Investigation of the Effectiveness of Hybrid Learning on Academic Achievement: A Meta-Analysis Study

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Abstract

Hybrid learning based on the integration of traditional face to face and online teaching- learning paradigms has become popular with the improvement of technology. This popularity creates a need for making a reinterpretation of the findings of recent empirical studies conducted on the effectiveness of hybrid learning. Thus, it is aimed to present the overall effect of hybrid learning on students' academic achievements by analyzing 45 research findings obtained from 44 quantitative studies published between 2010 and 2020. Relevant studies were identified from the databases of scholarly publications. The sample was examined using the Comprehensive Meta-Analysis (CMA) program. Publication type, education level, discipline, and duration of the intervention were determined as moderator variables. The results show that the effect of hybrid learning on students' achievement is statistically higher (d = 1.032) in the random-effects model. A heterogeneous distribution was obtained from the sample Further subgroup analyzes using Analog ANOVA revealed that only the discipline variable is statistically significant. It was concluded that the discipline of biology has the highest effect size and the discipline of science has high effect size respectively. Furthermore, the impacts of these findings were discussed and relevant suggestions were given for future researches.

Keywords: Academic Achievement, Effect Size, Hybrid Learning, Meta-Analysis

DOI: 10.29329/ijpe.2022.426.14

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INTRODUCTION

The highly contagious Covid -19 virus, emerged towards the end of 2019, spread rapidly all over the world in a short time, especially in Europe (WHO, 2020). In order to break the transmission chains of the Covid-19 virus, which is rapidly transmitted by human contact and respiration (Huang et al., 2020), the activities of educational institutions, which are one of the institutions where human contact is intense, have been suspended (De Luca, 2018). The impact of Covid-19 on updating educational activities is anticipated to be significant moving forward (Bragg, Walsh & Heyeres, 2021). In this context, due to the pandemic all over the world, central exams were postponed, face-to-face education activities were terminated, and distance education was conducted (Can, 2020). In the 21st-century, with the rapid development of technology and the speed of access to information, distance education activities have been rapidly adopted all over the world, and the use of hybrid education applications that combine traditional education with distance education has come to the fore in the post-pandemic period. Hybrid learning, considered as the final point reached in distance education, where technology and educational applications meet, has become the focus of attention of educators and researchers.

Pesen (2014) defined hybrid learning as an ideal approach for combining the strongest aspects of classroom and online learning and developing the knowledge and communication skills necessary for success. It is inferred that the main purpose is to contribute to the learning of students by making the most effective and efficient use of the educational environment created by combining face-to-face learning with technology-supported teaching. In the hybrid learning process, face-to-face lessons are taught with in-class activities, while some activities and practices should continue outside the classroom. In order to carry out these practices outside the classroom in an appropriate way, there is a need for an auxiliary tool that can manage the distance education process (Çırak Kurt et al., 2018). Some web tools are used for presenting and managing learning material and course content on the web in the distance part of blended learning environments, sharing the presented material in different ways such as chat or discussion platforms, evaluating and observing the students' performance, homework, exams, providing feedback on assignments and exams. These web tools include Moodle, Blackboard, Edpuzzle, Blogs, Camtasia Studio, E-learning Platform, Google Docs, Learning Management Systems, Blackboard, Khan academy, Moodle, Prezi, Storyline, Youtube.

A brief literature analysis shows that many independent studies are examining the effect of hybrid learning application on students' academic success. An examination of the studies in the literature demonstrates that some studies reported that blended learning application increased academic success (Author & , 2014; Obiedat et al., 2014; Umar & Reis, 2014; Gürdoğan & Bağ, 2018; Roomy & Althewini, 2019; Al-Qatawneh et al., 2020; Kadirhan & Korkmaz, 2020), while others have revealed that it has no effect on academic achievement (Arano-Acuaman, 2010; Li et al., 2013; Öner et al., 2014; Çiftçi & Dönmez, 2015). Given this situation, this study aims to conduct a reliable meta-analysis study called analysis of analysis in a systematic effort to interpret the findings of previous studies and to guide future research. Although there are a number of meta-analysis studies in the literature (Batdı, 2014; Çırak Kurt, Yıldırım, & Cücük, 2018; Kök, 2018; Korucu & Kabak, 2020; Means et al., 2013; Bernard et al., 2014; Vo et al., 2017; Mahmud, 2018), there is not a comprehensive international meta-analysis for the period of 2010-2020. Especially following the onset of the coronavirus pandemic, the emergence of distance education has also increased the popularity of hybrid learning, and the continuation of education based on this learning has come to the fore. For this reason, a meta-analysis study on this subject is considered necessary to investigate the quantitative results of existing studies which have examined the effect of hybrid learning on academic achievement. As a consequence, the current study set out to synthesize these results and establish the overall magnitude of the effect. For this main purpose, answers to the following research questions (RQ) were sought:

RQ_1. What is the effect size of hybrid learning on academic achievements?

RQ_2. How does the effect of hybrid learning on academic achievements vary as a function of moderator variables (education levels, type of publication, disciplines, and intervention duration)?

Research Methodology

The meta-analysis statistical method following the meta-analytic procedures suggested by Glass et al. (1981), which include (1) literature search and inclusion criteria, (2) coding the features of the studies, (3) calculating the effect sizes of each study's outcome measures, and (4) investigating the moderating effects of a study's characteristics on the outcome measures is selected.

Literature Search and Inclusion Criteria

The data were collected from articles, master and doctoral theses that met the inclusion criteria given in Table 1. Studies were identified with the help of national and international databases in the field of education and published electronically such as ERIC, Web of Science, EBSCOHost, Google Scholar, SCOPUS, PROQUEST, CHE Thesis Center from January to March 2021. In addition, the bibliography sections were examined in the studies reached, in an effort to identify earlier works that may not have been published electronically.

Table 1 Inclusion criteria for the selection of studies

Criteria	Inclusion
Publication period	Completed between 2010 and 2020.
Publication type	An article published in a national or international refereed journal or a master's / doctoral thesis.
Language	Turkish or English.
Research design	An experimental design with a control group. The control group should be taught with the traditional method, while the experimental group with the hybrid learning.
Outcome	Academic achievement
Implementation	Measure the effect of the hybrid learning in the field of education.
Accessibility	Full text available.
Data	Sample size, standard deviation, and mean values.

The researchers identified some keywords to assist the resource search. Binary combinations of such keywords as 'blended learning and academic achievement', 'hybrid learning and academic achievement', 'mixed-mode learning and academic achievement' were scanned in all databases during the research. Overall, the keyword search provides 1326 studies. Next, 489 studies were eliminated because of the duplication, and 593 of them were removed for not being suitable for the research problem. Considering the inclusion criteria, 200 studies were deemed inappropriate. As a result, 44 were selected to form the study sample. However, as Pesen and Oral (2014) showed the effect of hybrid learning on success in their study by working with 2 different disciplines, the researchers were able to increase the size of the sample to 45. A Prisma flow diagram in Figure 1 shows the search and selection process.

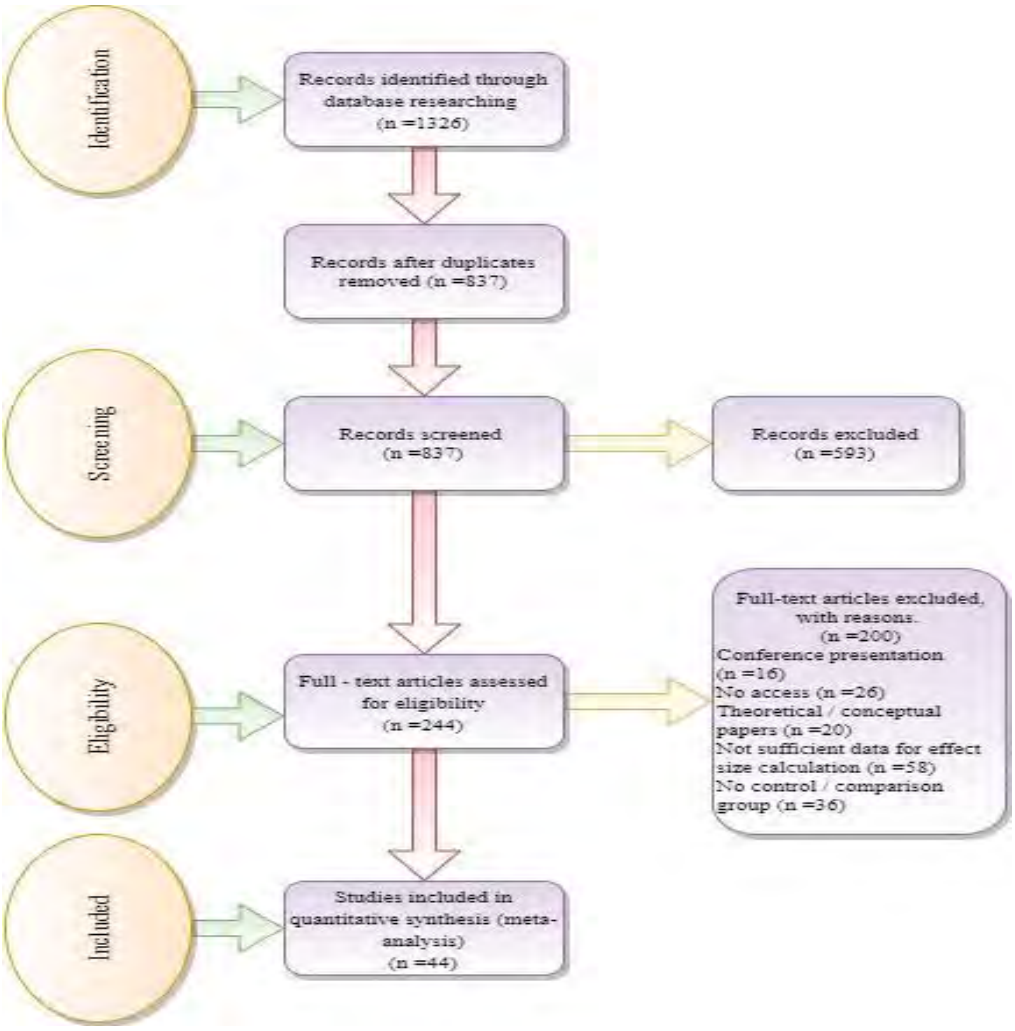


Figure 1 Prisma Flow Diagram

Coding the Features of the Studies

The data of the studies included in the scope of the study were coded by opening an Excel file and numbering the studies. In order to ensure the reliability of the data encoded in the research, the coding process was performed by the first coder having a doctorate in the field of curriculum instruction and education, and also by the second coder, being an expert in that field. After the coding process was completed, the compatibility between the coders was evaluated. Inter-encoder reliability calculation *(consensus / (consensus + disagreement) x 100)* (Miles & Huberman, 1994) and the reliability was found to be 98%.

The validity of a meta-analysis study is proportional to the validity of the studies included in the study (Petitti, 2000). In this context, the validity findings of the studies included in the study were examined and an effort was made to ensure their validity. Besides, studies using inappropriate data and research methods were not included in the meta-analysis and contributed to increasing their validity.

Data Analysis

The data analysis process includes the calculation of the effect size for each study, the control of publication bias, the heterogeneity test, and the calculation of the combined effect size. The Comprehensive Meta-Analysis (CMA Version 3) program was used to analyze the data. The analyses in this study were performed by calculating the 'Cohen d' values. Cohen's (1988) effect size classification is as follows:

- 0.20 - 0.49= small
- 0.50 - 0.79= medium
- 0.80 and above= large effect size.

Two different models are used in the calculation of effect sizes in meta-analysis. These are fixed effects model and random-effects model. The researcher needs to determine in advance which model to act according to the analysis process (Dinçer, 2014). In order to make a more generalizable study and because it is a model recommended to be used in the field of social sciences (Cumming, 2012), this study was based on the random-effects model. On the other hand, meta-analysis aims to determine how the effect size varies across studies. In this respect, the random-effects model has a distribution of true effects. Regarding that the moderator effect can vary across studies, as well as the sampling variability, the random-effects size model was selected to match the expected heterogeneity in this meta-analysis.

RESEARCH RESULTS

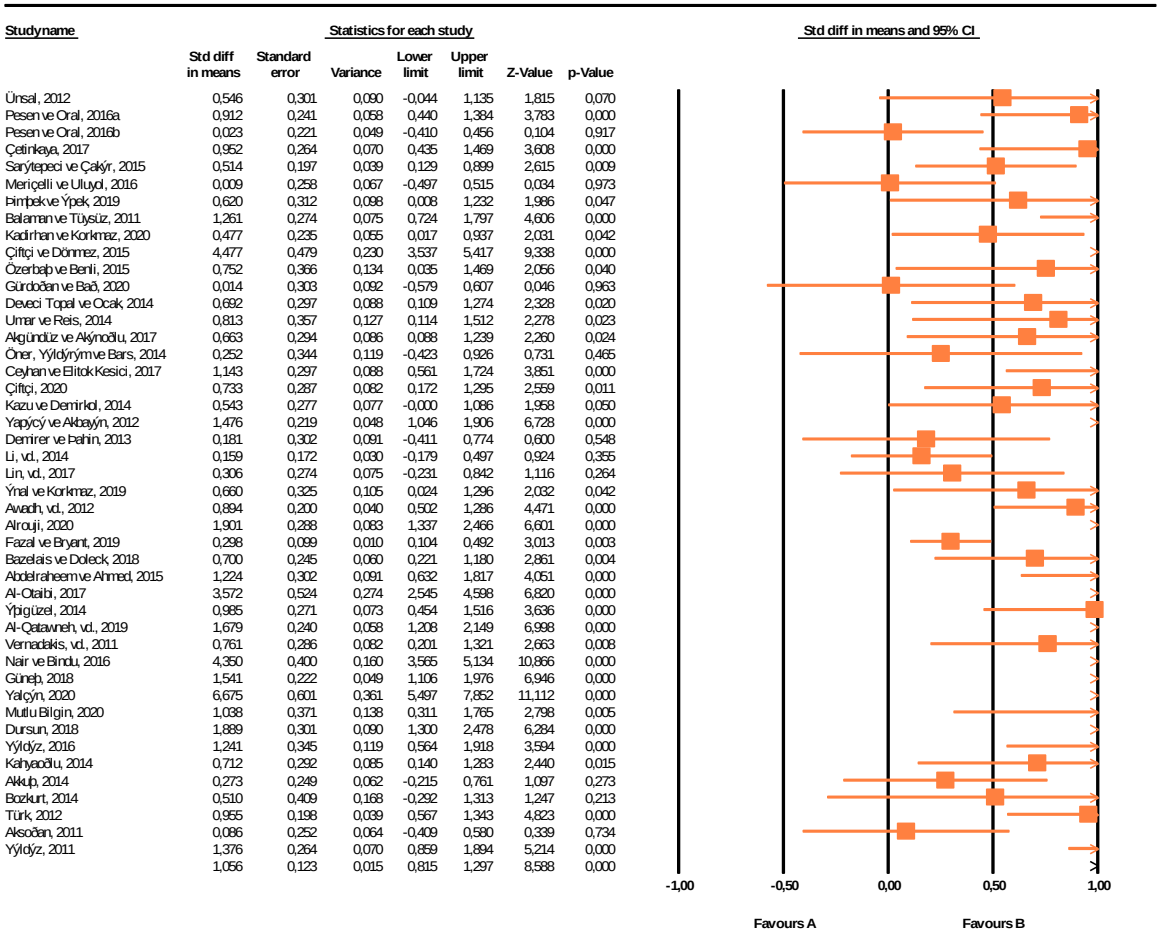
Meta-Analysis Findings of the Studies Included in the Study

In meta-analysis studies, a general conclusion is drawn from the effect size of each study. So as to examine the effect of hybrid learning on the students' academic achievement, 45 studies were included in the meta-analysis process, and the effect size for all studies included in the meta-analysis was calculated. Findings regarding general effect size and heterogeneity were given in Table 2.

Table 2 Table of heterogeneity, confidence interval, and average effect size regarding the effect of hybrid learning on academic achievement

95% CI					Test of Mean		Heterogeneity	
Model	K	ES	Lower	Upper	Z	p	Q	P
Fixed	45	0.777	0.705	0.850	20.956	.000	443.328	.000
Random	45	1.032	0.800	1.264	8.726	.000		

As seen in Table 2, heterogeneity test is significant (Q model = 443.328; df (Q) = 46; p =. 000). On the other hand, I^2 value above 75% is an indicator of high heterogeneity (Higgins & Thompson, 2002), I^2 value can be interpreted that it is 89% highly heterogeneous ($I^2 = 89.624$). The examination of the obtained data showed that the effect size was 0.777 by the fixed effect model and the random effect model effect size was 1.032 and was significant (p =.00 <0.5). The latter corresponds to a 'large effect' value according to the effect size classification of Cohen et al. (2007). A forest plot of the studies demonstrating the distribution of effect size values calculated by the random-effects model is shown in Figure 2.



Meta Analysis

Figure 2 Forest plot demonstrating the distribution of effect size

In the forest plot, the part determined with black vertical lines indicates the effect size of the relevant study in the meta-analysis, while the horizontal lines around it indicate that the effect size of that study is in the 95% confidence interval. In other words, the longer the horizontal line, the larger the confidence interval is. According to the forest plot given in Figure 2, it is seen that the study with the largest confidence interval was attributed to Yalçın (2020), while the study with the smallest confidence interval was published by Fazal and Bryant (2019).

When Figure 2 is examined in terms of effect sizes of the studies included in the meta-analysis, it can be seen that the study of the lowest effect size (d = 0.014) belongs to Gürdoğan and Bağ (2020), the largest belongs to (d = 6.675) Yalçın (2020). While 30 studies (66.66%) have effect sizes below the average effect size, it is seen that 15 studies (33.34%) have a value above the average effect size of the study.

Publication Bias

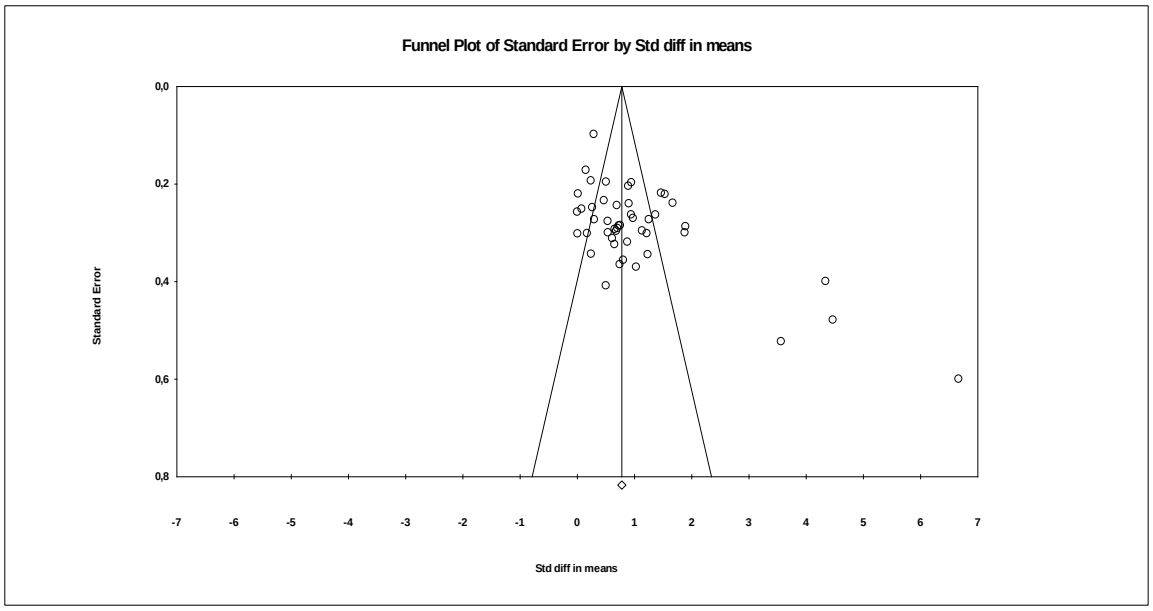


Figure 3 Funnel plot of standard error by effect size

Publication bias was evaluated using a funnel plot, the classic fail-safe N, and Orwin's fail-safe N. As shown in Figure 3, it was found that the funnel plot had a symmetrical distribution. Therefore, there was no publication bias in the present meta-analysis. The results of the classic fail-safe N indicated that 6721 missing studies far larger than 235 (5k+10) would be needed to nullify the effect size. Furthermore, the result of Orwin's fail-safe N revealed that 3607 missing studies would be needed to reduce Cohen's d to a trivial level (0.01). Therefore, the findings indicated that this meta-analysis was not affected by publication bias.

Findings Regarding the Moderator Variables

Studies included in the sample for meta-analysis consist of articles, masters and doctoral dissertations. Due to the scarcity of master's and doctoral theses, they were combined and included in the moderator analysis under the 'theses' subgroup. The findings obtained as a result of the analysis were presented in Table 3.

Table 3 Effect of hybrid learning on academic achievement according to the type of publication

Moderator Variable	Heterogeneity	P	K	ES	CI (95%)	SE
Publication type						
Article	0.892	0.345	34	0.960	[0.703; 1.216]	0.13
Thesis			11	1.242	[0.715; 1.769]	0.26

Table 3 shows that the highest effect size belonged to the thesis type (ES = 1.242), and lower effect size to article type (ES = 0.960). It can be stated that there is no significant difference according to the type of publication of the studies ($Q_b = 0.892$; $p = 0.342>.05$).

The studies included in the meta-analysis were applied at primary, secondary, high school, and university. In order to explain the heterogeneity found, it was included in the moderator analysis. The findings obtained as a result of the analysis were presented in Table 4.

Table 4 Effect of hybrid learning on academic achievement according to education levels

Moderator Variable	Heterogeneity	P	K	ES	CI (95%)	SE
Education Level						
Primary school	6.137	0.10	2	0.717	[0.296; 1.137]	0.214
Secondary school			15	1.515	[0.966; 2.065]	0.280
High school			6	0.752	[0.317; 1.187]	0.222
University			22	0.841	[0.582; 1.099]	0.132

According to Table 4, the highest effect size was found at the secondary school level (ES = 1.515) and the lowest effect size at the primary school level (ES = 0.717). It can be said that there is no significant difference according to the education levels of the studies ($Q_b = 6.137$; $p = 0.10 > .05$).

In order to facilitate analysis, the various periods used by the studies in the sample to measure applications of hybrid learning were categorized as '2-5 weeks', '6-9 weeks', '10 -13 weeks', and '14 weeks and above'. The findings obtained as a result of the analysis were presented in Table 5.

Table 5 Effect of hybrid learning on academic achievement according to the duration of intervention

Moderator Variable	Heterogeneity	p	K	ES	CI (95%)	SE
Duration of intervention						
2-5 weeks	3.883	0.27	12	0.904	[0.422; 1.387]	0.246
6-9 weeks			19	1.319	[0.900; 1.737]	0.213
10-13 weeks			4	0.864	[0.258; 1.471]	0.309
14 weeks and above			10	0.741	[0.302; 1.181]	0.224

According to Table 5, the highest effect size (ES = 1.319) was performed between 6-9 weeks, the lowest effect size (ES = 0.741) was performed for 14 weeks or more. It can be assumed that there is no significant difference according to the application time of the studies ($Q_b = 3.883$; $p = 0.27 > .05$).

The studies included in the meta-analysis were applied to investigate the effect of hybrid learning on the academic achievements of 13 different disciplines. However, the studies, which investigated the effectiveness of hybrid learning on the disciplines of German, chemistry, and material design, were removed from the Analog ANOVA since there was only one study of these disciplines. Thus, the findings obtained as a result of the analysis of 42 research findings were presented in Table 6.

Table 6 Effect of hybrid learning on academic achievement according to the discipline

Moderator Variable	Heterogeneity	p	K	ES	CI (95%)	SE
Disciplines						
Arabic	22.748	0.03	2	1.280	[0.519; 2.041]	0.388
Physical education			2	0.962	[0.497; 1.426]	0237
Computer (ICT)			6	0.732	[0.406; 1.059]	0.167
Biology			3	2.097	[0.275; 3.918]	0.929
Edu. Technologies			2	0.703	[0.319; 1.725]	0.521
Science			9	1.562	[0.739; 2.386]	0.420
English			4	1.200	[0.582; 1.818]	0.316
Math's			7	0.661	[0.302; 1.020]	0.183
Social studies			5	1.142	[0.328; 1.957]	0.415
Medicine			2	0.371	[0.140; 0.881]	0.260

According to Table 6, the highest effect size (ES = 2.097) was performed on the discipline of biology, the lowest effect size (ES = 0.371) was performed on the discipline of medicine. Considering the effect sizes between the groups formed according to the disciplines of the studies included in the meta-analysis ($Q_b = 22.748$; $p = 0.03 < .05$), it can be interpreted that there was a significant difference in the experimental group according to the discipline that the hybrid learning applied. In

other words, it was determined that the effect size of the hybrid learning on academic achievement varies from the difference in the discipline in which hybrid learning applied.

DISCUSSION

Over the past decade, using learning environments supported by digital technology is being increasingly valued. Especially nowadays, the coronavirus pandemic has forced humanity to safeguard itself by interrupting every activity in which face-to-face communication takes place. The emergence of technology and a variety of electronic devices have gained a great deal of attention in educational settings. Recently, a lot of work, as well as education, has been continued online with the help of technology (Ioannou & Ioannou, 2020). Thus, even after the pandemic process, the integration of technology with education has been planned to put into practice in the coming periods. A series of innovative learning methods and courses using educational technologies and theories have also been used to enhance the effectiveness of student learning (Chang, Lee, Tang & Hwang, 2021). One of the innovative learning methods, hybrid learning which is based on combining face-to-face education with online teaching and learning by utilizing the pros of both approaches, became the focus of researchers and educators. On the other hand, the rapid development of technology is an encouraging situation to carry out current studies on this subject (Dikmen & Tuncer, 2018). Therefore, there has been a requirement for examining the results of the studies that investigated the effect of hybrid learning on academic achievement. Over the last decade, there have been several meta-analyses that have addressed the impact of hybrid learning environments and its relationship to learning effectiveness (Zhao et al. 2005; Sitzmann et al. 2006; Bernard et al. 2009; Means et al. 2010, 2013; Bernard et al. 2014). Each of these studies has found small to moderate positive effect sizes in favor of hybrid learning when compared to fully online or traditional face-to-face environments. With the need of updating these kinds of researches, this study aimed to determine the effect of hybrid learning on the academic achievement of students with the method of meta-analysis. In this context, 45 findings out of 44 studies that measure the effect of this model on academic achievement with the experimental method meeting the criteria were included in the meta-analysis process. As a result of the analysis, the distribution of the studies included in the meta-analysis (Q value = 443.328, df = 46, p =.000) was found to be heterogeneous. On the other hand, since it is known that a value of I^2 above 75% means that it is highly heterogeneous (Higgins & Thompson, 2002), I^2= 89.624 and 89% proved to be highly heterogeneous. Hence, this result confirmed that high heterogeneity of the effect size may come from the variety of the design, type, application period, assessment, population, and quality of the selected studies. As a result of the analysis, it was observed that only disciplines explained a significant degree of effect size heterogeneity among the moderator variables that were determined to explain the heterogeneity.

The findings in this study were interpreted on the basis of the knowledge that it is more appropriate to use the random effects model in the field of social sciences (Field, 2010). The average effect size of the studies included in the meta-analysis was found d = 1.032; p =.00. According to Cohen's (1988) classification, a large effect was concluded on this classification. In other words, it can be concluded that hybrid learning has a high level of positive effect on academic achievements. It has been seen that Batdı (2014) found the average effect size as d =.66 from 9 research findings. On the other hand, Çırak Kurt et al. (2018) and Kök (2018) reached similar results and found a moderate effect according to Cohen's (1988) classification. Additionally, Means et al. (2013), Bernard (2014), Vo et al. (2017), and Mahmud (2018) reported that hybrid learning affected academic achievement positively. Accordingly, it is possible to comment that experimental studies that measure the effect of hybrid learning on academic achievements have reported a positive effect. Regarding this comment, our present study is considered to contribute a more meticulous perception of the impact of this type of learning on learners' achievement compared with the traditional learning approach.

Publication Type

Since the studies included in the meta-analysis were approved by at least one jury or referee, they were selected from theses and articles. For the publication type, it was found that there was no

significant difference among the two publication types. This result was similar to the findings of Kök (2018). However, this study revealed that the highest effect size belongs to the article type in contrast to the study conducted by Kök (2018).

Education Level

The studies included in the meta-analysis consisted of studies conducted at primary, secondary, secondary, and higher education levels. However, no significant difference was reached, and it was concluded that the hybrid learning of the teaching level could not explain the effect on academic achievement. Similarly, Means et al. (2013) and Çırak Kurt et al. (2018) determined the teaching level as the moderator variable in their meta-analyses, the findings of these studies support this result. Çırak Kurt et al. observed the highest effect size on a secondary school level similar to this research findings.

Intervention

In this meta-analysis study on the effect of the hybrid learning on academic achievement, the duration of applying the model to the experimental group was determined as another moderator variable. It was understood that there was no significant difference according to the duration of intervention. In other words, the duration of applying the model to the experimental group did not affect the average effect size. Moreover, the present study revealed that the medium intervention duration (6-9 weeks) produced the largest effect size. The main reason might be that too long durations will produce potential variation, and too short durations cannot validate the effectiveness of the method (Zheng et al., 2020).

Discipline

The studies included in the meta-analysis were conducted in various disciplines. These were German, Arabic, physical education, computer, biology, educational technologies, science, English, chemistry, maths, material design, social studies, and medicine. Nevertheless, the studies conducted with German, chemistry, and material design were removed from the analysis since there was only one study. From the 42 findings, it was concluded that the studies with the highest effect size were the discipline of biology, the lowest effect size belonged to the discipline of medicine. It was concluded that there is a significant difference according to the discipline to which the hybrid learning was adopted. In other words, the effect size of the hybrid learning on academic achievement differs with the discipline that the hybrid learning was used. The present study confirmed that the discipline of biology and science has high effect size respectively and this result supports Vo et al. (2017) research findings as biology and science are one of the STEM disciplines. On the other hand, Stockwell et al. (2015), found that a hybrid learning is a more effective strategy for science education compared with traditional approaches. Similarly, Seage and Türegün (2020) confirmed that students tend to achieve higher science scores when placed in a blended learning environment. These findings are supported by Bidarra and Russman (2015) who also claimed that blended learning bridged academic gaps for students especially in science education. Hwang et al. (2020) reached that the students educated with hybrid learning exhibited higher performance in science rather than the ones with traditional learning. In this respect, it is possible to comment that comparison of experimental studies that measure the effect of the hybrid learning on science education have reported a positive effect. Our present study is considered to contribute a more meticulous perception of the impact of this type of learning on learners' science achievement compared with the traditional learning approach.

CONCLUSIONS AND IMPLICATIONS

To conclude, hybrid learning provides strong effects of both face-to-face and online education by gathering them in educational settings. The world is forced by current pandemic periods to use technology to achieve the goals. Thus, it can be anticipated that educators will have to continue to facilitate online teaching with face-to-face education in the future. This situation paves the way for a

need to examine the research findings based on the effects of hybrid learning on academic achievements. The present study aims to examine these studies meta-analytically. These findings are very promising and provide insight into the implementation of the hybrid learning in the future. This study concluded by the large effect size according to Cohen's classification. On the other hand, it is understood that the effect size differs with the discipline in favor of biology and science. Consequently, this paper emphasized that hybrid learning paves the way of academic achievement especially in science and biology education. It is considered that this study contributes to the literature and shed the lights for researchers and readers to apply hybrid learning especially in science education.

In the light of the findings obtained at the end of the research, it was seen that the effect size of the hybrid learning on the academic achievement of the students was at a high level. In line with the results obtained, it was deemed appropriate to make the following suggestions:

- As a result of the analysis, it was understood that the hybrid learning had a large effect on the academic achievement of the students. For this reason, the use of hybrid learning in educational environments should be encouraged, and the necessary infrastructure and facilities should be provided.

- It was understood that the discipline was a distinctive variable on the academic achievement of hybrid learning. It was found that studies applied to the disciplines of biology and science had higher effect sizes. For this reason, it can be suggested that the application of the hybrid model in especially biology and science classes should be encouraged.

- This meta-analysis study focuses on publication type, education level, duration of intervention, and discipline as moderator variables. Future studies can focus on different aspects.

Acknowledgements

There is no acknowledgement.

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NOTE: References marked with ‘’indicate studies included in meta-analysis.