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Research Article

Mastery learning approach supported by flipped classroom: Does it affect academic achievement and self-regulation skills?

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This study examined the impact of flipped classroom (FC) within the framework of mastery learning approache (MLA) on academic achievement, application time, and students' self-regulation skills. To this aim, a quasi-experimental pre- and post-test design was adopted. In the experimental group, MLA was supported by FC model, whereas only the MLA was applied in the control group. In order to collect data on academic achievement and self-regulation skills, an *academic achievement test for measuring perimeter and area* and a *self-regulating learning strategies scale* were used. Data were collected for 51 4th-grade students, and a t-test was used to analyze the gathered data. Consequently, the MLA supported by the FC model significantly improved the academic achievement of the experimental control group. In addition, students' self-regulation skills were not affected by the approach. Experimental group applications were conducted in a timeframe set by the Turkish Ministry of Education, while control group applications were delayed.

Keywords: Flipped classroom, mastery learning approach, 4th grade 'measuring learning area

1. Introduction

Since the instructional process is limited to classroom applications, a variety of activities is impractical. Due to the limited number of instructional techniques used during the teaching and learning process, students are unable to grasp topics in depth and organize them in their minds (Hodges, 2015). In order to support students who are slower learners, it is important to provide opportunities for learning with different instructional techniques and practices. Technology can facilitate the use of instructional methods and techniques so that learning and instruction can continue outside of the classroom. Due to the ease with which technology facilitates access to information, coupled with its continued proliferation, educational software and educational videos have become available on the Internet for students, paving the way for more active learning (Phillips & Trainor, 2014). Bergmann and Sams (2012), two American middle school teachers, recognized that technology could be used for the purpose of teaching and learning, and developed the FC to save both students and teachers time during the classroom experience.

2. Literature Review

2.1. FC Model

The FC model allows students to learn the theoretical aspects of a topic outside of the classroom through the use of instructional tools such as movies, videos, audio files, articles, and books, which is completely opposite to the traditional classroom model (Bergman & Sams, 2012). As a result, students are exposed to each subject multiple times, resulting in high-level cognitive activities and theoretical learning before entering the classroom. The greatest benefit of this model, according to Williams (2013), is that it provides a solution to one of today's most pressing problems. Students are expected to demonstrate high levels of thinking skills in completing their homework and in

analyzing, synthesising, and evaluating their work. Students who learn at a knowledge and understanding level under the guidance of a competent teacher are expected to exhibit higher levels of cognition. As a result, many students fall below their desired level of learning when they have to complete homework on their own. Due to the fact that students have access to knowledge and comprehension level information outside of the classroom through the content prepared by the teacher in a FC, they are subject to learning processes that include teacher-guided hands-on activities, addressing higher cognitive levels, and comprehensive outcomes. As we can see from the applications of this model, different techniques are used to deliver course content, such as preparing videos for students to view and facilitating teacher-led activities in classrooms without a single method of teaching (Tucker, 2012). Furthermore, teachers can share content prepared by them and/or existing content with students via compact disks, flash disks, whiteboards, and/or online platforms such as YouTube, Facebook, Edmodo, etc.

It is generally accepted that teachers who are unable to carry out planned activities, especially due to lack of time, can provide an effective learning environment by using a FC (Bergman & Sams, 2012). It has been suggested that using this model in conjunction with the MLA may result in effective outcomes, since it offers benefits to both teachers and students, including the ability to conduct more hands-on activities in the classroom and better prepare students mentally for instruction. In addition, this idea is based on the premise that while implementing the MLA takes a lot of time (Akata, 2012), which is a significant limitation, using a FC provides teachers and students with more classroom time. The MLA model can provide up to 10 minutes more instruction time than the FC model (Öztürk & Kalyoncu, 2018).

2.2. The MLA

Before moving on to a new unit in MLA, it is necessary to provide students with preliminary information to prepare them cognitively. Following the provision of preliminary information, subject teaching and other appropriate activities can be conducted. Students are then assessed during and after the lesson using tests. Moreover, if students fail to achieve a specified level of success, additional instruction may be conducted (Bloom, 1979). *Due to the lack of information in the MLA, in the theoretical teaching of the subject, and/or in additional phases of teaching, video preparation in a FC was expected to make the MLA applicable to the classroom in a shorter period of time.* Additionally, it was assumed that students would be more prepared within the classroom because they were learning at their own pace at home, thus having more opportunities to apply high-level cognitive activities. By using the MLA in this way, it is believed that learning achievement will improve. By integrating the MLA with the FC model, in which technology is actively used in mathematics instruction, problems related to the time available for its implementation have been solved at least during the study.

According to Bloom (1979), if achievement scores at each grade level are correlated positively, the MLA can have a significant impact on the education of students for the next level, which is particularly important when applied to primary school students. As a result, a FC can increase its applicability by eliminating problems related to time availability, which are considered a significant limitation of the MLA.

2.3. Self-Regulated Learning

Student self-regulation refers to their ability to determine their own goals regarding the learning process and to arrange their behavior, cognition, and motives in accordance with them (Pintrich, 2000), which is similar to learning to learn (Zimmerman & Schunk, 2001).

A FC allows students to decide how many times they will watch a video, what strategies they will use to learn, and to what extent they will learn the information presented. *According to this method, students' self-regulation skills will be positively affected as their responsibility for learning increases (Ingram et al., 2014).* Students' self-regulation involves choosing their learning goals and arranging their behavior, cognition, and motives accordingly (Pintrich, 2000), which is what Zimmerman and Schunk (2001) calls learning to learn. Self-regulation has also been shown to be positively

associated with academic achievement in the literature proposing its inclusion in student learning (e.g Fadlelmula et al., 2015; Mousoulides & Philippou, 2005; Velayutham & Aldridge, 2013; Zimmerman, 2002).

3. Purpose of the Research

This study aimed to examine whether the MLA supported by the FC model affects 4th-grade students' mathematics achievement as well as their self-regulation skills by considering the time of learning compared to those in the classical teaching approach.

4. Method

4.1. Research Model

In this study, MLA-supported FC and classical application of MLA were measured as independent variables in a 2x2 pre and post-test design. The dependent variables of the research were students' mathematics achievement, their self-regulation skills, and the application time of the MLA.

In this study, the MLA supported by a FC approach was used in the experimental group determined by unbiased assignment among two groups, and the classical MLA model was used in the control group. In addition, an unbiased assignment was used to determine the experimental group. The experimentation process was conducted while teaching the subjects *measuring perimeter and area* as part of the *measurement* learning area.

Data from both the experimental and control groups were collected through an *academic achievement test for measuring perimeter and area* and a *self-regulating learning strategies scale* before and after the intervention.

Table 1
Pre-test and post-test control group experimental design of 2x2

Groups	*Pre-Tests*		*Operation*	*Post-Tests*	
Experimental	$ABT_{1.1}$	$ÖÖSÖ_{1.1}$	X_1	$ABT_{1.2}$	$ÖÖSÖ_{1.2}$
Control	$ABT_{2.1}$	$ÖÖSÖ_{2.1}$	X_2	$ABT_{2.2}$	$ÖÖSÖ_{2.2}$

4.2. Participants

An appropriate sampling method was chosen based on the ease of accessibility of the study group. Therefore, the experimental group consisted of 4th-grade students at a district primary school where one of the researchers was employed.

As a result of applying the pre-tests for measuring students' academic achievement in the mathematics course to the study group participants, two equal groups were ultimately included. Then, a matching method was used to determine which group was the experimental group and which was the control group. As a result, 51 students, 26 in the experimental group and 25 in the control group, were enrolled in the current study.

4.3. Data Collection

Academic achievement test for measuring perimeter and area developed by the researcher and the adapted version of the *self-regulating learning strategies scale* were both used to measure the students' mathematics achievement and self-regulation skills as dependent variables.

During the adaptation process of the scale into Turkish, a validity study was conducted with 1114 students. Following the application, the confirmatory factor analysis removed a total of 11 items from the finalized scale. The students were given a 5-point Likert scale with 44 items. Following the consultation of experts, it was determined that the scale developed for 5th-grade students could also be applied to 4th-grade students.

To measure students' mathematics achievement, the researcher developed a 20-question multiple-choice test to measure the *academic achievement test for measuring perimeter and area.* An item pool consisting of 24 questions was presented to experts during the preparation phase of the assessment. The assessment was applied to 10 fifth-grade students after the necessary amendments

were made according to their suggestions. Upon receiving feedback from students, the questions were revised. The validity and reliability of the prepared academic achievement test were tested with 100 students in the 5th grade at a district primary school.

Following the validity study, four items with item distinctiveness below 0.19 were excluded from the test. It was calculated that the KR-20 value (Kuder-Richardson) was 0.70 for the test. To measure the *academic achievement test for measuring perimeter and area,* we used an academic achievement test comprised of 20 questions selected from a pool of 24 questions.

4.4. Characteristics of Teachers' Participating in the Intervention

The equivalence of the experience of the teachers who actively participated in the application part of this study was considered as a criterion for selection. Therefore, it was assumed that these teachers had equal experience for participating in the present study based on their backgrounds. One male and one female teacher in their fourth year of teaching were enrolled in the study, and their participation was voluntary. Both teachers implemented the prepared lesson plans simultaneously.

4.5. Implementation

4.5.1. Pilot study

A pilot study was conducted to ensure that all technological infrastructure requirements were met and that MLA supported by the FC model, an independent variable, was applicable. Additionally, the pilot study addressed any issues that may have arisen in implementing this approach, as well as the opportunity to address any concerns before conducting the main study.

A total of 22 4th-grade students from an elementary school in the Seljuk district of Izmir, Türkiye participated in the pilot study. Additionally, the course was limited to perimeter measurement as part of a mathematics course. The "Edmodo" website was used to share the prepared videos with the FC model students since it was more suitable for their level.

Students in the experimental group were explained how to use the Edmodo website before receiving the virtual classroom code. The researcher also provided a video to the parents' "WhatsApp" group explaining how to use the website and how to perform the activities, "so that parents were involved in the process. The researcher also sent the students a test along with the videos. This test was used to check the students' understanding of the topic through the mobile program. Students were sent the videos and test three days before class on "measuring perimeter" so they could watch the videos and answer the questions.

To plan the instructional process appropriately, the assessment questions were used to determine the students' academic achievement level. Thus, the influence of the application was evaluated as a result of the differences found among achievement test scores before (Mean (M) = 46) and following the intervention (Mean (M) = 77). Finally, t-test results were considered and it was examined whether the FC Model increased students' achievement levels.

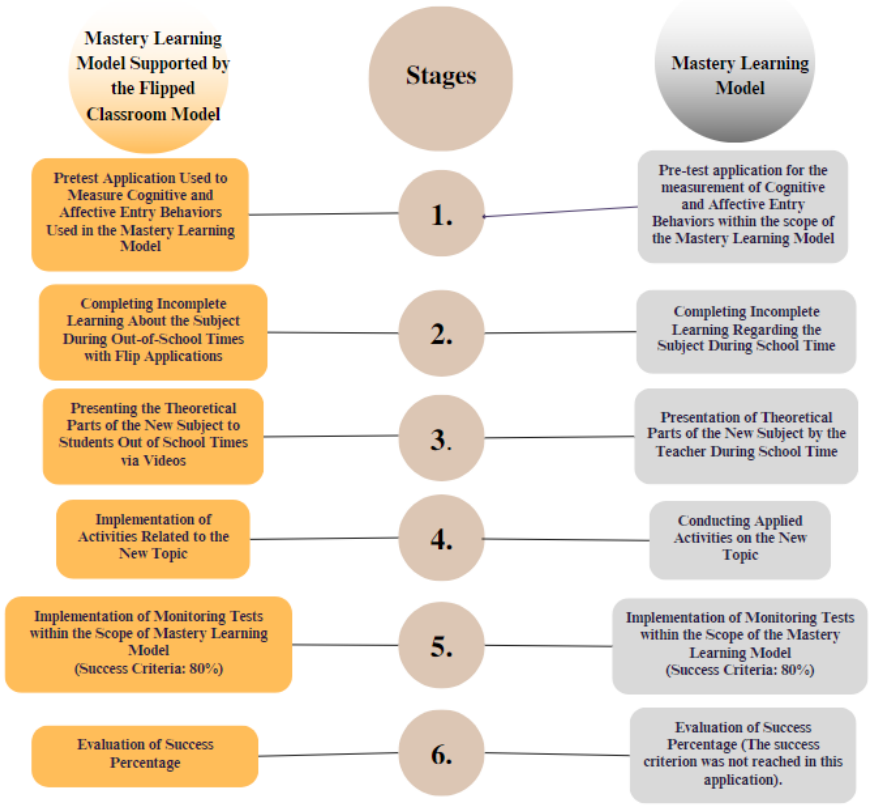
4.5.2. Intervention in the experimental group

In the beginning, six videos were prepared by the researcher that incorporated the MLA and supported by a FC, each lasting eight, nine, 10, 11, 12, and 14 minutes. Two videos provide students with the preparation information they need to understand the topics. In addition, two videos were prepared for the purpose of improving knowledge and understanding. The last two videos were created as additional educational opportunities for students who did not meet the success criteria in the MLA model post-tests. Supplemental instructional videos were designed to provide missing information to students, particularly those who did not achieve the desired level of success, and primarily addressed theoretical aspects of the topic. In order to guide students through the learning process, animated characters were used in the videos. Students were thoroughly introduced to the Edmodo platform prior to the actual application stage. Following the creation of the virtual classroom, the code was shared with students. After that, students were informed how the application process would work. Afterward, the teacher asked students to view

two videos uploaded to the virtual classroom on the previous weekend and to answer questions related to the videos.

To assess the students' preliminary knowledge about perimeter as well as their affective status, the students took a cognitive entrance test (cognitive entry test and affective entry scale). Later, the video prepared for providing missing information and learning was shared with the students. Following the correction of the missing information, the teacher instructed the experimental group on the theoretical knowledge they had gained from watching the videos on the Edmodo platform. On the topic of measuring perimeter, the first video provided to students was used to observe their cognitive input behaviors. The second video was used to determine students' theoretical knowledge regarding the same topic (see Figure 1). Following the arrangement of the videos, two participating students watched the virtual classroom videos on the teacher's tablet during out-of-school hours on the weekend. A video prepared by the researchers was then shared with students to complete any missing parts of the learning process. Following the provision of any missing information, students were provided with short evaluation questions accompanied by animation-based videos that explained theoretical concepts of the subjects.

Figure 1
Frame of the implementation



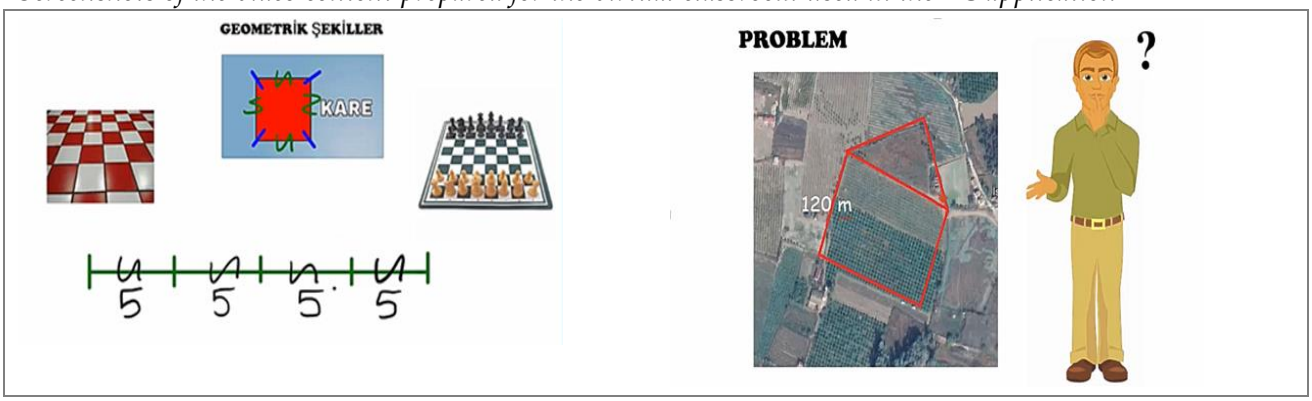
After that, the teacher briefed the students on only the content information, since they had already been informed about the subject information by watching the videos. Following the teacher's answers to students' questions regarding the videos they had watched prior to class, he moved on to the prepared classroom activities in which the students participated actively and used concrete materials. In this process, close attention was paid to the implementation of the active participation portions of the activities, along with the feedback, correction, and reinforcement steps, and the principles of the MLA. The students also completed follow-up tests throughout the application process, which benefited them in showing the students' learning progress. In addition, 80% of the class had to obtain at least 70 points during both the implementation and completion of the monitoring tests.

Lesson plans were applied by students in pairs under the guidance of the teacher. The teachers were also regularly consulted during the implementation of the lesson plans. Teachers were also interviewed frequently to ensure that the implementation process worked in parallel with the lesson plans. Researchers followed the teaching process closely and recorded the lesson plan application steps in the classrooms with a video camera. Following the evaluation tests at the end of the subject instruction, the next topic -measuring area - was introduced. If students failed to meet the success criteria threshold, a third video with simplified content was shared with them.

As all participants achieved the required success criterion in the assessment at the end of the subject instruction, no additional teaching applications were required. To teach measuring area materials, the same stages followed for measuring perimeter were adapted. Based on the results of the experimental group, 11 lesson hours were required for students to learn the subjects at the desired level. Figure 2 shows the MLA application supported by a FC applied in the experimental group.

Figure 2

Screenshots of the video content prepared for the virtual classroom used in the FC application



Note. Translation of the text - Geometrik şekiller: Geometric shapes; Kare: Square.

During the course process, any missing information was corrected with students in the control group based on their prior knowledge. Due to teachers and students spending more time on the information, there was not enough time left during classroom instruction to practice the subject material in these cases. Although theoretical teaching in the experimental group was conducted via Edmodo, sufficient time remained during classroom hours to practice activities.

Consequently, when the model was examined regarding the stage of watching videos prepared for each unit, in the MLA supported by the FC, it was determined that the students were able to be prepared for the lesson by watching the two videos provided to them prior to attending the classroom instruction. In these two videos, the first video introduced cognitive behaviors to the students, while the second video provided theoretical information.

In the other stage of the model, when the FC supported the entire learning process, the videos prepared for the students who were unable to meet the success criteria were not viewed. These videos were not necessary for students in the experimental group since they had already achieved the predetermined level of success.

4.5.3. Study performed in the control group

In the control group, where the FC application did not support the MLA, the prepared teaching plan was similar to that used in the experimental group. Only the videos used to observe the effect of FC application on the MLA differed between the two.

Unlike the experimental group, the control group only completed any incomplete learning of the cognitive input behaviors during classroom lessons. As part of an ongoing process, the theoretical teaching of the subject, as well as any additional instruction prepared for students in the control group who did not reach the desired success criterion according to the evaluations made after the course, were also applied during instruction time within the classroom.

4.5.4. Interviews with the teacher and students

Participants were interviewed both before and during the application process. Interviews were conducted to identify any deficiencies in the implementation process, correct any identified deficiencies, and follow up on the process in general.

During the interview with the teacher who implemented the lesson plans, it was stated that the FC Model provided students with any missing information they needed and increased their motivation through the animation-based content to complete the lesson. This situation also contributed to students' active participation in the lesson, according to the teacher interviewed.

Furthermore, in their interviews, students stated that the theoretical learning activities used through the virtual classroom to provide any missing information and the subject material supported by animations were both interesting and different from their usual approaches. Further, it was noted that the time they spent in class was more enjoyable and productive because they had already learned about the subject outside of class. As part of the Edmodo virtual classroom software, students said they did not have any difficulty watching videos or answering evaluation questions.

4.6. Data Analysis

The data analysis stage of this study began with an analysis of the scales and achievement tests applied to experimental and control groups before and after the application process.

According to the normality analysis, the data distribution in the applied tests was normal, so it was considered as part of the next analysis. In this study, ANCOVA, a powerful tool for controlling pre-test effects, was not used due to the absence of convenient homogeneity conditions for the variances. Academic achievement tests and self-regulation skills scores were compared using a t-test for independent groups before the application process.

To compare the repetitive tests conducted with the dependent group prior to and after the application process, a t-test was performed on the results of the academic achievement test. An independent group t-test was used to compare the post-test results of the experimental and control groups following the application process. Next, as part of the analysis, the total scale scores of students' self-regulation skills before and after the application process were calculated. Following the completion of the application, a t-test of the independent groups was conducted to compare the scale scores of the experimental and control groups. As a final step, the repetitive scale scores of the dependent groups were analyzed using their t-test scores.

5. Findings

As part of the current study, the scores from the experimental and control groups were compared to examine how the FC model impacts the academic achievement of fourth-grade mathematics students by taking into account the time of learning and their self-regulation skills. Based on the sub-problems, academic achievement, and self-regulation skills as dependent variables were compared.

5.1. Impact of the MLA supported by a FC and classic MLA

The effect of the MLA supported FC on students' mathematics achievement was investigated in a classroom of 26 students chosen as an experimental group. It was shown in the analysis results that a significant difference was observed between the average of the pre-application exam scores ($Mean_{pre}$ = 48.65) and the post-application exam scores ($Mean_{post}$ = 75.88) [$t(25) = -9.75$, $p < .01$]). These findings were in regard to the comparison of Academic Achievement Test scores of the 'control group' to whom only the MLA was supported and the academic achievement test scores in the experimental group to whom the MLA was supported by the FC. The results ultimately showed a significant difference in the average pre-application exam scores.

As a result, the effect size calculated in the analysis (d = 1.91) showed that this difference is considerably high (Hinkle et al., 2003). This situation confirmed that the MLA application supported by a FC had a dramatic effect on the mathematics achievement of the experimental

group. In Table 2, the analysis results regarding the achievement scores from the pre- and post-test scores for the experimental group are provided.

Table 2
The analysis results of the academic achievement test for dependent groups applied to the experimental group

Measurements	*n*	*Mean*	*SD*	*df*	*t*	*p*
Pre-test	26	48.65	14.73	25	−9.75	0.00
Post-test	26	76.15	11.94			

5.1.1. Comparison of the 'academic achievement test for measuring environment and area' scores of the control group which used the classical MLA

In the application of the MLA within mathematics lessons, it was examined if there was a difference in 4th-grade students learning of the subject of *measuring perimeter and area*. For this purpose, an academic assessment was given to students in a 25-person classroom both prior to and following the application. Next, the assessment results were analysed, and a *t*-test was used on the related samples to understand if there was any difference between the prior or latter assessment.

The results revealed a significant difference between the average assessment scores before ($Mean_{pre}$ = 50.40) and after the application ($Mean_{post}$ = 58.00) [$t(24) = -2.46$, $p < .05$]. Test scores showed a moderate difference (d = 0.49) based on the calculated effect size (Hinkle et al., 2003). The results indicated that 'the MLA' applied in the control group did have a moderate impact on mathematics achievement. Table 3 presents the results of the comparative analysis of the achievement scores from the pre- and post-tests applied to the control group.

Table 3
Dependent samples t-test results in terms of academic achievement scores of the control group students

Measurements	*n*	*Mean*	*SD*	*df*	*t*	*p*
Pre-test	25	50.40	16.19	24	−2.46	0.02
Post-test	25	58.00	20.81			

5.1.2. Comparison of the academic success scores of the experimental and control groups for measuring perimeter and area

An examination of the impact of MLA supported by a FC model versus the classical application of MLA was also conducted in the aforementioned classroom. An independent samples t-test was applied to test scores from both experimental and control groups to determine which teaching model was most effective. Additionally, an independent samples t-test was also applied to reveal the effectiveness of the models implemented in both groups. There was a significant difference observed between the average test scores of students who had participated in the MLA application supported by a FC (Mean = 76.15) as well as those exposed to the classical application of the MLA (Mean = 58.00).

The calculated effect size of the test (d = 1.09) showed that this difference was considerably high (Hinkle, Wiersman, & Jurs, 2003). As compared to the classical application of the MLA, the MLA supported by a FC had a significant positive effect on mathematics achievement. In Table 4, achievement scores of experimental and control groups are compared.

Table 4
The results of the academic achievement test scores of the experimental and control groups after instruction

Groups	*n*	*Mean*	*SD*	*df*	*t*	*p*
Experimental	26	76.15	11.94	49	3.83	0.00
Control	25	58.00	20.81			

5.2. The Effect of Teaching with the MLA Supported by a FC on Students' Self-regulation Skills

The second aim of the study was to examine whether the intervention affected students' self-regulation skills. It was also evaluated how the classical application of the MLA affected these skills. To achieve this, we compared the scores separately for the experimental and control groups as well as between them. The results revealed that there was no statistically significant difference between the experimental and control groups' self-regulation skill scores. Students from the experimental and control groups scored similarly on self-regulation skills.

5.2.1. Comparison of the self-regulation skill scores of the experimental group applied the MLA supported by a FC

A dependent samples t-test was applied to determine whether there were differences between mean scores from the pre- and post-tests when examining the effect of the MLA application on students' self-regulation skills. Analyses showed that there was no significant difference between mean scores obtained prior to application ($Mean_{pre}$ = 153.42), and those obtained after application ($Mean_{post}$ = 147.69) ($t(25) = 1.54$, $p > .05$).

Also, the results showed that the experimental group students exposed to the MLA supported by the FC had no difference in their self-regulation skills. The pre- and post-test analysis scale scores for the experimental group are provided in Table 5.

Table 5
Dependent sample t-test results according to self-regulation skills of the experimental group students

Measurements	*n*	*Mean*	*SD*	*df*	*t*	*p*
Pre-test	26	153.12	20.22	25	1.54	0.13
Post-test	26	147.69	28.40			

5.2.2. Comparison of the self-regulation skill scores of the control group applied the classical MLA

To determine whether there was a difference between the mean scores of the pre- and post-tests, a dependent samples t-test was used to examine the effect of MLA application on students' self-regulation skills. The analysis results showed that there was no significant difference between the pre- ($Mean_{pre}$ = 143.96) and pos-test mean scores ($Mean_{post}$ = 133.20) [$t(24) = -2.07$, $p > .05$]. Furthermore, students from the control group exposed to classical MLA application showed no improvement in self-regulation skills. Table 6 shows the analyzed values of the scale scores for the pre- and post-tests in the control group.

Table 6
Dependent sample t-test results according to self-regulation skills of the control group students

Measurements	*n*	*Mean*	*SD*	*df*	*t*	*p*
Pre-test	25	143.96	23.82	24	−2.07	0.49
Post-test	25	133.20	15.36			

5.2.3. Comparison of the self-regulation strategies scale scores for experimental versus control groups

One of the assumptions of this study was that applying the MLA supported by a FC during mathematics instruction may affect students' self-regulation skills. This hypothesis was grounded in the possibility that these approaches could help students become aware of their learning and control it.

The mean scores of the self-regulation strategies scale for the students in the control group (Mean = 133.20) were close to those in the experimental group (Mean = 147.69). The t-test results showed no statistically significant difference between the two groups [$t(49) = 1.970$, $p > .05$].

Based on these findings, the MLA application supported by the FC had no significant effect on students' self-regulation skills. In Table 7, the results of the post-test analysis of the self-regulation strategies scale scores for the experimental and control groups are presented.

Table 6
Comparison of the self-regulation strategies scale post-test for experimental and control groups

Groups	*n*	*Mean*	*SD*	*df*	*t*	*p*
Experimental	26	147.69	28.40	49	1.970	0.055
Control	25	133.20	23.82			

5.3. Findings Regarding the Duration of Instruction in the Experimental and Control Groups

One limitation of the MLA is the length of instruction time. Therefore, the hypothesis that MLA supported by FC could reduce learning time was tested in the experimental group. As a result, the test scores of the experimental group were compared to those of the control group.

In the experimental and control groups, the time to reach the desired success criterion in the MLA was determined. The researcher then taught another subject after achieving the desired success criterion. Finally, the teaching times of the experimental and control groups were compared.

The planned course duration for the teaching of -measuring perimeter and area- subject within the official curriculum is 11 hours (Ministry of National Education [MoNE], 2018). In order to verify the hypothesis, this detail was noted. Due to the use of a video-supported application plan, only the experimental group showed a difference. It was found that after the research, when the lesson hours of the experimental and control groups, where the same lesson plans were applied, were compared, that the experimental lesson plans could be completed successfully in 11 hours, while those in the control group could be completed successfully in 11 hours. The group took 17 hours.

On a subject-by-subject basis, the time it took in the experimental group to reach the desired success period was six lesson hours for -measuring perimeter-, and five lesson hours for -measuring area-, respectively. As per the classical teaching practice of MLA, -measuring perimeter- took nine hours and -measuring area- took eight hours. Moreover, it took six hours for the experimental group to reach the desired success in measuring perimeter, and five hours for measuring area. In classical MLA teaching, measuring perimeter took nine hours and measuring area took eight hours.

Using an MLA supported by a FC to achieve the targeted success criterion within the official program time revealed that there was less time spent in favor of the experimental group. The control group, which applied classical teaching to the MLA, also achieved the desired success criterion. However, the official specified program time for achieving the criterion goals was exceeded.

6. Discussion and Conclusion

Based on the results of the current study, both the MLA supported by a FC and the classical application of the MLA increased students' mathematics achievement in the topic of measuring perimeter and area. However, the academic achievement mean scores differed between experimental and control groups according to the effect sizes. In the experimental group, the effect size was quite large (d =1.91), whereas in the control group, only a moderate effect was observed (d =0.49). Following the application of the MLA supported by a FC, there was a significant positive difference between the experimental (M=76.15) and control groups (M58.00) ($p < .01$). The intervention in the experimental group had a high effect size (d = 1.09) on increasing students' academic achievement compared to classical MLA.

It has been demonstrated in several studies in the literature that the FC application improves academic achievement (Álvarez, 2012; Butt, 2014; Çevikbaş& Kaiser, 2020; Hwang et al., 2015; McGivney et al., 2013; Overmyer& Robert, 2014; Sergis et al., 2018; Staker& Horn, 2012; Strayer, 2007; Syam, 2014; Tomory& Watson, 2015; Wei et al., 2020; Zou, 2020). However, other studies have found that FC approaches do not significantly affect academic achievement (Aydın, 2016; Clark, 2015; Howell, 2013; Yavuz, 2016). It is also important to note that almost all studies arguing

that FCs have no statistically significant effect on student learning also explain why they may have positive effects. For instance, although these studies have found no statistically significant difference in favor of FC in terms of academic achievement (Aydın, 2016; Yavuz, 2016), they have noted that students in the FC group performed more compared to those in the traditional group.

One of the key reasons for success is that more time is available in the classroom for the teaching process. In the literature, it is stated that the FC model facilitates better classroom teaching and provides more opportunities for hands-on activities, thus offering a high potential for student development (Clark, 2015). Furthermore, Howell (2013) claims that using the FC model not only increases student responsibility, but also facilitates their learning. Even in those studies that conclude that the FC model is not a statistically successful approach, there is a common point that the use of this model may result positive outcomes in high school and tertiary education. It has also been suggested that this model can be useful for teaching subjects such as algebra, physics, and computer science. Moreover, the findings of these studies indicate that FC teaching does not have a statistically significant impact on student learning, which could be explained by the teaching of subjects that are not appropriate for FC, and as a result, students have difficulty learning theoretical material.

On the other hand, several studies in the literature have validated the effectiveness of the classic MLA for a variety of classroom applications. Generally, the results obtained in these studies compare the effects of using any model with an MLA in the experimental group with the results obtained with traditional education. There have been other studies exploring the effectiveness of the MLA in supporting collaborative learning (Özder, 2000) and underlining material (Arslan & Senemoğlu, 1998), among other research areas. It is also investigated how the application affects students' development. Additionally, the current study compared the achievement of students in a group where MLA is supported by a FC model with those in a group without such support. The results showed that FC combined with MLA showed no difference in academic achievement. Arslan and Senemoğlu (1998) suggest evaluating the cumulative effects of the MLA on students' academic achievement using multiple combinations of the MLA. FC, when used in conjunction with MLA, contributed to students' academic achievement in the present study. In another study, Kalia (2005) showed that combining MLA and Inquiry-Based Instructional Model was more effective for improving science achievement than using either model separately.

In terms of self-regulation skills, the results revealed that teaching through MLA supported by a FC in the experimental group did not have a significant effect on students ' self-regulation skills. As for classical MLA application in the control group, no effect was found on students' self-regulation skills. According to previous studies, the application of FC did not affect students' self-regulation skills significantly (Hwang et al., 2015; Sırakaya, 2015; Talan & Gülsecen, 2018), which supports the results of the current study. However, even though these results were not fully supported, it is stated that the application of FCs improves students' self-regulation skills.

As the application period extends, this result is expected to change. Providing students with training on how to organize their learning at their own pace can be an extremely important contribution to increasing the impact of this approach, in addition to the videos prepared for the FC model. A self-regulation information system for the FC was embedded with videos, for example, by Van Alten et al. (2020). In conclusion, the use of a FC promotes students' self-regulation skills and there is a significant relationship between watching videos and self-regulation skills. Additionally, Ceylaner (2016) and Gomez-Garcia et al. (2020) found that the FC significantly improves students' self-regulation skills.

Different from the existing studies in the literature, this study investigated the time difference between two different applications of the MLA, such as those supported by the FC model and those supported by the classical application. As part of this process, the MLA was applied out-of-school hours and in environments that included FC support. Through the video application process in the FC approach, students learned at their own pace through stages such as cognitive and affective preparation, theoretical understanding of the subject, and instructional support services for students who were unable to achieve the sufficient level of success criteria.

Based on the results of this study, the MLA supported by the FC was successfully applied to teaching the subject measuring perimeter and area in the 4th grade mathematics class within 11 lesson hours. As an important point, this time corresponded to the amount of time recommended for the 4th grade mathematics curriculum by the MoNE.

The control group, however, reached the desired success criterion only after 17 hours of instruction using the classical MLA approach. Therefore, when comparing the limitations of the two different approaches, it is possible that the long application time of the MLA is one of its main limitations. By eliminating the obstacles associated with classical teaching methods, the MLA supported by a FC reduces the application time. Finally, teachers and students found that the MLA supported by a FC resulted in more effective and easier teaching and learning.

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