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THE EFFECTS OF PROJECT-BASED APPLICATIONS IN EDUCATION ON ACADEMIC SUCCESS SCORES OF STUDENTS: A META-ANALYSIS

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Abstract: This study sought to investigate the effects of project-based learning on students' academic achievement scores by conducting a meta-analysis of studies on the topic. The analysis comprised 60 post-graduate theses from 2007 to 2019 as well as articles scanned from the TR directory. The CMA 3.0 statistical tool and the Microsoft Excel 2013 program were used to analyze the data using the "transaction impact" method. The studies' homogeneity value was found to be 98.68, and the random-effects model was used to assess the effect size with a significance level of 95% and 40 degrees of freedom. According to the study's findings, project-based learning has a very high impact rate in the category of size rating (Cohen et al., 2007).

Keywords: Project Based, Meta-Analysis, Academic Achievement Scores.

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EĞİTİMDE PROJE TABANLI UYGULAMALARIN ÖĞRENCİLERİN AKADEMİK BAŞARI PUANLARINA ETKİSİ: BİR META-ANALİZ

Öz: Mevcut araştırmada, literatürde proje tabanlı/tabanlı öğrenmeye yönelik geliştirilen çalışmaların meta-analizi ile proje tabanlı/tabanlı uygulamaların öğrencilerin derslerdeki akademik başarı puanlarına etkisinin belirlenmesi amaçlanmıştır. 2007-2019 yılları arasında derslerde proje tabanlı/tabanlı uygulamaların öğrencilerin akademik başarı puanlarına etkisini belirlemeyi amaçlayan 60 lisansüstü tez ile birlikte TR dizininde taranan makaleler araştırmaya dahil edilmiştir. Bu çalışmada veriler "işlem etkisi" yöntemiyle analiz edilmiştir. Analiz aşamasında CMA 3.0 istatistik programı ve Microsoft Excel 2022 programından faydalanılmıştır. Araştırma kapsamındaki çalışmaların homojenlik değeri (Q=98.68) belirlendikten sonra incelenen ki-kare tablosunda anlamlılık düzeyinin %95 olduğu ve kırk serbestlik derecesine ulaştığı ve buna bağlı olarak çalışmalar rastgele etkiler modeli kullanılarak hesaplanmıştır. Araştırma sonucunda proje bazlı/bazlı uygulamaların boyut derecelendirme sınıflandırmasında çok yüksek etki oranına sahip olduğu belirlenmiştir (Cohen vd., 2007).

Anahtar Kelimeler: Proje Tabanlı, Meta-Analiz, Akademik Başarı Puanları.

INTRODUCTION

The curriculum, which has been implemented in Turkey since 2005 and stemmed from the constructivist approach that targets to equip individuals with an infrastructure that can access new information through experiences, research from primary sources, make sense of information and produce solutions to the problems they encounter in their daily lives. It is advocated that teachers should use project-based learning approaches in learning environments in order for the individual to achieve these goals.

The basis of the project-based learning approach is formed by the studies of theorists such as John Dewey, Kilpatrick, Piaget, Bruner, and Vygotsky (Korkmaz & Kaptan, 2001). When the underlying theories are scrutinised, it is cleared that project-based learning is based on the principle of solving the problems that students encounter in daily life. In addition, it provides opportunities for students to work on a scenario/ problem in a unique style by establishing connections with other disciplines in the

process, structuring their knowledge and producing products that can create solutions to the problem by combining this information into meaningful wholes. In addition, in project-based learning, students can use creativity, questioning, evaluation, reconstruction, and decision-making, within existing scenarios/problems and mental activities that allow both individual and group work (Demirel, 2001).

There are many studies in Turkey and abroad on the project-based learning approach, which contributes to students' high-level intellectual skills as well as their interests and attitudes toward the course. In these studies, the contribution of project-based learning on learners' educational success, students' scientific process skills, the permanence of learning, motivation towards the course, and critical thinking were examined in general (Altun, 2008; Ayaz & Sönmez, 2015; Aydemir, 2019; Baran, 2011; Demir, 2008; Ekiz, 2008; Gültekin, 2009; Güven, 2011; İmer, 2008; Karaçallı, 2011; Özahioğlu, 2012; Türkmen 2019). Attitude-scientific process skills-motivation-permanence-critical thinking) effects were found statistically significant (Aydemir, 2019; Doğay, 2010; Güven, 2011; Nuraydın, 2019; Türkmen, 2019), while it was statistically significant in some studies. The conclusion is that there is no difference (Değirmenci, 2011).

Educational research on the project-based learning approach in the literature and made from different perspectives need to be brought together (such as content-based learning), synthesized, and evaluated together (Ayaz & Sönmez, 2015; Karanfil, 2020). Because although these studies are scientifically designed to make comprehensive generalizations about a single success, the validity and reliability of the study group, time, transportation, and data collection tools may not be able to present very comprehensive findings due to their limitations. At the same time, they conclude by suggesting that more research on project-based learning is required (Özcan, 2007).

Comprehensive studies obtained by literature review in scientific research benefit from a large number of studies in order to obtain more general results on the subject (Cooper, 2010). Obtaining more general results is one of the main purposes of both literature review and meta-analysis studies. In a meta-analysis, the findings, and results of the studies on the subject are brought together in a logically and consistently composed design. (McLeod, 2019).

The purpose of this meta-analysis is to examine the impact of project-based learning, which is advised in the constructivist approach, on test scores for academic attainment. By conducting a meta-analysis of research on project-based learning in the literature, the study seeks to shed light on the effect of project-based learning on academic success. The study also seeks to pinpoint the traits that enhance the impact of project-based learning on academic achievement. The results of this study are

anticipated to inform future research on project-based learning and improve the effectiveness of project-based learning in the context of academic accomplishment.

1. METHODS

1. 1. Study Design

In this research, the meta-analysis method was used to determine the effectiveness of project-based/based applications on students' academic achievement scores. This method involves comparing and combining the results obtained in various experimental studies using statistical methods to determine effect sizes (Laken, 2022). In other words, meta-analysis is an analysis of the analyses conducted in different studies to draw more reliable and generalizable conclusions.

1. 2. Data Collection

Within the parameters of the study, the data were obtained from published and unpublished master and doctoral theses and articles scanned in the TR index, which investigated the effect of the "Project-Based/Based Approach" on the academic achievement of students and included statistical results suitable for meta-analysis.

The postgraduate theses included in the research were accessed from the YÖK National Thesis Center, and the articles were accessed from the TR directory of the ULAKBİM Cahit Arf Science Center (CABİM) website. First, 310 studies with the words "project-based learning" and "project-based learning" in their titles and also in the key concepts section are listed. The researchers examined the full texts of the studies. As a result of the examinations, 60 theses and articles on the effect of project-based/based learning approaches on academic achievement, which are suitable for the research subject and meta-analysis inclusion criteria, were comprising the meta-analysis research.

1. 3. Inclusion Criteria

A certain standard is established with inclusion criteria to ensure the reproducibility of the subject discussed in meta-analysis studies and to minimize the possible bias in the process of determining the studies to be included in the process (Petitti, 2001). The inclusion criteria used in this study are presented below.

Research Method: Experimental studies in which experimental and control groups were applied and parametric analyses were carried out were included.

Dependent variables: In the theses and articles, which include project-based/ based topics, and analyzed, the academic achievements of the students in the project-

based course were analyzed as the dependent variable, and the articles scanned in the TR index were included. Among the theses and articles examined, the studies that examined project-based learning, students' attitudes, remembering, transfer and retrieval, apart from academic achievement, were not included.

Time range: All publications scanned in the National Database and TR Index between 2006 and 2020 and allowed were added.

Adequate numerical data is crucial in the meta-analysis method. The number of students in the experimental and control groups (N), their academic achievement averages ($\bar{x}$) and standard deviation (Ss), and the p-value are all used to determine the effect size (Yavuz and Dinçer, 2012). Therefore, studies that lack or do not include this information were excluded from the analysis.

1. 4. Exclusion Criteria

Lipsey and Wilson (2001) think that the studies reached are not within the framework determined by the researcher and that they cannot be included in the meta-analysis in cases where there is not enough data. Therefore, studies that do not meet the specified criteria were not included in this study. Therefore, 60 studies that fulfilled the inclusion requirements were coded for meta-analysis.

1. 5. Coding Method

As in all scientific studies, it is necessary to systematically record the data obtained in meta-analysis studies, to check their suitability, and to code them for later analysis.

In order to ensure internal reliability in meta-analysis studies, a coding form should be created at the beginning of the process. This will contribute to providing a detailed explanation for future researchers and practitioners and ensure the external validity of the study (Başol et al., 2016). Because of the situation, the researchers developed a coding form to collect the data required for analysis and included it in the studies that fulfilled the inclusion criteria. Descriptive data of the experimental and control groups in the included studies (year of implementation, courses applied, cities applied, education level, etc.) and the main characteristics of the studies (sample size, academic achievement averages, and standard deviation) were recorded to be analyzed.

1. 6. Dependent Variables

The effect sizes relating to the contribution of the project-based learning technique on academic accomplishment in comparison to the conventional face-to-face approach are the dependent variables of the current study.

1. 7. Operating Characteristics

As the features of the studies that were used in the current study, the size of the sample/study group, the average values of the academic achievement scores, and the standard deviations of these scores were examined together with the education level where the application was made.

1. 8. Data Analysis

In this study, the "process effect" method was used to analyze the data. This method is preferred when the mean scores of the dependent variable in each study included in the meta-analysis are obtained from different scales (Cohen, 1988, as cited in Özcan and Bakioğlu, 2010; Lipsey & Wilson, 2001; Huffcutt, 2002). Hunter and Schmidt (1990) proposed the treatment effect method, which calculates the "d" value using the formula "(Xe-Xc)/SD" to determine the variance between the means of the control and experimental groups. The "d" value represents the "impact degree size," which is the main focus of the meta-analysis and also indicates the strength of the relationship between variables in the studies. This power also reflects the extent of the effect of an experimental intervention (Cheung, 2019).

In the meta-analysis research method, different models can be used for the main purpose of statistically combining the results obtained from the studies examined. The random-effects model was used in this study. Studies included in the random-effects model are used when there are different characteristics. In other words, the random-effects model is used in cases where differentiation is due to sampling errors, different characteristics in studies, and other random items (Lipsey & Wilson, 2001). Studies used in this research are heterogeneous since a wide variety of dependent variables and patterns are used, and it was deemed appropriate to use the random-effects model.

The effect sizes obtained from the meta-analysis results were interpreted based on arithmetic means. In addition to the effect sizes of project-based teaching and traditional methods, the analysis was also carried out according to the variable of education level. The CMA 3.0 statistical program and Microsoft Excel 2013 program were used to find the effect sizes and variances of each study and to calculate the total effect size. Publication bias and homogeneity of the studies were also taken into consideration during the analysis.

a) Insignificant impact value: 0.15 and less;
b) Minor effect value: between 0.15-0.40;
c) Medium effect value: between 0.40 and 0.75;
d) Large-level effect value: between 0.75-1.10;

e) Very large effect value: 1.10 - 1.45; and

f) Excellent level of potency: 1.45 and above (Thalheimer and Cook, 2002).

2. RESULTS

During the data analysis phase, the studies and courses where project-based learning was applied were identified in the current study. Table 1 shows the distribution of publications based on the fields where project-based learning was implemented.

Table 1. *The number of majors included in the study.*

Courses investigated	**Number of studies**
Science	28
Social Studies	10
Maths	6
Biology	5
Art	3
English	2
Physics	1
Introduction to Life Skills	1
Electronics	1
Sociology	1
Computer Education	2
TOTAL	50

As shown in Table 1, it has been calculated that project-based/based applications are mostly applied in science (f:28) courses. However, it was checked that 10 of the included studies were applied in social studies courses.

Within the scope of this research, project-based/based applications were examined in the years they were implemented. In Table 2, the distribution of academic research based on the of publication of project-based/based applications is given.

Table 2. Studies examined and grouped by year basis.

Date of publication	Number of research
2006	4
2007	8
2008	13
2009	4
2010	6
2011	2
2012	3
2014	5
2015	3
2016	2
2019	10
TOTAL	60

When Table 2 is analysed, it has been determined that most studies on project-based learning were conducted in 2008 (f: 13). However, it has been determined that project-based studies were mostly implemented before 2010. Within the scope of this study, educational levels where project-based learning is applied have also been determined. Table 3 presents the distribution of studies according to education levels.

Tablo 3. *Education levels and number of studies*

Level of education	Number of studies
Primary	8
Secondary	39
High school	6
Tertiary	7
Total	60

When Table 3 is scrutinised, it has been determined that most studies on the project-based learning approach are at the secondary school level (f:39). However, while there are studies at the primary and university level, it has been determined that the least application is made at the high school level.

Comparison by Random Effects Model

Project-based applications and traditional teaching applications were compared according to the random-effects model, and the findings are presented in Table 4 below.

Table 4. *Average Effect and Degrees of Homogeneity by Random Effects Model*

Average Effect Size	Total Heterogeneity Q	Chi-Square	Confidence Interval %95 Lower	Upper
1.123	97.87	0.00	1.112	1.242

The analysis revealed that the mean effect size was 1.177, with a standard error of 0.050 and a 95% confidence interval ranging from 1.112 to 1.242, as presented in Table 4. This indicates that the project-based teaching approach has a greater impact on students' academic success compared to the traditional teaching method. Moreover, the effect value of 1.10 and above suggests a very large effect size (Cohen, 2000, as cited in Camnalbur & Erdogan, 2008). Table 5 displays the homogeneous distribution grade, mean effect size, and bottom-up 95% confidence intervals of the 60 studies that investigated the contribution of project-based/traditional teaching practices to academic achievement scores.

Table 5. *Results of Average Effect and Degrees of Homogeneity by Random Effects Model*

Model Type	N	Z	Q	ES	Effect Size Low	High
Random Effects Model	60	22.512	97.87	1.177	1.112	1.242

When the project-based activities are against the conventional way of instruction, it is identified that the random-effects model has an effect value of 1.177 and has a large effect in favour of project-based learning. The homogeneity value meets the critical value between 97.87 and 95% confidence interval.

Comparing the Teaching Levels Variable According to the Random Effects Model

In order to investigate the educational level effect of project-based learning and traditional teaching method, a comparison was made according to the random effects model and the findings are shown in Table 6 below.

Table 6. *Findings Regarding Education Level Variable Based on Random Effects Model*

Level of education	Number of studies	Mean Effect size	Total Heterogeneity	Confidence Interval %95 Lower	Upper
Primary	8	1.179	97.432	0.932	1.426
Secondary	31	1.365	97.844	1.283	1.447
High school	5	0.440	98.643	0.086	0.794
Tertiary	7	1.132	97.604	0.870	1.394

As exhibited in Table 6; The average effect size of project-based teaching in primary schools is 1.179, the average effect size of studies in secondary schools is 1.365; the effect size of studies conducted in high school was 0.44; The average effect size of studies conducted at the university level was found to be 1.132. Accordingly, it has been understood that project-based applications have a more critical effect on academic achievement scores than old-school teaching. While it was seen that the effect value had a wide effect in primary school, secondary school, and university, it was determined that the effect was moderate at the high school level.

3. DISCUSSION, RECOMMENDATIONS AND CONCLUSIONS

This research examined 60 studies that were conducted for the effect of the project-based/based approach on academic achievement and were suitable for the inclusion criteria of the research were examined by meta-analysis method. It was determined that the homogeneity value (Q=97.87) of the studies examined according to the fixed effects model, as well as the critical value of the degree of freedom, exceeded forty-one degrees of freedom at the 95% significance level. To address this issue, the researchers employed the random-effects model to estimate the effect size of the studies included in their analysis. The overall effect size of the studies was found to be within the confidence interval of 1.112 to 1.242, with an effect value of 1.177. This result indicates a very large effect (falling between 1.10 and 1.45) according to the effect size classification updated by Kraft (2020).

Kaşarcı (2013) conducted a meta-analysis of theses between 2002-2013 on the impact of project-based approaches on academic achievement in science. The calculated

effect size value was 1.018, within a confidence range of 0.763 to 1.273, indicating a significant effect. Similarly, Ayaz and Söylemez (2015) found an effect size value of 0.112 for project-based teaching in science. These results suggest that project-based teaching has a larger effect on academic success compared to traditional teaching methods. The study also found that at least 1594 studies are needed to reduce the effect size value from 0.60 to 0.01, indicating the reliability of the results.

This study also investigated the impact of project-based learning on academic achievement based on education level. The effect size of project-based learning studies conducted at the primary school level was found to be ES=1.101, indicating a higher effect than traditional teaching methods. The effect size of project-based learning studies conducted at the secondary school level was found to be ES=1.295, which is classified as a very wide level of impact according to Cohen et al. (2007), suggesting that project-based learning has a positive effect on the academic success of secondary school students.

The meta-analysis found that the effect size of project-based learning at the high school level was ES=0.341, which falls into the small effect size classification created by Cohen et al. (2007). Nonetheless, this value still indicates that project-based/based applications are more effective than traditional teaching methods used at the high school level. On the other hand, the effect size of project-based learning at the university level was found to be ES=1.132, which falls into the very wide impact size classification created by Cohen et al. (2007). This suggests that project-based/based applications have significant positive effects on the academic achievement of university students. Furthermore, as described in the study by Karanfil and Özet (2021), project-based learning could be enhanced by utilizing web tools in education and online learning.

This study's limitations are similar to those of the meta-analysis studies. The inclusion of experimental research in this analysis that used a control group pretest-posttest approach is the first of these limitations. The study's inclusion of studies from our nation is yet another drawback. Yet, it is expected that the current research will help determine the educational policies in our nation and highlight the significance of project-based learning in the studies that will be carried out for each educational level.

Peer-review
Externally peer-reviewed
Author Contribution

The author contributed to the entire study.

Conflict of Interest

The author has no conflict of interest to declare.

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