family education provided to the children of families with high socio-economic status reduce the effect of the FCM on higher-order thinking. On the other hand, children from families with low socio-economic status may have been more disadvantaged both economically and in terms of parental education, and the effect of the FCM may have been greater. The fact that the FCM provides a flexible learning environment may have encouraged the LSELS students to participate more in the lessons (Aslan, 2020; Mazur et al., 2015; Ök, 2019; Rudow & Sounny-Slitine, 2015).

Conclusion

In the present study examining the effect of FCM-based teaching on students' success, it was concluded that the model had a moderate or high effect on the achievement and permanence levels of students from families with different socio-economic backgrounds. It is known that Turkey ranks first among OECD countries in terms of the relationship between socio-economic background and success (OECD, 2021). In families with high socio-economic status, there are high levels of parental education as children receive more support from their parents with private lessons or private courses during extracurricular time thanks to their financial opportunities. According to the results obtained, it can be said that although the FCM cannot equalize these students in socio-economic terms, it helps to eliminate this disadvantage in learning environments.

It was found that the FCM had a positive effect on students' critical-analytic thinking skills in both schools, but this effect was not statistically significant in either school. Based on the adjusted mean scores and the effect size of the model established in the present study, it was concluded that the FCM was more effective in the critical-analytic thinking skills of the students in the LSELS. The fact that the students in the LSELS were more successful despite having limited access to books and other resources as well as limited parental support to improve their critical-analytic thinking levels throughout their entire academic life shows that the model can also be implemented in such schools.

Statement of Responsibility

The authors contributed equally to the design and implementation of the research, to the analysis of the results, and to the writing of the manuscript. Therefore, each author is equally responsible.

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