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Research Article

The effect of the flipped classroom model on pre-service teachers' academic achievement, self-regulated learning skills, and classroom engagement

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This study aimed to examine the impact of the flipped classroom model applied in the information technologies courses on pre-service teachers' candidates' academic achievements, self-regulated learning skills, and classroom engagement. The research was conducted with a total of 96 pre-service teachersteacher candidates, 48 in the experimental group and 48 in the control group. After the seven-week implementation period, the data obtained were analyzed using descriptive and inferential statistical techniques. According to the analysis results, a significant difference was found in favor of the experimental group between the post test and delayed post- test scores of the experimental and control groups. This result indicates that the flipped classroom model positively affects academic achievement in the context of the information technology course. However, no significant effect of the model on self-regulated learning skills and classroom engagement has been observed. In this context, suggestions for the design and implementation of the flipped classroom model have been presented.

Keywords: Academic achievement; Classroom engagement; Flipped classroom model; Pre-service teachers; Self-regulated learning skills

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1. Introduction

In parallel with the changes in learner needs and characteristics in the digitalized world, alternative options have emerged for structuring educational environments. One of these options is the flipped classroom model [FCM] based on the constructivist learning approach and active learning theory (Shih et al., 2019). FCM is a popular pedagogical approach that emphasizes active learning for 21st-century learners (Xiu & Thompson, 2020). This approach has attracted attention in recent years because it offers a flexible structure in which students can apply active learning strategies by considering their differences, unlike the traditional teaching method [TTM] in which information is transferred by the teacher (Campillo Ferrer & Miralles Martínez, 2021; Morton, 2020).

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The literature reveals that research has been carried out at both K–12 and higher education levels, focusing on various variables—particularly academic achievement—and demonstrating the effectiveness of FCM (Busebaia & John, 2020; Onyema et al., 2021). However, it has been observed that different results regarding the model's effects are presented in the studies conducted, and more research is needed to address different disciplines and student groups (Akçayır & Akçayır, 2018; Ölmefors & Scheffel, 2023). At the same time, the limited number of experimental studies on the use of the model in teacher training programs, along with the restricted topics of IT courses in these studies, necessitates the presentation of more evidence in the literature (Duman, 2019; Turan, 2015). Therefore, the lack of evidence in these areas makes it difficult to clearly demonstrate the applicability and effectiveness of FCM in teacher training and IT courses.

FCM is based on active learning processes in which students work in online learning environments and perform individual and group activities in the classroom (Nerantzi, 2020). Due to these features, the model is compatible with self-regulated learning (Zou et al., 2020). In FCM, students' involvement in a different learning process compared to TTM by taking responsibility for learning can affect the development of self-regulated learning skills differently (Öztürk, 2018). In addition, it is stated that classroom engagement in FCM, which encourages students to interact in the classroom and allows them to perform more practices, may also differ from TTM (Busebaia & John, 2020). Especially in IT courses, due to its application-oriented structure, the transfer of theoretical knowledge in the classroom with traditional methods significantly limits the time that can be allocated to practical activities (Turan & Göktaş, 2015). Therefore, trying to present both theoretical and practical knowledge during class hours can make it difficult to plan the course. In FCM, the fact that theoretical explanations are moved outside the classroom for students' individual learning allows class time to be allocated to practical application and active learning activities. Therefore, FCM offers a pedagogically appropriate and functional approach for the IT course (Onyema et al., 2021). However, there are a limited number of applied studies in the literature that examine the effects of the model on both students' self-regulated learning skills (Campillo Ferrer & Miralles Martínez, 2021; Park & Kim, 2021) and their engagement (Meyliana et al., 2022; Subramaniam & Muniandy, 2019), and the effects of the model on these variables continue to be discussed. There are also debates in the literature to determine how much the model improves learner outcomes such as academic achievement and student performance compared to TTM (Goedhart et al., 2019; Latorre Cosculluela et al., 2021). Therefore, more studies are needed to provide more evidence to the literature (Meyliana et al., 2022; Subramaniam & Muniandy, 2019). In this context, it is considered helpful to compare students' academic achievement, self-regulated learning skills, and classroom engagement with TTM and to interpret the model's effectiveness.

Within the scope of the research, the topic of office software in the information technology course, which includes subjects such as office software, internet and web technologies, data security, and ethics, has been covered through Google's tools (Google Docs, Google Slides, and Google Sheets). Indeed, the study differs from other studies in terms of the student population, the course applied, the scope of the course, and the variables addressed. For this reason, it is thought that the results obtained within the scope of the research will provide an application suggestion for the use of the model in teacher education and IT courses and will make significant contributions to future studies. This study aimed to examine the effect of the FCM on pre-service teachers' academic achievement, self-regulated learning skills, and classroom engagement in teaching information technologies courses at higher education levels. In line with this purpose, answers to the following research questions were sought.

Pre-service teachers in the experimental group where FCM was applied and pre-service teachers in the control group where TTM was applied;

RQ 1) Is there a significant difference between their academic achievement?

RQ 2) Is there a significant difference between their self-regulated learning skills?

RQ 3) Is there a significant difference between their classroom engagement?

2. Background

2.1. Flipped Classroom Model

FCM is an approach in which lectures are taken outside of school through tools such as videos, and class time is allocated to various interactive activities (Bergmann & Sams, 2012). In this respect, it differs from the teacher-centered TTM in which lectures are delivered in the classroom. In FCM, student-centered content is presented before the lesson (video, textbooks, interactive tutorials, etc.), and students are individually prepared for the content and participate in the classroom learning process (Fang et al., 2021). In this way, students have a flexible learning experience where they have more control over their learning (Heron & Thompson, 2019). In FCM, students are provided with rich learning opportunities through individual or group activities to encourage higher-order learning (Morton, 2020). In these activities, teachers can monitor students' progress and provide feedback and guidance (Cho et al., 2021). In this direction, flipped classrooms not only rearrange the teaching sequence but also transform the roles of teachers and students. With this transformation, students are expected to act more autonomously in the learning process (Abeysekera & Dawson, 2015). This paradigm shift makes the need for effective learning strategies such as self-regulation even more evident.

2.2. Flipped Classroom and Self-regulated Learning

In FCM, students employ self-regulated learning skills in the pre-class phase as they individually prepare for the content with various educational materials. In the classroom phase, they use different self-regulated learning skills to fulfill individual activities (Shih et al., 2019). In this context, students' self-regulated learning skills are necessary not only for the pre-class phase of the model but also for the in-class phase (Van Alten et al., 2020).

FCM provides a flexible and appropriate learning environment to support student self-efficacy and self-regulated learning, enriched with active learning strategies used in the classroom (Lage et al., 2000). Indeed, in flipped classrooms, students take responsibility for their learning processes and progress at their own pace (Lai & Hwang, 2016). That makes students' self-regulated learning skills more important (Van Alten et al., 2020). Students' ability to self-manage time, resources, and strategies is essential for achieving learning goals (Lai & Hwang, 2016). However, very few students have self-regulated learning skills to help them learn (Butzler, 2016). Students who lack these skills may struggle to prepare adequately for class, leading to reduced participation in activities.

2.3. Classroom Engagement in Flipped Classrooms

Classroom engagement, which refers to students taking an active role in the activities in the learning process, has become a research topic that has been emphasized and attracted attention in recent years. It can be said that this interest in engagement stems from the vital link between it and students' learning, success, and academic progress (Çevikbaş, 2018). Indeed, it is argued that student engagement guides learning and predicts various desired academic and life outcomes (Bundick et al., 2014). In this context, class attendance is a variable examined and discussed in studies on different methods and techniques, recognizing that it has significant effects on success and learning in higher education (Busebaia & John, 2020). In contrast to TTM, FCM has a student-centered structure that encourages student engagement through lesson preparation activities in online learning environments and active learning activities in the classroom (Steen Utheim & Foldnes, 2018). For this reason, studies on FCM have focused on the model's effect on students' learning and classroom engagement (Huang et al., 2023).

3. Methods

3.1. Participants and Context

This research was conducted in an IT course with 96 pre-service teachers studying in the first grades of two different teaching departments of a state university in Turkey. In the IT course, there is not enough time left for applications and activities in the classroom if TTM is used since applications and demonstration techniques should be used in addition to theoretical lectures (Turan & Göktaş, 2015). Therefore, the research was conducted in the IT course, and FCM was used to overcome time constraints. In IT courses, department students were divided into two sections to use the laboratory effectively and efficiently. Group 1 was formed by selecting B sections of the departments, while Group 2 was formed by selecting A sections within the scope of the research. Demographic information of the research groups is presented in Table 1.

Table 1
Demographic information about the research groups

Group	*Average University Placement Score*	*Section*	*Male*	*Female*	*Total Number of Students*
		A			
Group 1	317.49	-EMT	8	15	23
		-GPC	5	20	25
		B			
Group 2	319.48	-EMT	8	14	22
		-GPC	6	20	26

Note. EMT: Elementary Mathematics Teaching ; GPC: Guidance and Psychological Counseling.

Analysis of Table 1 indicates that both groups consisted of an equal number of students, with comparable university placement scores, gender distributions, and departmental affiliations. Table 2 presents the results of the pre-tests administered to assess whether the groups were similar in terms of demographic characteristics, academic achievement, self-regulated learning skills, and classroom engagement.

Table 2
Independent samples t-test results for the pre-test scores of the research groups

Dependent Variable and groups	*N*	Mean	*SD*	*df*	*t*	*p*
Academic Achievement						
Group 1	48	60.42	15.22	94	−0.152	.880
Group 2	48	60.92	17.05			
Self-regulated Learning Skills						
Group 1	48	89.48	11.41	93,44	−0.260	.795
Group 2	48	90.06	10.56			
Classroom Engagement						
Group 1	48	58.10	10.12	94	0.748	.456
Group 2	48	56.68	8.34			

Examination of Table 2 revealed no significant differences between the groups in terms of academic achievement ($t(94) = -0.152$, $p = .880 > .05$), self-regulated learning skills ($t(93.44) = -0.260$, $p = .795 > .05$), and classroom engagement ($t(94) = 0.748$, $p = .456 > .05$). After determining that the groups were equivalent, Group 1 was designated the experimental group, and Group 2 was designated the control group.

3.2. Instruments

3.2.1. Academic achievement test

The researchers developed an achievement test to determine whether FCM affects academic achievement in IT courses. In the development phase of the test, eight objectives related to the subjects (Google Docs, Google Slides, and Google Sheets) to be included in the application process were determined. A question pool consisting of 71 multiple-choice questions was prepared to cover each of the related learning outcomes. After the opinions of five experts were taken for the content validity of the test, 37 questions were edited. The pilot study was conducted with 311 pre-service teachers from eight teaching departments who had previously taken the IT course. Item difficulty and item discrimination indices were calculated using the data obtained from the pilot study. As a result of the analysis, 46 items were removed from the achievement test by taking expert opinion, and the test was reduced to 25 items to cover each outcome and ready for application. In this context, the highest score that can be obtained from the test is set at 100, while the lowest score is set at zero.It was determined that the item difficulty indices of the remaining questions in the 25-item test, finalized after the item removal procedures, were between 0.38 and 0.74, and the item discrimination indices were between 0.31 and 0.67. The average item difficulty and item discrimination indices of the 25-item test were calculated as 0.54. The test's internal consistency coefficient (KR-20) was calculated as 0.83. The achievement test was used as pre-test, post-test, and delayed post-test.

3.2.2. Self-regulated learning skills scale

The Self-Regulated Learning Skills Scale, developed by Velipaşaoğlu and Musal (2017), determined pre-service teachers' self-regulated learning skills. The scale consists of 23 five-point Likert-type items and six sub-dimensions. The lowest score that can be obtained from the scale is 23, and the highest score is 115.Its internal consistency coefficient (Cronbach's alpha) was calculated as .839. According to the sub-dimensions of the scale, the internal consistency coefficient was calculated as follows: metacognitive strategies = .610; planning strategies = .777; achievement expectancy and intrinsic motivation = .728; personal responsibility and discipline = .777; external factors = .675; learning strategies = .630.

3.2.3. Classroom engagement scale

The Classroom Engagement Scale, developed by Eryılmaz (2014), determined pre-service teachers' engagement levels. The lowest score that can be obtained from the scale consisting of 15 five-point Likert-type items is 15, and the highest score is 75. The internal consistency coefficient (Cronbach's alpha) of the scale is .92. The scale has three sub-dimensions: emotional, behavioral, and cognitive engagement. The internal consistency coefficients for these dimensions were .84, .86, and .84, respectively.

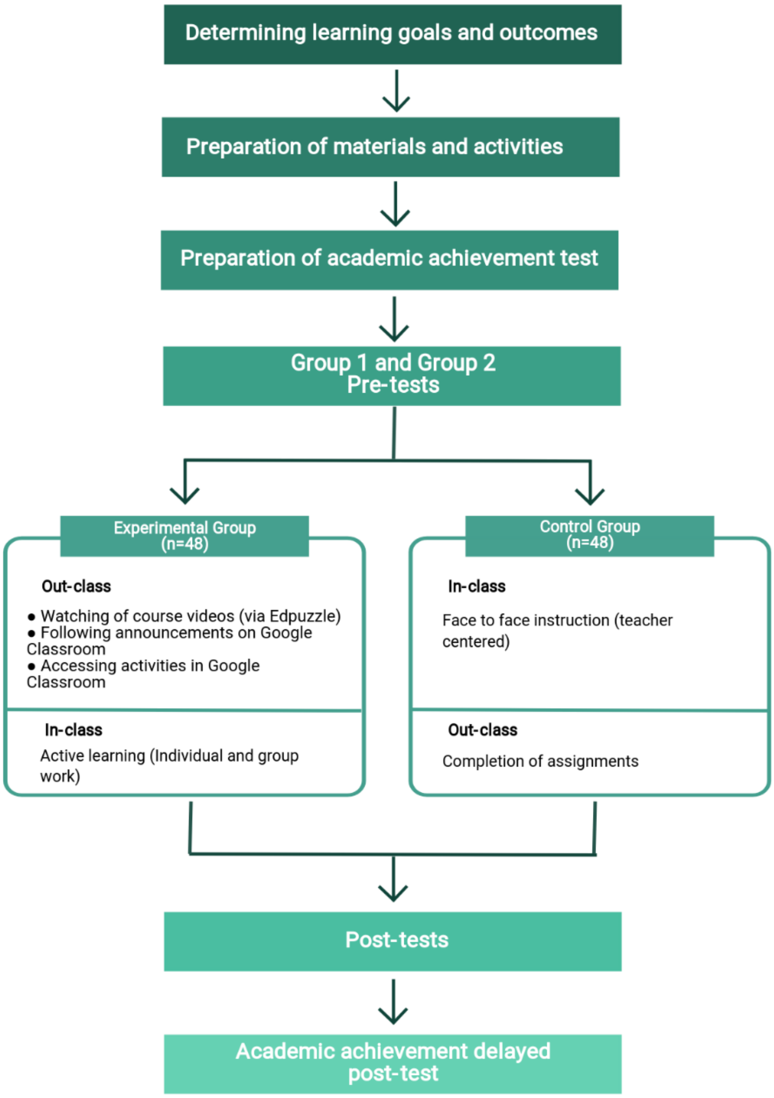
3.3. Experimental Procedure

The study used a pre-test post-test quasi-experimental study with a control group, one of the quantitative research methods. A quasi-experimental design was preferred because it enables unbiased assignment over existing groups (Cohen et al., 2007) since randomly assigning students to groups in educational settings is challenging. In addition, a pre-test post-test design was adopted since measurements were required before and after the instruction in both groups to determine the relationship between the variables discussed in the study. Accordingly, the procedures carried out within the scope of the study are summarized in Figure 1.

After the materials and tests were prepared, the implementation process was completed in nine weeks. In the first week, the pre-tests were administered to the students with the necessary explanations. The process was explained to the students in the experimental group by giving information about FCM, and they were allowed to register on the Edpuzzle, where the course videos were shared. The same topics were taught to the students assigned to the experimental and control groups for seven weeks by the same instructor for three lesson hours per week. In the control group, all lessons were conducted face-to-face in the computer laboratory with the instructor's lectures. After lectures, the students were asked to review and practice the week's subject. In the experimental group, the lectures were carried out with videos uploaded to the

Edpuzzle weekly and applied individual and group activities were carried out in the computer laboratory.

Figure 1
Steps in the implementation process



The researchers prepared some of the lecture videos, while others were used with permission from a Computer Education and Instructional Technology field expert's YouTube channel. The organization of the videos and presentation of the content considered multimedia design principles, including attracting attention, coherence, redundancy, and fragmentation. In addition, 22 videos ranging from 3 to 17 minutes were prepared considering the suggestions given in the literature (Bordes et al., 2021) that lecture videos should not be monolithic and too long. The videos were uploaded to the Edpuzzle weekly to ensure that students watched the videos (Bergmann & Sams, 2012). To encourage students to watch the videos, 37 open-ended and multiple-choice questions were added to the 22 videos uploaded to Edpuzzle. It is seen that course videos and questions embedded in these videos are used in FCM to improve students' self-regulated learning skills (Van Alten et al., 2020). In this study, learning environments were presented where students could take their learning responsibilities and improve their self-regulated learning skills by using course videos that they can review and manage in the pre-course stage according to their learning speed. According to the Edpuzzle system report, it was determined that almost half of the students (N=20) who participated in the study completed the total lesson video duration of 219 minutes and 38 seconds, and the majority of the remaining students (N=21) completed more than half of it. The average number of correct answers to the 37 questions in the lecture videos was 23.68.

In FCM, in-class practices and activities are as important as the course videos prepared (Eisenhut & Taylor, 2015). For this reason, two activities were prepared for the first five weeks of the seven weeks of the experimental process, one with the group and one individually. For the last two weeks, only one group activity was prepared due to the intensity of the topics (see Appendix 1). In this process, care was taken to ensure that the activities were appropriate for the target audience, related to the lecture videos, and designed to allow students to apply the information presented. In addition, to make the activities attractive to the students, a problem situation was presented through a case study related to the teaching profession, and they were asked to apply to find a solution to this problem. In this direction, 12 activities were prepared. During the implementation process of the research, 12 students participated in 12 activities, 13 students participated in 11 activities, 16 students participated in 10 activities, 5 students participated in 9 activities, and 2 students participated in 8 activities. The reason for this situation is that some students do not attend classes during certain weeks of the research process. The differences in students' attendance have also reflected in their participation numbers for the activities. Therefore, not every student has been able to participate equally in all activities.

3.4. Data Analysis

The research data were analyzed using predictive statistical techniques. Before the analysis, the normality distribution of the data and the fulfillment of the assumptions regarding the tests were examined. For normality, it was checked that the kurtosis and skewness coefficients of the data were between −3 and +3, the significance level was greater than .05 according to the normality tests, and the histogram and Q-Q plot graphs showed a normal distribution (Kalaycı, 2010). In this direction, after it was determined that the data were normally distributed and met the assumptions regarding the tests, independent samples t-test, and dependent samples *t*-test were used.

4. Results

4.1. Findings related to Academic Achievement

Students' achievement test scores in the experimental and control groups were analyzed to evaluate their academic achievement at the end of the application. An independent samples t-test was conducted to determine whether there was a statistically significant difference in the groups' academic achievement post-test scores. The results are presented in Table 3.

Table 3
Independent samples t-test results for academic achievement post-test scores

Group	*N*	*Mean*	*SD*	*df*	*t*	*p*	*r*
Experiment	48	92.42	5.23	94	2.94	.004	.60
Control	48	89.00	6.09				

Analysis of Table 3 showed a statistically significant difference in post-test academic achievement scores between the groups in favor of the experimental group ($t(94) = 2.94$, $p = .004 < .05$, $r = .60$). The effect size was moderate. In this context, it was revealed that FCM contributed more to students' academic achievement than TTM. In addition, the delayed post-test scores of the groups' academic achievement were compared to evaluating the delayed post-test of the information they learned after the implementation process. The results of the independent samples *t*-test analysis are presented in Table 4.

Table 4

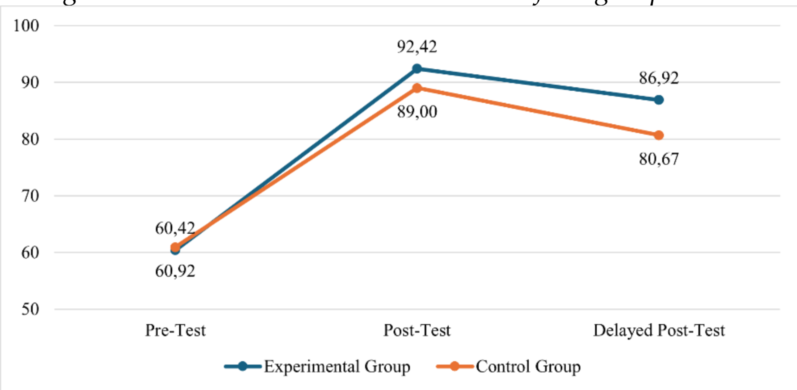
Independent samples t-test results for academic achievement delayed post-test scores

Group	*N*	*Mean*	*SD*	*df*	*t*	*p*	*r*
Experimental	48	86.92	7.27	81.56	3.28	.002	.67
Control	48	80.67	10.98				

Examination of Table 4 revealed a statistically significant difference in the delayed post-test academic achievement scores between students in the experimental and control groups, favoring the experimental group ($t(81.565) = 3.28$, $p = .002 < .05$, $r = .67$). The effect size indicates a moderate impact. In other words, the FCM was found to contribute more effectively to the long-term retention of learned material compared to the TTM. To illustrate this contribution more clearly, the changes in mean academic achievement scores for both groups are depicted in Figure 2.

Figure 2

Change in the mean achievement test scores of the groups



As shown in Figure 2, the groups had nearly identical pre-test academic achievement scores. However, following the intervention, the experimental group outperformed the control group in both the post-test and delayed post-test. Although both groups exhibited a decline in delayed post-test scores compared to their post-test scores, the decrease was less pronounced in the experimental group.

4.2. Findings related to Self-regulated Learning Skills

At the end of the intervention, an independent samples t-test was conducted to examine whether there was a significant difference in self-regulated learning skills between students in the experimental and control groups. The results of this analysis are presented in Table 5.

Table 5

Independent samples t-test results for self-regulated learning skills post-test scores

Group	*N*	*Mean*	*SD*	*df*	*t*	*p*	*r*
Experiment	48	86.82	10.99	94	.17	.861	.018
Control	48	86.43	10.91				

Analysis of Table 5 indicated that there was no statistically significant difference between the post-test self-regulated learning skill scores of the experimental and control groups ($t(94) = 0.17$, $p = .861 > .05$, $r = .018$), suggesting a small effect size. These findings imply that the FCM did not significantly enhance students' self-regulated learning skills compared to the TTM. However, to assess whether the change in self-regulated learning skills within each group over the course of the implementation was statistically significant, paired samples t-tests were conducted using pre-test and post-test scores. The results are presented in Table 6.

Table 6
Dependent samples t-test results for self-regulated learning skills pre-test and post-test scores

Groups	*N*	*Mean*	*SD*	*df*	*t*	*p*	*r*
Experiment							
Pre-test	48	89.48	11.41	47	1.67	.100	.23
Post-test	48	86.82	10.99				
Control							
Pre-test	48	90.06	10.56	47	1.56	.123	.22
Post-test	48	86.43	10.91				

Examination of Table 6 revealed no statistically significant difference between the pre-test and post-test self-regulated learning skill scores for both the experimental group ($t(47) = 1.67$, $p = .100 > .05$, $r = .23$) and the control group ($t(47) = 1.56$, $p = .123 > .05$, $r = .22$). The effect sizes for both groups were small. These results indicate that the FCM did not lead to a significant improvement in students' self-regulated learning skills compared to the TTM.

4.3. Findings related to Classroom Engagement

An independent samples *t*-test was conducted on the post-test scores to examine whether there was a significant difference in classroom engagement between the experimental and control groups based on the instructional method applied. The results of this analysis are presented in Table 7.

Table 7
Independent samples t-test results for the post-test scores of classroom engagement

Group	*N*	Mean	*SD*	*df*	*t*	*p*	*r*
Experiment	48	54.27	12.59	94	−0.66	.948	.007
Control	48	54.41	8.75				

As shown in Table 7, there was no statistically significant difference between the post-test classroom engagement scores of the experimental and control groups ($t(94) = –0.66$, $p = .948 > .05$, $r = .007$). The effect size was minimal, indicating that the FCM did not yield any meaningful improvement in students' classroom engagement compared to the TTM.

5. Discussion and Conclusions

5.1. The Effect of FCM on Academic Achievement

This study showed a significant difference in academic achievement between the experimental and control groups, which favored the experimental group. In addition, in the study, it was revealed that academic achievement post-test scores, as well as delayed post-test scores, were higher in favor of the experimental group. This situation reveals that FCM is more effective than TTM in increasing students' academic achievement within the scope of IT courses. This result is consistent with studies applying FCM in IT courses at different teaching levels (Duman, 2019; Onyema et al., 2021; Turan, 2015). The positive effect of FCM on academic achievement may be related to the fact that students acquire knowledge at their own pace with educational resources, such as videos in the out-of-class environment, and perform more hands-on activities in the classroom environment. Unlike TTM, the transition to student-centered learning in FCM provides opportunities for students to construct knowledge through active learning experiences (Strayer, 2012). Indeed, Freeman et al. (2014) emphasize that active learning increases students' academic achievement.

In FCM, presenting the course content with online materials and students being active in the learning process and progressing at their own learning pace may not be sufficient alone to increase academic achievement. Planning and designing the implementation process also have a significant effect on obtaining positive outcomes in learning environments where the model is applied (McGivney Burelle & Xue, 2013). In this context, it is stated that it is helpful to determine learning goals by considering learner needs, designing learning environments in line with these goals, keeping the content simple and evaluating student performance appropriately, and providing immediate feedback (McGivney Burelle & Xue, 2013; McLaughlin et al., 2014). In this study, it was observed that the IT courses given in the flipped classroom, which were planned and designed by considering student needs and characteristics, were effective in terms of students' academic achievement. Similarly, studies in literature support this result (Duman, 2019; Turan, 2015).

5.2. The Effect of FCM on Self-regulated Learning Skills

Within the scope of the research, it was determined that there was no significant difference between the students' self-regulated learning skills in the experimental and control groups. Likewise, no significant within-group improvements were observed post-intervention. Accordingly, this lack of development may be related to the fact that the research was conducted after the pandemic. In this direction, it can be said that students who gained distance education experience during the pandemic were included in the application with improved self-regulated learning skills. Both groups were observed to have mean scores very close to the highest score that could be obtained from the scale. In this direction, it is understood that students' following their lessons and taking on learning responsibilities through emergency distance education during the pandemic process positively affects their self-regulated learning skills (Alanoğlu & Doğan, 2021).

In FCM, students' self-regulated learning skills improve when they take responsibility for learning by autonomously studying course materials outside the classroom at their own learning pace and according to their study styles and perform applications that require high-level skills with what they have learned (Hewitt et al., 2014). While there are many studies in the literature that FCM improves students' self-regulated learning skills (El Senousy & Alquda, 2017; Eser, 2021; Hewitt et al., 2014; Shyr & Chen, 2018), it is surprising that the implementation process designed and planned according to FCM in this study did not improve students' related skills. Although it is surprising, some studies in the literature support this result (Aydemir Altaş & Mede, 2020; Elakovich, 2018; Sun et al., 2017). Although the model is compatible with self-regulated learning in theory (Zou et al., 2020) and that students are responsible for learning in practice may not be sufficient for developing self-regulated learning skills. Students may not always successfully organize their learning, especially in technology-based learning environments (Lee et al., 2009). That may be due to students' difficulty adapting to the model, encountering some technical difficulties, or increasing their workload due to how the model is used (Elakovich, 2018).

In the research implementation process, the next lesson's learning objectives were explained in each lesson so that students could set simple and realistic goals. In this direction, students planned for their learning, watched videos from the Edpuzzle, and answered questions in the videos to track their progress and direct their learning by making comparisons with the learning goals they set. As a result of these strategies used for seven weeks to improve students' self-regulated learning skills, it was observed that the relevant skills did not improve. As a matter of fact, it is emphasized that course videos may be insufficient to support independent learning (Sletten, 2017). In this context, the literature suggests that strategies such as e-books, commands and explicit instructions embedded in lecture videos, and learning analytics can also be used to improve students' self-regulated learning skills with FCM (Lai & Hwang, 2016; Van Alten et al., 2020).

5.3. The Effect of FCM on Classroom Engagement

In this study, it was revealed that there was no significant difference between the experimental and control groups in terms of classroom engagement. In this context, it was concluded that FCM did not have any effect on students' classroom engagement compared to TTM. Although this result differs from many studies in the literature (Çoruk et al., 2020; Dooley et al., 2018; Steen Utheim & Foldnes, 2018), it is consistent with the results of some studies (Garner & Chan, 2019; Subramaniam & Muniandy, 2019). Classroom engagement has three dimensions: behavioral, affective, and cognitive (Fredricks et al., 2004). Students’ concentration on assigned tasks, their effort to complete them, and their tendency to ask questions are indicators of behavioral engagement (van Uden et al., 2013); their willingness and desire to accomplish tasks reflect affective engagement (Mahatmya et al., 2012); and their active involvement in the learning process through various strategies and cognitive effort indicates cognitive engagement (Fredricks et al., 2004). In this context, in the study, students were encouraged to engage in the classroom by offering individual and group activities related to the teaching profession, adding questions to the lesson videos on the Edpuzzle, and explaining the objectives of the next lesson in the classroom process. Despite this, it is noteworthy that there was no improvement in students' classroom engagement. However, it is stated in the literature that there is a positive relationship between students' self-regulated learning and classroom engagement skills (Song & Kim, 2021). However, although the students' self-regulated learning skills were high in this study, their low classroom engagement indicates a situation beyond the strategies mentioned in the literature and applied.

The fact that the engagement of the students in the experimental group did not increase at the end of the research may be due to the education they received during the pandemic. The students in the study took compulsory online courses with emergency distance education during the pandemic. After this process, they were included in the FCM, which includes an online learning environment. Some studies indicate that some students had negative experiences in distance education during the pandemic and had negative attitudes towards distance education (Abakumova et al., 2020; Diab & Elgahsh, 2020). While students' negative attitudes may result in not enjoying online courses and not being willing to fulfill the tasks, it may have had a similar effect on students' engagement in this study.

FCM is based on students watching course videos in online learning environments and participating in interactive and active learning activities in the classroom learning process (Bergmann & Sams, 2012). In this context, in FCM, students are expected to exhibit observable behaviors related to learning and academic tasks. For this reason, in addition to students' self-assessments, it is valuable to consider the rate of watching course videos and the rate of participation in classroom activities to evaluate and comment on their engagement in the classroom (Huang et al., 2019). In the literature, findings on classroom engagement are obtained through indicators such as participation records, activities, or task completion in addition to scale data (Çevikbaş, 2018; Huang et al., 2023). According to the Edpuzzle system records in the study, it was determined that students mostly completed the videos and answered the majority of the embedded questions correctly. In addition, it was determined that they participated in individual or group activities in the classroom to a great extent. Although it was determined that the students' engagement in the experimental group was not positively affected according to the scale data, their performances in both online and in-class environments contradict this result. In this context, it can be said that students' self-evaluations of their engagement in the classroom do not reflect their behaviors. This situation is stated as a limitation of data collection tools based on self-assessment in the literature (Demetriou et al., 2015).

6. Limitation and Future Studies

There are some limitations in this research. The research is limited to certain subjects of the IT courses in which 96 pre-service teachers participated. In order to increase the generalizability of the research results, experimental studies can be carried out with students from different levels of education on different topics of the IT courses. Research data were collected using achievement tests, scales, and system records. In this process, it was observed that the findings related to the scale data and system records regarding the classroom engagement of the students involved in FCM were contradictory. In this context, data diversity can be provided using alternative measurement tools such as portfolios, project assignments, system records, and observations for the variables addressed. By using portfolios and project assignments, evidence can be obtained of students' planning, implementation and self-assessment processes that reflect their self-directed learning skills. Observation and system records help objectively monitor students' active engagement in the class. Thus, the limitations of measurements based on a single type of data can be overcome, and more valid and reliable results regarding learning outcomes can be achieved. In order to improve students' self-regulated learning skills in FCM, lesson videos were uploaded to the Edpuzzle for seven weeks, and questions were embedded in the videos. In future studies, Edpuzzle and similar platforms can be used to support students in taking responsibility for their learning and learning at their own pace. In addition, the effects of different types of online materials and longer-term studies on self-regulated learning skills can be investigated. Since students' self-regulated learning skills were high in this study, but their engagement in the classroom was low, it may be recommended to examine students' attitudes toward distance education. In this study, although students' self-regulated learning skills were high, their classroom engagement was low, which may require an examination of their attitudes toward distance education. In this context, examining students' attitudes towards distance education can be added to the pilot studies conducted to adapt to FCM before the research. Thus, both the features of FCM can be introduced in detail in line with students' attitudes towards distance education, and the designed research process can be tested in advance.

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Appendix 1. Implementation process

Week	*Subject*	*Activity*
Week 1	• Explaining FCM and providing information about the process • Implementation of pretests • Students register on the Edpuzzle.	
Week 2	Google Docs • Access to Google Docs • Recognize the file menu • Basic text formatting operations • Alignment, line spacing and column options • Use of bulleted and numbered lists	• Activity-1. Students prepare exam papers in line with the instructions provided to them. • Activity-2. Students prepare worksheets about disasters in groups of three in line with the instructions presented to them.
Week 3	Google Docs • Paragraph indents • Use of headers, footers and page numbers • Add images, tables, special characters and graphics	• Activity-3. Students prepare a worksheet about the weather in line with the instructions given to them. • Activity-4. Students in groups of three prepare worksheets related to the math lesson in line with the instructions given to them.
Week 4	Google Slides • Access to Google Slides • Recognize the Google Slides interface and create slides • Organize slide sheets • Insert and format text boxes, images, shapes, shapes, lines and videos	• Activity-5. Students prepare about the states of matter in line with the instructions presented to them. • Activity-6. Students prepare a presentation on punctuation marks in groups of three in line with the instructions given to them.
Week 5	Google Slides • Insert and format tables, charts, Word art and special characters • Add transition effect and animation • Save the presentation in different formats and share it with others • Using presentation mode	• Activity-7. Students organize the presentation about triangles in accordance with the instructions. • Activity-8. Students prepare a presentation about the continents in groups of three in line with the instructions given to them.
Week 6	Google Sheets • Access Google Sheets and recognize interface components • Cell and page concepts • Autofill function • Identifying and organizing data types • Cell formatting operations	• Activity-9. Students format the spreadsheet presented to them according to the instructions and identify the data types. • Activity-10. Students prepare an income and expenditure statement in line with the instructions provided to them.
Week 7	Google Sheets • Row and column formatting operations • Page operations • Data duplication, migration and search operations • Use of formulas and calculation operations	• Activity-11. Students organize the ticket sales spreadsheet presented to them in line with the instructions and make the requested calculations using formulas.
Week 8	Google Sheets • Conditional formatting feature • Adding and editing charts	• Activity-12. Students organize the spreadsheet about the cereal production of the countries presented to them, make the required calculations on the spreadsheet and create graphs.
Week 9	Administration of the posttest related to the academic achievement test (AAT) and scales	