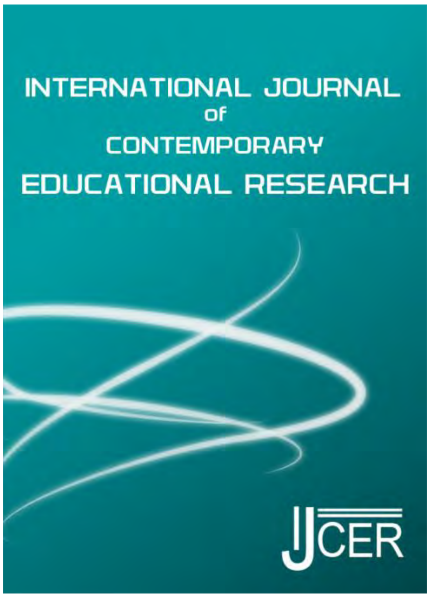

Article History
Received: 10.07.2023
Received in revised form: 04.09.2023
Accepted: 09.10.2023
Article Type: Research Article

International Journal of Contemporary Educational Research (IJCER)

www.ijcer.net

Project-Based Learning and the Flipped Classroom Model Supported Project-Based Learning's Impact on Academic Success, Retention, and Individual Innovation Competence

Güliz Aydın[1], Osman Mutlu[2]
[1]Muğla Sıtkı Koçman University, 0000-0001-5119-8238
[2]Muğla Sıtkı Koçman University, 0000-0002-3648-3994

To cite this article:

Aydın, G. & Mutlu, O. (2023). Project-based learning and the flipped classroom model supported project-based learning's impact on academic success, retention, and individual innovation competence. *International Journal of Contemporary Educational Research*, *10*(4), 823-833. https://doi.org/10.52380/ijcer.2023.10.4.532

IJCER International Journal of Contemporary Educational Research
Volume 10, Number 4, December 2023, 823-833 ISSN: 2148-3868

Project-Based Learning and the Flipped Classroom Model Supported Project-Based Learning's Impact on Academic Success, Retention, and Individual Innovation Competence

Güliz Aydın[1*], Osman Mutlu[1]
[1]Muğla Sıtkı Koçman University

Abstract

The aim of this study is to investigate the effects of Project-Based Learning (PBL) and Flipped Classroom Model (FCM) supported by PBL on sixth grade students' academic achievement, retention of knowledge, and individual innovation competence. A quasi-experimental design with a pre-test and post-test control group was used in the study. While the PBL method was applied to the first experimental group, FCM-supported PBL was applied to the second experimental group. In the control group, teaching was carried out according to the science curriculum. The study was conducted with 80 sixth grade students from three classes during the 2021–2022 school year at a public middle school in Muğla, a province in Turkey. The Matter and Heat Achievement Test (MHAT) and the Individual Innovation Competence Scale (IICS) were used as pre- and post-test measurements. The results revealed that the students who participated in the PBL group and FCM-supported PBL achieved significantly higher post-test scores than those in the control group, indicating increased academic achievement. However, no significant difference was found between the groups in terms of individual innovation competence. It was also observed that the PBL group had significantly higher retention scores than the control group. Investigating the long-term effects of these instructional approaches across different subjects and grade levels would be beneficial.

Keywords: Project based learning, Flipped classroom, Academic achievement, Innovation, Science education

Introduction

In today's digital age, educators face increasing challenges in teaching students to learn through their own efforts. To overcome these challenges, integrating technology into the learning process and encouraging active participation can enhance students' educational experiences and outcomes by facilitating the transition from passive to active learning. Active learning refers to any instructional strategy that engages students in the learning process. By implementing active learning methods and integrating technology, educators can encourage students to actively engage with the material and collaborate with peers.

Project-Based Learning (PBL) is an active learning method where students work on real-world projects to advance their knowledge and abilities. Students in project-based learning apply what they have learned by working on real-world projects or solving problems that are relevant to them (Capraro & Slough, 2013; Larmer et al., 2015). PBL is an inquiry-based teaching method that gives students goals for their learning. In PBL, students choose research questions related to the topic, conduct investigations, evaluate the findings, and develop new questions. This method encourages ownership of learning (Wilhelm et al., 2019). PBL allows students to identify their unique learning abilities by considering their learning preferences and styles (Aksela & Haatainen, 2019). PBL engages students in authentic, real-world projects that require them to apply their knowledge and skills to solve complex problems (Chistyakov et al., 2023).

Applications such as project-based learning (PBL) can be combined with the flipped classroom model (FCM). The FCM complements PBL by shifting the acquisition of foundational knowledge to independent study outside of class time (Akçayır & Akçayır, 2018). FCM enables students to acquire basic information with the help of educational videos presented as homework before coming to the classroom. Videos assigned as pre-class homework primarily address the lower levels of Bloom's taxonomy. This allows for more interactive and engaging in-class activities focused on higher-order thinking skills (Haak & Burand, 2016; Morsch, 2016). Watching videos before class prepares students for in-class activities so that they can focus on applying the basic concepts from the videos. Students become active participants in class time, enhancing collaboration and communication skills as they work together to solve problems, discuss ideas, and present their findings (Triana

* Corresponding Author: *Güliz Aydın, gulizaydin@mu.edu.tr*

et al., 2020). Students apply what they have learned from the videos during in-class activities, which are often interactive and collaborative. They might solve problems, analyze case studies, or conduct experiments, all aligning with Bloom's taxonomy's upper levels (Morsch, 2016). In this way, extra time can be devoted to practice, cooperation, research, and project work.

Studies have shown that active learning strategies such as project-based learning and the flipped classroom model are generally beneficial (Capraro & Slough, 2013; Çakıroğlu & Öztürk, 2016; Rau et al., 2017; Triana et al., 2020). Both PBL and the FCM promote collaboration and teamwork among students. Students collaborate in groups, share ideas, and work towards project goals. They develop communication skills as they present their projects, articulate their thoughts, and engage in meaningful discussions with peers and teachers.

Research conducted by Baepler et al. (2014) examined how the FCM affected both students' learning and perception. The results showed that in a flipped classroom, the student-faculty contact time was cut in half while student learning outcomes were at least on par with and, in one comparison, significantly superior to those of a typical classroom. Furthermore, students' overall impressions of the classroom environment saw positive shifts. According to the study by O'Flaherty and Phillips (2015), the flipped classroom can have several different models depending on the instructor. In the flipped classroom model, teachers generally give presentations in advance. Students learn through various resources, including videos, podcasts, demonstrations, and investigations. The educator is available for consultation and clarification during class time. Students can ask and discuss with their peers to understand the material (Bergmann & Sams, 2012).

Elian and Hamaidi (2018) studied the influence of the FCM on academic achievement. According to the findings, experimental groups exhibited a more positive attitude toward science than students in the control group. In a different study, similar findings were reported by González-Gómez et al. (2016), who identified that students who took part in flipped classrooms scored significantly better than students who did not. On the other hand, Ryan and Reid (2016) conducted research to assess the influence of the FCM on students' academic achievement and retention in general chemistry. They found that the outcomes of the experimental and control groups were not substantially different. Güngör (2022) stated that there was a medium-level significant relationship between high school students' individual innovation levels and their English course achievement. Individual innovation, which is related to taking risks, being open to new ideas, experiences, and different perspectives, accepting them, and being willing to learn, is an individual personality trait indicating the willingness to try new things (Goldsmith & Foxall, 2003). Deveci and Kavak (2020) stated in their study that the academic achievement variable had a significant effect on the innovative thinking tendency and that the innovative thinking tendency of students with high general academic achievement was at a higher level. Therefore, it is thought that it is important to include activities and practices that support innovation in learning environments for meaningful learning.

Today, skills such as creativity, teamwork, and innovative thinking are of great importance for a quality education. Innovation, which involves creating new products, developing new methods, or providing new services, plays a vital role in driving a country's economy (Gülhan, 2016; Keinänen et al., 2018). When examining studies on innovation, Kirton (1976) proposed a theory that classifies individuals into two profiles based on their decision-making abilities and problem-solving approaches: innovative individuals and adaptive individuals. Innovative individuals strive to make a difference in their problem-solving efforts by challenging norms and exploring new ideas, while individuals in the adaptive profile focus on improving existing methods. This classification is reinforced by Scott and Bruce (1994), who identified four sub-dimensions of innovative behaviors: creativity, self-efficacy, persistence, and openness to experience. Additionally, Kleysen and Street (2001) suggested five dimensions enabling individuals to innovate: discovering opportunities, productivity, formative review, championship, and application.

Education is a central determinant in developing innovation competencies, but one of the most challenging obstacles is that educational institutions cannot meet these competencies' needs (Keinänen et al., 2018). A research study conducted by Ovbiagbonhia et al. (2019) examined whether the way students learn in school encourages them to be innovative, if the things they learn in their classes help them develop new ideas, and if the learning environment supports their ability to be creative and innovative. The study results showed that students felt that their learning environments needed to provide more support to be innovative and develop their creative skills. Appropriate methods and techniques are needed to develop innovation competencies. Educators can use PBL and FCM to integrate knowledge and skills (Bell, 2010). According to research by Keinänen and Kairisto-Mertanen (2019), students with more exposure to innovative learning approaches demonstrated improved abilities in being innovative and creative. The study indicates that the experience of engaging with innovative learning methods positively influences students' capacity to think innovatively and generate creative ideas. Yıldırım (2022) stated that digital education and robotic coding practices positively affected the individual innovation levels of third-year pre-service science teachers. Students who initially had a low level of innovation reached a medium level of innovation after the treatment. Varas-Contreras et al. (2021) stated that employing a teaching strategy supported by innovation-oriented projects and design thinking methodology is beneficial for developing innovation skills. Barak and Usher (2021) examined the innovation levels of team projects among engineering students in hybrid and MOOC (Massive Open Online Course) environments. Hybrid courses integrate traditional face-to-face instruction with digitally enhanced educational elements, including pre-recorded video lectures, interactive ebooks, web-based activities, interactive simulations, and online tests. MOOCs provide access to video lectures and instructional resources that can be delivered entirely online or integrated into a hybrid educational model. Projects from hybrid groups received higher evaluation scores. Hybrid group projects were considered more innovative because they demonstrated greater creativity and had the potential to make more significant contributions to the field of engineering.

The combination of project-based learning and the flipped classroom model can equip students with the 21st-century skills necessary for achievement in an increasingly complex world (Bell, 2010). By emphasizing 21st-century skills, these approaches can prepare students to succeed in academic, professional, and personal settings and to become lifelong learners capable of dealing with the challenges and opportunities of this century (Asbjornsen, 2015). Further research is necessary to explore the combined use of project-based learning (PBL) and the flipped classroom model (FCM) in middle school settings. While PBL and FCM have been studied independently, there needs to be more understanding of how they can be effectively integrated for middle school students. This study compares the experimental and control groups' learning achievement, retention levels, and innovation competences after PBL and FCM-supported PBL interventions.

Method

Research Design

The researchers adopted a quasi-experimental design with a pre-test and post-test in their investigation. The purpose of quasi-experimental research is to evaluate the effects of a treatment or to estimate the causal result of a specific variable, but randomization is not employed. They are often used when randomization is considered unfeasible (Creswell & Creswell, 2017).

The present study applied PBL as the primary teaching method in the first experimental group while also combining with FCM to support the application of PBL in the second experimental group. These two teaching methods were compared with instruction with activities based on the Science Curriculum in the control group. In Table 1, the study's research design is displaced.

Table 1. Research design

Groups	O (Pre-test)	X (Treatment)	O (Post-test)	O (Retention Test)
PBL	T_1, T_2	Project-Based Learning	T_1, T_2	T_1
TYS+PBL	T_1, T_2	FCM-Supported Project-Based Learning	T_1, T_2	T_1
Control Group	T_1, T_2	Instruction with activities based on the Science Curriculum	T_1, T_2	T_1

T1 is the Academic Achievement and Retention Test. A multiple-choice test assesses students' academic knowledge, understanding, and ability to reason, analyze, and solve problems. The same test is used as a retention test that evaluates a student's ability to learn and retain academic knowledge, essential facts, and concepts under the same conditions. T2 is the Individual Innovation Competence Scale measure that evaluates students' capacity to create new and valuable processes and products.

Study Group

In the 2021-2022 school year, the study included 80 sixth-grade students from three different classes at a public middle school in the Menteşe district of Muğla province in Turkey. The Matter and Heat Academic Achievement Test and Individual Innovation Competence Scale were applied to these three classes, whose achievements in the previous year's Science course were equivalent to each other, as a pre-test. The results revealed no significant differences among the scores obtained from the test. Based on their similar scores, three classes were assigned to the groups using a random lottery process.

Before the main application, a pilot application lasting two weeks (8 lesson hours) was carried out on the topic of Density in order to ensure the adaptation of the study group. The main application lasted 16 lesson hours (4 weeks) for the subjects and acquisitions in the "Matter and Heat" unit, as recommended in the Science Curriculum In the context of this study, the PBL (Project-Based Learning) group, supported by the FCM (Flipped Classroom Model), was assigned short 5-10 minute videos related to the subject of "Matter and Heat" as part of their initial homework. These videos were specifically designed to align with students' prior knowledge and comprehension. A total of five videos were developed for the students. Over the four-week "Matter and Heat" unit, one video was assigned to students each week, covering topics related to "Matter and Heat" and "Fuels." The fifth and final video provided guidance to students on how to effectively prepare for their project presentation. For PBL, heterogeneous groups of four or five students with different achievement levels were formed, emphasizing the importance of teamwork in preparing innovative projects. The groups were guided to design, develop, and present their project work collaboratively. During the implementation, students carried out two different projects. In the first PBL activity, titled "Thermally Insulated House," during the first week of implementation, students conducted research on thermal insulation materials and the parts of the house where these materials would be applied. Group members with different skills were encouraged to collaborate on developing innovative projects or new products. Groups were also encouraged to generate original ideas and innovative project designs. Each group was tasked with creating an innovative thermal insulation material. Furthermore, the groups were encouraged to incorporate a different material into their project design, a choice they made themselves. During the implementation process, students designed various window and door shapes and created original and innovative projects by developing insulation materials suitable for these designs. In the second week of implementation, the groups finalized their innovative projects and shared them with other students and the teacher. Each group was asked to explain why their insulation was innovative. In the third week of the implementation, the groups created sub-questions related to the driving question, "How can we prevent carbon monoxide poisoning?" They were asked to conduct research and design innovative projects to address these questions. In the fourth and final week of PBL implementation, students finalized their projects in line with their group designs and made presentations. The teacher and other groups provided feedback and criticism for the projects presented. The projects were evaluated in terms of their originality, innovation, and success in thermal insulation. With the students in the control group, the "Matter and Heat" unit topics were taught with the activities in the textbook based on the 2018 Science Curriculum.

Data Collection Tools

The "Matter and Heat Achievement Test" (MHAT) and the "Individual Innovation Competence Scale" (IICS) were used as the pre- and post-tests for the research to collect the data.

A multiple-choice MHAT was created to examine the potential impact of various research methods on students' academic achievement and retention of knowledge. A group of experts, including three academic members with expertise in science education and two experienced science teachers, carefully analyzed the achievement test. Their primary focus was to ensure the acceptability and content validity of the test items, selecting those that accurately represented the intended subject matter. A total of 302 seventh-grade students have completed the MHAT. Utilizing the Kuder-Richardson 20 (KR-20) method, the reliability of the achievement test was assessed. KR-20 score is .88 for the MHAT. Scores above 0.70 represent a reasonable level of internal consistency and reliability. The experimental and control groups each took a pre-test and a post-test that consisted of a 25-question multiple-choice MHAT. After six weeks, the MHAT was administered once more as a retention test to measure the extent to which the learners retained the knowledge over time. By comparing the performance of the two experimental groups and the control group on the retention test, the researchers tried to determine the effectiveness of the interventions provided to the experimental groups.

The researchers developed the Individual Innovation Competence Scale (IICS) (Mutlu & Aydın, 2023) as a valid and reliable measurement tool to assess the levels of individual innovation competence among middle school students. The development process involved data collection from 933 middle school students enrolled in the science course in the Menteşe district of Muğla province. Exploratory Factor Analysis (EFA) was conducted on the collected data, revealing a three-factor structure: behavioral, social, and affective skills. The scale accounted for 55.373% of the total variance and demonstrated good internal consistency The scale was composed of 11 items: eight positively worded items and three negatively worded items. The reliability coefficients, as measured by Cronbach's alpha, were found to be 0.693, 0.651, and 0.717 for the subscales and 0.793 for the overall scale.

Data Analysis

A pre-test was administered to evaluate and account for any pre-existing differences between the groups. The analysis can be focused on examining the impacts or changes in the post-test scores while statistically controlling for the influence of the pre-test scores, if the pre-test scores are accounted for as a covariate. This allows the analysis to be more accurate. Considering the nature of the variables and their distributions within the groups, the study intended to ensure robust and accurate data analysis by employing the appropriate statistical tests based on the fulfillment of assumptions. The first step in quantitative data analysis is to check the data to understand how the values are distributed. Parametric statistical procedures assume that the sample distribution

is normally distributed. Nonparametric statistical methods do not use parametric assumptions about population distribution (Büyüköztürk, 2018). When the assumptions of normality were met, one-way Analysis of Variance (ANOVA) was used to compare the means of the outcome variable between the three groups (two experimental groups and one control group). Nonparametric analyses were utilized when the assumptions of ANOVA were not met. A nonparametric alternative to one-way ANOVA, the Kruskal-Wallis test, was used to compare the medians of the outcome variable across the three groups.
The Shapiro-Wilk Test was utilized to determine whether the distribution of test scores collected from groups was normally distributed after the MHAT was administered as a pre-test, post-test, and retention test; the findings are displayed in Table 2.

Table 2. Shapiro-Wilk normality test results for MHAT data

Test	Groups	N	Shapiro-Wilk	p	Skewness	Kurtosis
Pre-test	Experiment 1 (PBL)	25	.93	.08	-0.47	-0.82
	Experiment 2 (FCM+PBL)	28	.95	.20	0.45	-0.48
	Control	27	.96	.33	0.79	1.01
Post-test	Experiment 1 (PBL)	25	.73	.00*	-1.87	2.80
	Experiment 2 (FCM+PBL)	28	.86	.00*	-0.97	-0.22
	Control	27	.90	.01*	-1.06	0.46
Retention test	Experiment 1 (PBL)	25	.86	.00*	-1.23	0.91
	Experiment 2 (FCM+PBL)	28	.86	.00*	-1.20	0.72
	Control	27	.84	.00*	-1.25	0.62

*p<0.05

According to Table 2, it seems that some of the data follow a normal distribution. To determine whether the normally distributed data created a difference between the groups, ANOVA was employed. Post-test and retention test data do not show a normal distribution. Therefore, a nonparametric test, the Kruskal-Wallis, was utilized to evaluate the differences between the groups' post-test and retention test results.

To assess students' innovation competences, the researchers employed a scale referred to as the Individual Innovation Competence Scale (IICS). Table 3 displays the Shapiro-Wilk Test statistics that compare the scores of students on the IICS before and after the intervention.

Table 3. Shapiro-Wilk normality test results for ICCS data

Test	Groups	N	Shapiro-Wilk	p	Skewness	Kurtosis
Pre-test	Experiment 1 (PBL)	25	.94	.13	-0.77	0.20
	Experiment 2 (FCM+PBL)	28	.89	.01*	-1.22	1.55
	Control	27	.90	.01*	-1.10	1.07
Post-test	Experiment 1 (PBL)	25	.84	.00*	-1.26	0.73
	Experiment 2 (FCM+PBL)	28	.90	.01*	-0.60	-1.02
	Control	27	.91	.02*	-0.76	-0.52

*p<0,05

According to Table 3, the pre- and post-test Shapiro-Wilk Test results show that the assumptions of a parametric test are not fulfilled. Therefore, the data were evaluated using nonparametric tests such as the Kruskal-Wallis test to compare the individual innovation test scores for groups.

Results

The following section presents the study's results, which aimed to assess the impact of PBL and FCM-supported PBL on students' academic achievement, retention, and individual innovation competence in science courses.
A one-way ANOVA was used to compare the pre-test outcomes of all three groups (PBL, FCM-supported PBL, and control group). The ANOVA test assumes that the variances across the groups are equal. However, to confirm this assumption, Levene's test was employed. Levene's test is designed to assess the equality of variances. If the test yields a significant result, it suggests that the assumption of equal variances is violated,

indicating that the groups have unequal variances (Field, 2018). A p-value of 0.321, which was higher than the typical significance level of 0.05 in hypothesis testing, showed that the results of Levene's test, in this case, demonstrated that the variances between the groups were indeed equal. Table 4 provides more details about the results of the ANOVA conducted in this study.

Table 4. ANOVA results regarding academic achievement pre-test scores

	Sum of Squares	df	Mean Square	F	p
Between Groups	94.529	2	47.265	2.709	.073
Within Groups	1343.471	77	17.448		
Total	1438	79			

According to the results of the ANOVA, which are summarized in Table 4, there is not a statistically significant difference between the groups in terms of their academic achievement pre-test scores. [F (2, 77) = 2.709, p>0,05]. In other words, the groups were similar in terms of their academic achievement levels prior to any intervention.

To examine the relationships between the means of post-test results and academic achievement across the three groups, the researchers employed the Kruskal-Wallis test. This nonparametric statistical test is used to compare the mean ranks among multiple groups when the data does not meet the assumptions of normality or homogeneity of variances (Field, 2018). Table 5 summarizes the relationship between the groups regarding the post-test results.

Table 5. Comparison of post-test scores by using the Kruskal-Wallis test for academic achievement

Group	N	Mean of Ranks	sd	x^2	p
Experiment 1 (PBL)	25	48.68	2	10.661	.005*
Experiment 2 (FCM+PBL)	28	44.34			
Control	27	28.94			

*p ≤ .05

Table 5 shows the Kruskal-Wallis H test results, which were used to determine if different teaching methods affect post-test academic achievement. The PBL group's mean rank score was 48.68, the FCM+PBL was 44.34, and the control group's was 28.94. The Kruskal-Wallis H test revealed a statistically significant difference between the three groups ($x^2(2) = 10.661$, p = .005). This result suggests that the methods used in this study impact academic achievement. However, it is essential to note that this test does not indicate where the differences between the groups lie. Further post-hoc analysis was used to make specific comparisons between the groups. To identify which groups are truly different, the Mann-Whitney U test was performed to compare the mean rank for each group as a follow-up analysis. Table 6 shows the results of the Mann-Whitney U test.

Table 6. Comparisons of post-test academic achievement mean ranks

Group	N	Mean of Ranks	Sum of Mean Ranks	U	Z	p
Experiment 1 (PBL)	25	28.22	705.50	319,5	-0,548	.58
Experiment 2 (FCM+PBL)	28	25.91	725.50			
Experiment 1 (PBL)	25	33.46	836.50	163.5	-3,207	.001*
Control	27	20.06	541.50			
Experiment 2 (FCM+PBL)	28	32.93	922.00	240	-2,333	.020*
Control	27	22.89	618.00			

*p < 0.05

When examining the findings in Table 6, it can be observed that students who participated in both Experiment 1 (PBL) and Experiment 2 (FCM+PBL) did perform better in the post-test for academic achievement compared to those in the control group. The p-values, which indicate statistical significance, are below the conventional 0.05 threshold for both Experiment 1 group (PBL) versus Control group (p=.001) and Experiment 2 group (FCM+PBL) versus Control group (p=.020). This indicates that the improved academic achievement for students in the PBL and FCM+PBL groups is statistically significant.

Six weeks after the post-test, the experimental and control group students were subjected to another round of academic achievement tests. This second testing phase allows us to assess the durability of students' learning over time. The Kruskal-Wallis was conducted to analyze the data obtained from the retention test. The results of the Kruskal-Wallis test, including the test statistic and other relevant data, are presented in Table 7.

Table 7. Kruskal-Wallis test statistics for the retention test

Group	N	Mean of Ranks	sd	x^2	p
Experiment 1 (PBL)	25	47.64	2	5.975	.050*
Experiment 2 (FCM+PBL)	28	42.07			
Control	27	32.26			

*p ≤ .05

Table 7 shows that the p-value (.05) is at the commonly accepted threshold for significance. This suggests that there is a statistically significant difference in the medians of at least two of the groups. However, it is essential to remember that the Kruskal-Wallis test only tells us if there is a difference somewhere among the groups, but it does not tell us where the difference lies. Post-hoc tests were conducted to determine which groups differed from each other.

Pairwise comparisons were performed between the experimental and control groups based on their mean rankings from the Kruskal-Wallis test. These comparisons can be seen in Table 8.

Table 8. Mann-Whitney U test statistics for the retention test

Group	N	Mean of Ranks	Sum of Mean Ranks	U	Z	p
Experiment 1 (PBL)	25	29.04	726.00	299	-0,916	.36
Experiment 2 (FCM+PBL)	28	25.18	705.00			
Experiment 1 (PBL)	25	31.60	799.00	210	-2.3351	.019*
Control	27	21.78	588.00			
Experiment 2 (FCM+PBL)	28	31.39	879.00	283	-1.616	.106
Control	27	24.48	661.00			

*p < 0.05

Table 8 shows that implementing the project-based learning (PBL) method had a statistically significant effect on retention test scores compared to the control group. This means that the students who received PBL instruction could remember and retain more information than the students in the control group who had instruction with activities based on the Science Curriculum.

The pre-test data obtained from the Individual Innovation Competence Scale (IICS) did not exhibit a normal distribution. The Kruskal-Wallis, a nonparametric statistical test, was utilized to compare the medians of the three groups. This test is a nonparametric version of the regular one-way analysis of variance (ANOVA). Table 9 shows pre-test scores.

Table 9. Kruskal-Wallis results of IICS pre-test scores

Group	N	Mean of Ranks	sd	x^2	p
Experiment 1 (PBL)	25	41.02	2	0.019	0.991
Experiment 2 (FCM+PBL)	28	40.21			
Control	27	40.31			

When examining the results in Table 9, it can be observed that the PBL group has a slightly higher mean score than the other two groups. However, the lack of statistical significance in the pre-test results ($p > 0.05$) indicates that there were no significant differences between the groups in terms of innovation before the interventions were introduced ($x^2(2) = 0.019$; $p>.05$). This shows that the groups had similar innovation levels at the beginning of the study.

Since the post-test data acquired after the intervention from the Individual Innovation Competence Scale (IICS) did not exhibit a normal distribution, the assumptions necessary for carrying out parametric tests were not met. As a result, a nonparametric statistical test called Kruskal-Wallis was employed to compare the medians of the different groups. Table 10 presents the three groups' Kruskal-Wallis results of the IICS post-test scores.

The results in Table 10 allow us to assess the effectiveness of the interventions on individual innovation competence by examining the differences in post-test scores among the groups.

Table 10. Kruskal-Wallis results of IICS post-test scores

Group	N	Mean of Ranks	sd	x^2	p

Experiment 1 (PBL)	25	44.64	2	1.239	0.538
Experiment 2 (FCM+PBL)	28	37.77			
Control	27	39.50			

The results presented in Table 10 indicate that there aren't any statistically significant differences in the post-test scores observed among the groups ($x^2(2) = 1.239$, $p > .05$). The post-test innovation competence score of the PBL group showed growth. However, the post-test scores of the FCM-supported project-based learning group and the control group did not show growth.

According to what is presented in Table 10, the mean ranks on the IICS post-test showed a difference in the results that is likely not due to chance between the groups. The results of the PBL group's post-test were compared to the group's scores from the pre-test. The PBL group's post-test score exceeded their pre-test scores and therefore displayed growth in their innovation competence scores. FCM-supported PBL and the control group had similar post-test results.

Conclusion

This study primarily dealt with the impacts of Project-Based Learning (PBL) and the combination of Flipped Classroom Model and Project-Based Learning (FCM+PBL) on students' academic achievement and retention scores. In this study, the findings suggest that both PBL and PBL, which is supported by the FC model, were effective for improving students' academic achievement compared to those who participated in 2018 Science Curriculum-based textbook activities. Bekereci (2022) found that the integrated application of PBL positively impacted students' academic achievements and facilitated the retention of knowledge, mirroring the results of this study. However, other studies, such as Topçu (2019), and Dilşeker and Serin (2018), did not find a statistically significant difference in academic achievement with PBL, suggesting the outcomes might depend on the specific implementation or the context of the PBL. These results from this study also align with many previous studies examining the effects of the FC model. For instance, Keskin et al. (2021), Çakır and Yaman (2018), and Aydin and Demirer (2022) all found positive effects of the FC model on academic achievement. Yıldırım-Yakar's (2021) meta-analysis and the study by Güler et al. (2023) also identified the FC model as beneficial for academic achievement in mathematics. However, Cabi (2018) found that the FC model did not significantly impact students' academic achievements, showing that the model's effectiveness might vary across different settings.

As indicated in the findings, in the retention test that was carried out six weeks after the post-tests, it was discovered that the retention levels in the PBL group were significantly higher than the levels of the students who had participated in the control group. Most FC model retention studies have been conducted at the university and high school levels (Alsancak-Sirakaya & Ozdemir, 2018). It is asserted that the influence of the FC model on retention in learning is debatable and that further quantitative research is required on this topic (Ryan & Reid, 2016). The fact that the retention level was only positive for the PBL group in this study raises the question of whether learning that takes place outside of the classroom setting has a negative impact on the amount of information that can be recalled.

In theory, combining the FCM and PBL strategies might seem like a promising approach: students get an initial exposure to the material at home (FCM) and then do project work in class (PBL), potentially getting the best. However, the results of this study suggest that adding an FC component to the PBL approach did not further improve retention scores. The reasons for this could be diverse; it might be that the FC component was not implemented effectively, or it could be that the added complexity of the FC component did not provide additional benefits over the PBL approach alone. Further research would be needed to understand this better. Therefore, the key result from this study is that while the PBL approach appears to be effective in improving retention of knowledge, adding a Flipped Classroom component does not necessarily enhance this effect.

Regarding innovation, this study indicated that neither PBL nor FCM+PBL significantly affected the post-test scores related to individual innovation competence. This might be seen as contrasting with studies like Akdeniz (2020) and Perçin (2019), which found positive impacts on individual innovative behavior with specific interventions. This discrepancy might be attributed to the specific methods used in each study or how "innovation" is defined and measured. Moreover, this study extends the understanding of how these educational strategies impact innovation competence, an area that needs to be explored in previous studies. Although no significant effect was found in this study, this adds valuable information to the ongoing discussion about the role of pedagogical strategies in fostering innovation.

One of the critical contributions of this study lies in exploring the integrated use of Project-Based Learning (PBL) and the Flipped Classroom Model (FCM). This study has demonstrated that PBL and FCM+PBL positively impact post-test academic achievement scores. This study also showed that combining FCM and PBL was beneficial.

Recommendations

Despite the potential benefits of the PBL-FCM integration, it is essential to acknowledge its limitations and the need for further research. One of the critical challenges is the requirement for significant changes in teaching practices and infrastructure. Teachers must be trained to implement and manage this integrated approach effectively, and sufficient technological resources must be available to support PBL with FCM. Furthermore, ensuring that all students can equitably access these resources is another area that needs attention.
Research on the impacts of the PBL-FCM integration is still relatively developing, and more studies are needed to strengthen understanding of its impacts on various learner populations. Longitudinal studies would be valuable to assess the long-term impacts on academic achievement, retention, and the development of innovation competencies. Future research should also consider the role of assessment in a FCM-PBL environment.

Author (s) Contribution Rate

The outhors contributed equally to this research.

Conflicts of Interest

The authors declare that they have no personal and financial conflict of interest associated with this publication to disclose.
This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Ethical Approval

Ethical permission (05.11.2019-192) was obtained from Muğla Sıtkı Koçman University Human Research Ethics Committee for this research.

References

Akçayır, G., & Akçayır, M. (2018). The flipped classroom: A review of its advantages and challenges. *Computers & Education*, *126*, 334–345. https://doi.org/10.1016/j.compedu.2018.07.021

Akdeniz, M. Y. (2020). *The Effect of innovation education program on teachers' individual innovation behavior*. [Unpublished master's thesis]. Necmettin Erbakan University, Konya.

Aksela, M., & Haatainen, O. (2019). *Project-based learning (PBL) in practise: Active teachers' views of its' advantages and challenges*. In Proceedings of the 5th International STEM in Education Conference Post-Conference (pp. 9–16). Queensland University of Technology. Retrieved from http://hdl.handle.net/10138/304045

Alsancak-Sirakaya, D., & Ozdemir, S. (2018). The effect of a flipped classroom model on academic achievement, self-directed learning readiness, motivation and retention. *Malaysian Online Journal of Educational Technology*, *6*(1), 76-91.

Asbjornsen, D. J. (2015). The development of innovation skills through project based learning. *International Dialogues on Education Journal*, *2*(2), 94-109. https://doi.org/10.53308/ide.v2i2.191

Aydin, B., & Demirer, V. (2022). Are flipped classrooms less stressful and more successful? An experimental study on college students. *International Journal of Educational Technology in Higher Education*, *19*(1), 1–17. https://doi.org/10.11186/s41239-022-00360-8

Baepler, P., Walker, J. D., & Driessen, M. (2014). It's not about seat time: Blending, flipping, and efficiency in active learning classrooms. *Computers & Education*, *78*, 227-236. https://doi.org/10.1016/j.compedu.2014.06.006

Barak, M., & Usher, M. (2021). The innovation level of engineering students' team projects in hybrid and MOOC environments. *European Journal of Engineering Education*, *47*(2), 299-313. https://doi.org/10.1080/03043797.2021.1920889

Bekereci, Ü. (2022). *The effect of the use of project-based learning methods and station technique in stem learning model on students' academic achievement, retention, towars attitudes to STEM*. [Unpublished doctoral dissertation]. Gazi University, Ankara.

Bell, S. (2010). Project-based learning for the 21st century: Skills for the future. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *83*(2), 39–43. https://doi.org/10.1080/00098650903505415
Bergmann, J., & Sams, A. (2012). *Flip your classroom: Reach every student in every class every day*. ISTE.
Büyüköztürk, Ş. (2018). *Data analysis handbook for social sciences*. Pegem Academy Publishing.
Cabi, E. (2018). The impact of the flipped classroom model on students' academic achievement. *International Review of Research in Open and Distance Learning*, *19*(3), 202–221. https://doi.org/10.19173/irrodl.v19i3.3482
Çakır, E., & Yaman, S. (2017). The effect of flipped classroom applications on students' academic success and intellectual risk-taking skills in science course. *Journal of Science Teaching*, *5*(2), 130–142. http://dx.doi.org/10.35826/ijetsar.699
Çakıroğlu, Ü., & Öztürk, M. (2016). *Examination of the application trends of the flipped classroom model*. 10th International Computer and Instructional Technologies Symposium (ICITS) in Proceedings Book (pp. 168–180).
Capraro, R. M., & Slough, S. W. (2013). *Why PBL? Why STEM? Why now?* (R. M. Capraro, M. M. Capraro & J. R. Morgan Eds.) In STEM project-based learning: An integrated science, technology, engineering, and mathematics (STEM) approach. (pp. 1–5). Brill. Retrieved from https://brill.com/display/book/edcoll/9789462091436/BP000002.xml
Chistyakov A, Zhdanov, S., Avdeeva, E., Dyadichenko, E., Kunitsyna, M., & Yagudina, R. (2023). Exploring the characteristics and effectiveness of project-based learning for science and STEAM education. *Eurasia Journal of Mathematics, Science and Technology Education*, *19*(5), 1–7. https://doi.org/10.29333/ejmste/13128
Creswell, J. W., & David, C. J. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage Publications.
Deveci, İ., & Kavak, S. (2020). Innovativeness perceptions and innovative thinking tendencies of middle school students: An exploratory sequential design. *Journal of Qualitative Research in Education*, *8*(1), 346-378. https://doi.org/10.14689/issn.2148-2624.1.8c.1s.15m
Dilşeker, Z., & Serin, O. (2018). The impact of the use of project based learning methods in science and technology lesson on the 5th grade primary school students' attitudes, success in lesson and elimination of misconceptions towards science and tehnology lesson. *International Journal of New Trends in Arts, Sports & Science Education*, *7*(2), 1–30.
Elian, S. M., & Hamaidi, D. A. H. (2018). The effect of using flipped classroom strategy on the academic achievement of fourth grade students in Jordan. *International Journal of Emerging Technologies in Learning (IJET)*, *13*(02), 110. http://dx.doi.org/10.3991/ijet.v13i02.7816
Field, A. (2018). *Discovering statistics using IBM SPSS statistics* (5th ed.). Sage Publications.
Goldsmith, R. E., & Foxall, G. R. (2003). *The measurement of innovativeness*. L. V. Shavinina (Ed.), In The International Handbook on Innovation (pp. 321-330). Elsevier. Retrieved from https://doi.org/10.1016/B978-008044198-6/50022-X
González-Gómez, D., Jeong, J. S., Rodríguez, D. A, & Cañada-Cañada, F. (2016). Performance and perception in the flipped learning model: An initial approach to evaluate the effectiveness of a new teaching methodology in a general science classroom. *Journal of Science Education and Technology*, *25*(3), 450-459. https://doi.org/10.1007/s10956-016-9605-9
Güler, M., Kokoç, M., & Önder Bütüner, S. (2023). Does a flipped classroom model work in mathematics education? A meta-analysis. *Education and Information Technologies*, *28*(1), 57–79. https://doi.org/10.1007/s10639-022-11143-z
Gülhan, F. (2016). *The effect of science-technology-engineering-mathematics integration (STEM) on 5th grade students' perception, attitude, conceptual understanding and scientific creativity*. [Unpublished doctoral thesis]. Marmara University, İstanbul.
Güngör, M. (2022). Examining the relationship between students' English achievement and self-regulation and individual innovation levels. *International Journal of Social Sciences*, *6*(24), 237-258.
Haak, M. D., & Burand, M. W. (2016). *Less class time, more learning: The evolution of a hybrid general chemistry course for science majors*. J. L. Muzyka & C. S. Luker (Eds.) In The flipped classroom Volume 2: Results from practice (pp. 39–53). American Chemical Society. Retrieved from https://doi.org/10.1021/bk-2016-1228.ch003
Keinänen, M. M., & Kairisto-Mertanen, L. (2019). Researching learning environments and students' innovation competences. *Education and Training*, *61*(1), 17–30. https://doi.org/10.1108/ET-03-2018-0064
Keinänen, M., Ursin, J., & Nissinen, K. (2018). How to measure students' innovation competences in higher education: Evaluation of an assessment tool in authentic learning environments. *Studies in Educational Evaluation*, *58*, 30-36. https://doi.org/10.1016/j.stueduc.2018.05.007

Keskin, E., Karagölge, Z., & Ceyhun, İ. (2021). Investigation of the effect of flipped classroom method on academic achievement of 10th grade students in “Acids, Bases and Salts” Unit. *Journal of Science Teaching*, *9*(1), 58–88.

Kirton, M. (1976). Adaptors and innovators: A description and measure. *Journal of Applied Psychology*, *61*(5), 622-629. https://doi.org//10.1037/0021-9010.61.5.622

Kleysen, R. F., & Street, C. T. (2001). Toward a multi-dimensional measure of individual innovative behavior. *Journal of Intellectual Capital*, *2*(3), 284-296.

Larmer, J., Mergendoller, J., & Boss, S. (2015). *Setting the standard for project based learning*. ASCD.

Morsch, L. A. (2016). *Flipped teaching in organic chemistry using iPad devices*. J. L. Muzyka & C. S. Luker (Eds.), In The Flipped Classroom Volume 1: Background and Challenges (pp. 73–92). American Chemical Society.

Mutlu, O., & Aydın, G. (2023). Development of individual innovation competence scale for secondary school students: Validity and reliability study. *The Journal of Buca Faculty of Education*, *56*, 682-704. https://doi.org/10.53444/deubefd.1237641

O’Flaherty, J., & Phillips, C. (2015). The use of flipped classrooms in higher education: A scoping review. *The Internet and Higher Education*, *25*, 85-95. https://doi.org/10.1016/j.iheduc.2015.02.002

Ovbiagbonhia, A. R., Kollöffel, B., & Brok, P. den. (2019). Educating for innovation: Students’ perceptions of the learning environment and of their own innovation competence. *Learning Environments Research*, *22*(3), 387–407. https://doi.org/10.1007/s10984-019-09280-3

Perçin, F. (2019). *The effect of flipped teaching method on students' achievement, technology attitudes and individual innovativeness levels in programming teaching*. [Unpublished master's thesis]. Marmara University, İstanbul.

Rau, M. A., Kennedy, K., Oxtoby, L., Bollom, M., & Moore, J. W. (2017). Unpacking “active learning”: A combination of flipped classroom and collaboration support is more effective but collaboration support alone is not. *Journal of Chemical Education*, *94*(10), 1406–1414. https://doi.org/10.1021/acs.jchemed.7b00240

Ryan, M. D., & Reid, S. A. (2016). Impact of the flipped classroom on student performance and retention: A parallel controlled study in general chemistry. *Journal of Chemical Education*, *93*(1), 13-23. https://doi.org/10.1021/acs.jchemed.5b00717

Scott, S. G., & Bruce, R. A. (1994). Determinants of innovative behavior: A path model of individual innovation in the workplace. *Academy of Management Journal*, *37*(3), 580-607.

Wilhelm, J., Wilhelm, R., & Cole, M. (2019). *Creating project-based STEM environments*. Springer International Publishing. Retrieved from https://doi.org/10.1007/978-3-030-04952-2_1

Topçu, R. (2019).*The effect of implementing project based learning approach in science lesson to the success of students*. [Unpublished master's thesis]. Necmettin Erbakan University, Konya.

Triana, D., Anggraito, Y. U., & Ridlo, S. (2020). Effectiveness of environmental change learning tools based on STEM-PjBL towards 4C skills of students. *Journal of Innovative Science Education*, *9*(2), 181–187.

Varas-Contreras, M. Maluenda-Albornoz, J. Chacano-Osses, D.&Vidal-Valenzuela, J. (2021). *Effects of a project based learning on the development of innovation competencies in online mode in first-year engineering students*. 40th International Conference of the Chilean Computer Science Society (SCCC), 2021-November, 1-5. Retrieved from https://doi.org/10.1109/SCCC54552.2021.9650414

Yıldırım-Yakar, Z. (2021). The effect of flipped learning model on primary and secondary school students' mathematics achievement: A meta-analysis study. *Cukurova University Faculty of Education Journal*, *50*(2), 1329–1366. https://doi.org/10.14812/cuefd.865337

Yıldırım, E. N. M. (2022). *Examination of science teacher candidates' attitudes towards digitalization in education and their level of innovation towards robotic coding*. [Unpublished master's thesis]. Necmettin Erbakan University, Konya.