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The Effect of Computer-Supported Collaborative Learning on Academic Achievement: A Meta-Analysis Study

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Abstract

This study aims to examine the effectiveness of Computer-Supported Collaborative Learning (CSCL) on academic achievement. The study was conducted using the meta-analysis method. In the present study, a total of 40 studies that were carried out between 2010 and 2020 and met the inclusion criteria were subjected to meta-analysis. In the present study, the values of the effect size and combined effect size of each study included in the meta-analysis were calculated using Comprehensive Meta-Analysis (CMA) software. The sample of the study consists of 3474 participants. The results of the study revealed that the studies were usually conducted at the university stage with a medium sample size, and published as articles. It was also revealed that most of the studies were carried out in the field of sciences and social sciences. Considering the intervention durations, it was observed that the studies were particularly carried out within a period between 1 and 4 weeks (37.8%). According to the results of the analysis, the average effect size was calculated as 0.523. Considering the results, it can be stated that CSCL has a positive and moderate effect on academic achievement. Also, the results of the moderator analysis revealed that the effect of CSCL on academic achievement did not change by the learning stage, domain subject, and the sample size but it changed by the intervention duration.

Introduction

The rapid changes and developments experienced in information and communication technologies in recent years have facilitated access to information anytime and anywhere. Today, access to information has been gaining importance, and developing technological possibilities has changed the nature of the learning environments. Therefore, it required the transformation of educational institutions to keep up with the times. The technological possibilities obtained through these transformations offered a different perspective to education; thus, it changed the structure of the education system and teaching-learning activities, and it caused education to focus on social and informal learning by getting rid of its traditional school-based formal structure (Ekici, 2012). CSCL, which came to the fore since educational technologies have been frequently used in

classes and collaborative learning method has been widely adopted in education, has been a widely used approach in education. This approach eliminated the requirement for students to come together in the same physical environment and enabled them to perform collaborative studies over computers and the internet (Alsancak & Altun, 2011; Stahl, Koschmann & Suthers, 2006).

In collaborative learning, students study together in small groups for a common purpose. Students are responsible for each other's achievement as well as their own achievements. Thus, the achievement of a student contributes to the achievements of other students in the group (Johnson & Johnson, 2002). The concepts of interaction, common purpose, task, and learning together come to the fore in collaborative learning. On the other hand, CSCL combines collaborative learning and computer-assisted teaching concepts (Ku, Tseng & Akarasriworn, 2013). In CSCL, students conduct their studies by interacting with each other using computers and/or computer technologies for a common goal such as a given task, group project, or intergroup competition (Alsancak & Altun, 2011; So & Brush, 2008). CSCL aims to use computer support for individuals to learn better as a member of a group. This support may include social and cognitive elements such as access to materials, providing various feedback (such as peer opinions, teacher's opinions), establishing intra-group and inter-group communication, and showing individual participation in the study (Reeves, Herrington & Oliver, 2004; Şenel, 2010). In CSCL studies, a wide variety of tools from discussion boards to simulations and from wiki sites to robots are used to support collaborative learning.

Considering the studies on CSCL, it is observed that CSCL has been one of the important learning methods, it has been used effectively in all educational institutions, particularly in higher education institutions, and the number of CSCL applications has been increasing each passing day. Moreover, CSCL has been widely adopted in various fields from science and social sciences to medicine and engineering. CSCL can be applied to campus-based classes (i.e., face-to-face), distance or online education (synchronous or asynchronous) settings, or blended/hybrid learning environments (Resta & Laferrière, 2007).

It is noteworthy that CSCL, which is based on discussion and interaction, has been associated with many learning-teaching theories in terms of its different dimensions. The fact that students study in groups and particularly it is based on interpersonal interaction constitutes the social dimensions of these environments (Solimeno et al., 2008). Another dimension is that the students set a common goal. The goals are of great importance to obtain the collaborative structure. Moreover, the computer-aided environment facilitates utilizing many tools in the learning processes. These environments are considered rich environments that can offer several alternatives in terms of both materials and functions to be used by students (Janssen et al., 2007; Şenel, 2010).

The studies on collaborative learning revealed that it offered several advantages over individual learning. These advantages can be listed as better performance, higher motivation, higher academic achievement, higher level of thinking skills, and a higher level of student satisfaction (Acun, 2004; Johnson & Johnson, 2002). The studies on CSCL also revealed that these advantages could be further improved using proper technology support (Kumar, 1996). Therefore, the innovations it introduced, its contributions to teaching practices, its positive

results for improving the academic achievement and satisfaction of the learner, as well as and the scientific views support these results, strengthen CSCL's position among other strong teaching practices (Çalışkan, Bardakcı & Teker, 2011; Kreijns, 2004).

The studies conducted on this subject stated that CSCL offered students the opportunity to progress individually within the group, it prepared an environment where they could make a positive contribution to the group, and it could give a feeling of being included in the group (Şenel, 2010). Moreover, it was stated that there were several opinions that CSCL could be used as a tool for structuring and sharing information (Liaw, Chen & Huang, 2008; Ziegler, Paulus & Woodside, 2006). Also, it can be stated that this environment offers several possibilities in terms of a constructivist teaching approach (Kynigos, Dimaraki & Trouki, 2007) and provides opportunities for learners to gain high-level cognitive skills in this process by increasing the social interaction opportunities (Arts, Gijselaers & Segers, 2002; Arnseth & Ludvigsen, 2006; Çalışkan & Deryakulu, 2014). Moreover, this learning approach was reported to have a positive effect on students' learning and academic achievement, to increase their awareness about the course, and to contribute to the improvement of their learning skills (Huang, Su, Yang & Liou, 2017; Watson, Dubrovskiy & Peters, 2020; Wu, 2003). Andres (2002) emphasizes that using the classroom environment and the internet together in collaborative learning can make students actively learning individuals who can configure information rather than passively receiving it, and if it is well structured, it can create a high motivation that cannot be achieved in the traditional classroom environment.

Although CSCL makes positive contributions to the learning process, the studies in the literature have revealed that some problems and deficiencies, particularly in achieving collaboration, were observed in such applications. The said problems were observed to be caused by designs and applications that were not compatible with the CSCL such as using an insufficient environment to meet the demands of the participants, including insufficient social interactions, trying to use them directly in the ordinary classroom settings, and not establishing the nature of group study (Arnseth & Ludvigsen, 2006; Kreijns, Kirschner & Jochems, 2002). CSCL environments do not look attractive due to poor interaction designs (Kreijns, 2004). Presenting pleasant and attractive designs increases the motivations of the learners to use these environments; thus, minor deficiencies that may be experienced in the CSCL environment become tolerable (Çalışkan, 2012; Norman, 2002). Technical and financial problems constitute another issue. Instructors who intend to use CSCL applications may not have the required hardware and software. Moreover, the instructors may not have the required competence and skills to use this technology although they provide the physical, economic, and technical conditions (Silva & Breleux, 1994). Even the integration of computers and the internet in schools is a big deal for teachers and school administrators. Moreover, collaborative learning applications using these tools are even more challenging (Acun, 2004). Therefore, eliminating such problems experienced in the applications by fixing them before using them in the class will improve the effectiveness of the learning process. Also, the instructors should avoid using CSCL applications before having institutional support and the necessary infrastructure (Atıcı & Gürol, 2002).

Although there are meta-analysis studies on CSCL in the literature, it can be stated that the number of these studies is still limited. For example, Jeong, Hmelo-Silver, and Jo (2019) presented a meta-analysis study on the effects of CSCL on STEM education. The researchers determined that 143 studies published on the CSCL

between 2005 and 2014 provided the inclusion criteria for their study. According to the results of the analysis, they concluded that the overall effect size of the CSCL in STEM education was moderate. Similarly, Sung, Yang and Lee (2017) conducted a meta-analysis study to examine the effect of mobile computer-supported collaborative learning (mCSCL) on collaborative learning by including 48 studies conducted between 2000 and 2015. In the study, the average overall effect size of mCSCL was found to be 0.516, and it was revealed that mCSCL provided significant improvements to collaborative learning. Also, Chen, Wang, Kirschner and Tsai (2018) conducted a meta-analysis study on the effects of CSCL. The researchers examined 425 studies published between 2000 and 2016 in their study. The results of the analysis indicated that collaboration in computer-based learning had significant positive effects on knowledge gain, skill acquisition, and student perceptions. The results of this study revealed that collaborative learning was more effective compared to individual learning.

The Purpose of the Study

With the developments in educational technologies and the widespread use of collaborative learning methods, the instructors began to use CSCL in educational settings. In the literature, several studies, which were carried out with various sample groups in various fields, reported that the CSCL approach was effective in academic achievement (Gündoğdu & Korucu, 2018; Huang, Su, Yang & Liou, 2017; Lin, 2013; Takači, Stankov & Milanovic, 2015; Watson, Dubrovskiy & Peters, 2020). Unlike these studies, some studies stated that the method has no effect or a low effect on academic achievement (Lin, Chan & Hsiao, 2011; Lin, Hsiao, Tseng & Chan, 2014; Peterson & Roseth, 2016; Razon et al., 2012). Therefore, the studies conducted to determine the effect of CSCL on academic achievement were found to report different results. In this case, it can be stated that comprehensive and reliable upper-level studies are required to contribute to a holistic analysis of these studies with different results, to reach a general judgment, and to make stronger interpretations. In light of this basic rationale, the present study aimed to examine the effectiveness of CSCL in academic achievement. It can be stated that conducting such a study is important in determining the effect size of CSCL in the students' academic achievement. Also, it can be stated that this study is also important to gaining knowledge provided by the existing studies, to guide future studies on the subject, and to provide a reference for them. In line with this purpose, answers to the following research questions were sought:

1. How is the distribution of descriptive statistics of the studies included in the meta-analysis?
2. What is the overall effect size of CSCL on academic achievement?
3. What is the level of the effect size of CSCL on academic achievement in terms of learning stages?
4. What is the level of the effect size of CSCL on academic achievement in terms of intervention durations?
5. What is the level of the effect size of CSCL on academic achievement in terms of courses/subject fields?
6. What is the level of the effect size of CSCL on academic achievement in terms of sample size?

Method

In this part, the meta-analysis method, which is conducted in the research, is described. In the data collection

section, information about the databases searched and the search criteria, as well as, the inclusion and exclusion criteria for the studies to be included in the study. Information about data coding, dependent variables, study characteristics, reliability and validity of the research, and data analysis is given in the following sections.

The Study Model

In this study, the meta-analysis method was used to synthesize the results of independent empirical studies examining the effect of CSCL on academic achievement. Meta-analysis comes fore as an analytical method that includes all the processes of gathering and combining the results of the published/unpublished studies made in different places and times (Şahin, 1999).

Data Collection

In the data collection process, firstly, the research databases and the search criteria were determined. The studies accessed at the end of the searches were subjected to some selection criteria to determine whether they are suitable for the research subject.

Databases Screened and Search Criteria

In the research, online articles published in scientific journals and all published/unpublished Master's Theses and Doctoral Dissertations theses on the meta-analysis subject were searched. The following terms are used as keywords to find the related studies in databases:

(i) terms about collaborative/cooperative learning (i.e., 'collaborative learning', 'collaboration', 'small groups', 'group work', 'cooperative learning', 'group learning', 'team learning', 'computer-supported collaborative learning', 'CSCL' etc.);
(ii) terms about technologies (i.e., 'computer', 'mobile', 'smartphones', 'tablets', 'iPad', 'technology', 'digital', 'online' etc.);
(iii) terms about academic achievement (i.e., 'achievement', 'success', 'performance', 'gains', 'learning outcomes' etc.).

In these searches, studies written in the Turkish and English languages were selected. In the present study, 'Web of Science', 'PsycINFO', 'Wiley Online Library Full Collection', 'Taylor & Francis Online', 'Educational Resources Information Center (ERIC)', 'Scopus (A&I)', 'Science Direct', 'ProQuest Dissertation & Thesis Global', 'Springer LINK', 'Turkish Academic Network and Information Center (ULAKBİM) ' and 'Turkish Council of Higher Education Thesis Center (YÖK)' databases were screened. The screening process was carried out by two researchers who studied in this field. Related studies were collected by examining whether the studies reached by the researchers were duplicates or not. The screening process was repeated at regular intervals to access the most up-to-date publications. The literature review process was terminated as of 1 July 2020.

Inclusion Criteria

The inclusion criteria for the present research are as follows:

(i) The studies must be conducted between 2010 and 2020,
(ii) The studies must use an experimental and/or quasi-experimental design with pretest/post-test control groups to examine CSCL,
(iii) The studies must examine the effect of CSCL on students' academic achievement,
(iv) The studies must report the quantitative data required to calculate the effect sizes or present data from which these values can be calculated [*Sample Size (N); Mean ($\bar{X}$); Standard Deviation (SD)]*.

The PRISMA flow diagram (Moher, Liberati, Tetzlaff, Altman & Group, 2009), which shows the process of obtaining the studies included in the meta-analysis during the literature review, is given in Figure 1.

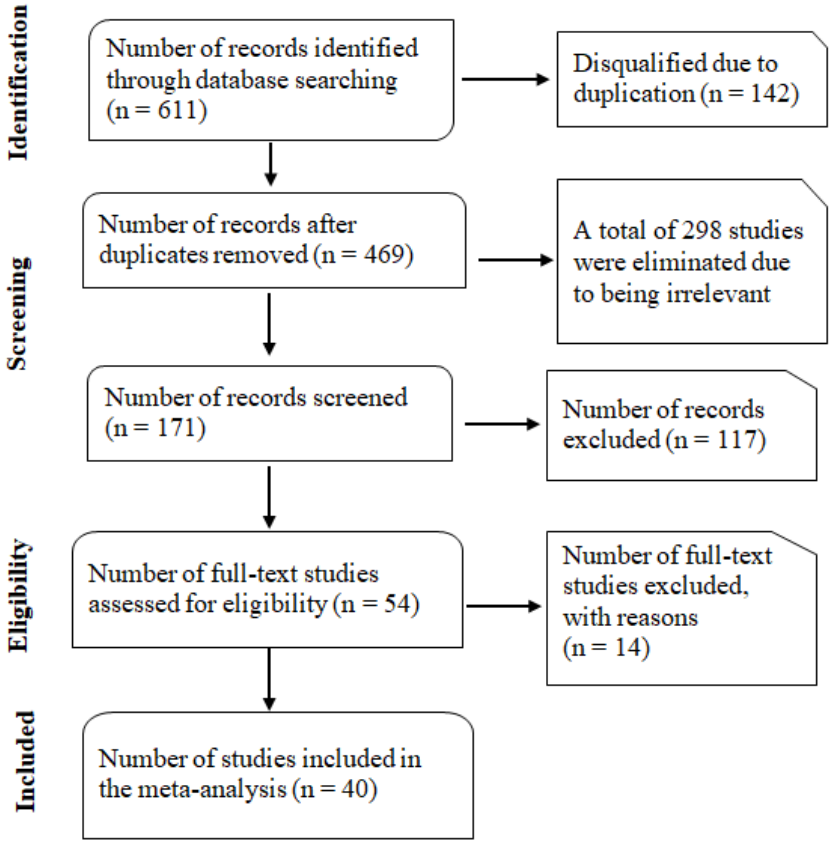

Figure 1. Flow Diagram for the Study Selection

Considering Figure 1, it is seen that a large number of publications (n=611) examining the effects of CSCL on academic achievement were found in the first searches made by screening the databases. Relevant filters were applied to these publications to narrow down the scope of the research. After the search criteria were applied, 142 of these studies were excluded because they were identical copies. Moreover, 298 studies were also excluded since their abstracts are irrelevant to their titles. In the end, 171 studies were included in the study.

Upon examining these studies in terms of the inclusion criteria, 117 of them were also excluded. Then, the remaining 54 studies were evaluated in terms of their suitability and quality. Finally, it was decided to include 40 studies in the meta-analysis since 14 studies were also excluded because they were not suitable for the study, in other words, they did not contain sufficient data and had poor quality. Considering all 40 studies included in the study, the present research was carried out based on the data obtained from these studies conducted with a total of 3474 participants, 1841(52.99%) in the experimental group and 1633 (47.01%) in the control group. In this case, it is seen that the number of study samples is high.

Exclusion Criteria

The studies that were not within the limits of the research or did not have the required statistical data for analysis were not included in the meta-analysis. In other words, the studies that did not meet the inclusion criteria were excluded from the study. Moreover, the fact that many studies did not include an experimental study section, and some studies were conducted before 2010 were among the reasons for exclusion. On the other hand, since some of the theses were also published as an article, the article version was taken as the basis and included in the meta-analysis study. It was determined that some of the studies obtained from the screening process were recorded in multiple databases and some of them were not experimental studies. Therefore, non-experimental studies were excluded from the analysis in this meta-analysis study.

Coding of the Studies

After determining the studies to be included in the meta-analysis, these studies should be coded. The purpose of coding the studies is to transform descriptive data into quantitative data. According to Camnalbur (2008), several methods can be used for coding. However, a coding system that can cover data from all studies and show the unique aspects of these studies should be used in coding.

In the present study, a coding form was developed to contain the necessary information for all studies included in the meta-analysis. The relevant data in the developed coding form are discussed under three headings (Table 1).

Table 1. Chapters of the Codification form and its Content

The identity of the study	**Contents of the study**	**The data of the study**
Study number	Learning Stage	Sample size (N)
The title of the study	Intervention duration	Mean ($\overline{X}$)
Author/Authors of the study	Domain subject	Standard deviation (SD)
Publication year		
Publication database		
Publication type		

The coding form, which was prepared in line with the purpose of the study, was reviewed by three experts in

their fields. Then, it was examined by a linguist and two researchers who had experience in content analysis studies. The form was finalized in light of the feedback received. Also, some corrections were made in the classification form by performing pilot applications. The content validity and face validity of the classification form were ensured after reformatting it according to the results of the opinions and the pilot applications. The Microsoft Excel 2010 software was used to save the data recorded in the coding form and transfer it into electronic media.

Dependent Variables

The dependent variable of the meta-analysis studies is the effect size. The dependent variables of this research are the effect sizes of CSCL on students' academic achievement determined in the studies included in the research.

Study Characteristics

The independent variables of the meta-analysis study are the study characteristics. These independent variables, which were obtained from the studies meeting the inclusion criteria, were recorded in the coding form since they would be used to evaluate the relationships between effect sizes. The study characteristics of this meta-analysis study are as follows:

- Publication type (Articles; Master's Thesis; Doctoral Dissertation)
- Publication year
- Learning Stage (Primary School; Secondary School; High School; University)
- Sample size (Small Sample; Medium Sample; Large Sample)
- Intervention duration
- Domain Subject (Computer; Maths; Medical Science; Science; Social Sciences)

Reliability and Validity of the Research

The consensus of the researchers was taken into consideration in the coding process of the studies included in the research, and the consistency of the coding process was examined. To ensure the reliability of the research, the data of each study were coded by two instructors in the field of educational technologies at different times and independently from the coding of the researcher. As a result, the inconsistencies observed in the studies were eliminated, and the analysis continued until full consensus was achieved.

The inter-coder reliability analysis was performed by calculating Cohen's kappa coefficient using the codings obtained from two coders, and the kappa coefficient was found to be 0.96. According to Viera and Garrett (2005), this value supports the reliability of the coding since it is within the range of the "almost perfect agreement". As a second way in the study, the coding process was repeated several times by the researchers at different times, and the consistency of the coding process was examined. It was examined whether there was an inconsistent coding by comparing these repeated encodings.

Data Analysis

While deciding on the model to be chosen during meta-analysis, it can be tested whether the effect sizes are distributed homogeneously or not. According to the result of this test, it can be stated that the fixed effects model can be used if the effect sizes show a homogeneous distribution. If effect sizes do not show homogeneous distribution, the random-effects model should be used (Ellis, 2010). According to the results of the heterogeneity test of the present study, the effect sizes of the studies were found to be statistically significant. In other words, the values show a heterogeneous distribution. Therefore, the overall effect sizes were calculated using the random-effects model in the study. Moreover, the effect sizes were also calculated using the fixed-effects model, and the obtained values were given in the results. For this purpose, Hedge's g coefficient was taken into account in the calculation of the effect size in the study, and the significance level of the statistical analyses was taken as 0.05.

The CMA 2.0 statistical software was used for conducting meta-analytical analyses. The funnel plot, Rosenthal FSN, and Egger test were used to test whether the study has a publication bias. Since the scale was large, the classification made by Thalheimer and Cook (2002) was taken into account in interpreting the effect sizes found from the statistical calculations.

Results

The results of the meta-analysis were presented in this part. In this context, the descriptive features of the studies were given at first. Then, the calculated values of the effect sizes and the changes found in the subcategory groups were examined.

Descriptive Statistics of the Studies

The learning stage, intervention duration, publication type, year of the study, domain subject, and sample size were the descriptive variables examined in this research. The descriptive statistics of these variables are presented in Table 2. Considering the table, it is observed that most of these 40 studies included in the meta-analysis were conducted at the university stage (45%) while the least number of studies were conducted at the high school stage (10%). It was observed that the publication type of a significant percentage of the studies (85%) was the article. Considering the intervention periods, it was found that the studies were carried out for particularly longer than 9 weeks and longer (30%). However, it was found that the intervention duration was not mentioned in 4 (10%) studies. Examining the sample sizes, it was observed that 12 (30%) studies were conducted with small samples, 19 (47.5%) were conducted with medium samples, and 9 (22.5%) were conducted using large samples. Finally, it was found that most of the studies were conducted in the field of science (27.5%) and social sciences (27.5%). Computer training was observed to follow them with 9 (22.5%) studies. It was determined that the least number of studies (5%) were conducted in the field of Medical Science.

Table 2. The Frequency and Percentage Values of the Studies

Learning Stage	**f**	**%**	***Year***	**f**	**%**
Primary School	7	17.5	2010/2012	12	30
Secondary School	11	27.5	2013/2015	15	37.5
High School	4	10	2016/2018	8	20
University	18	45	2019/2020	5	12.5
Intervention Duration			***Domain Subject***		
1-4	7	17.5	Computer	9	22.5
5-6	6	15	Maths	7	17.5
7-8	4	10	Medical Science	2	5
9-+	12	30	Science	11	27.5
Other	7	17.5	Social Sciences	11	27.5
Not mentioned	4	10			
Publication Type			***Sample Size***		
Articles	34	85	Small Sample (Between 1-49)	12	30
Master's Thesis	3	7.5	Medium Sample (Between 50-99)	19	47.5
Doctoral Dissertation	3	7.5	Large Sample (100 And Above)	9	22.5

Findings on the Effect Size of the Studies on Academic Achievement

Table 3 presents the heterogeneity value, average effect size, and confidence intervals according to the effect model of the studies included in the analysis. Considering Table 3, the heterogeneity test was found to be significant ($p < .05$). The Q value was found to be 47.114 with degrees of freedom of 40. Thus, it is concluded that the distribution was not homogeneous. Moreover, the I^2 index, which was found to be 73%, indicated that the heterogeneity level of the studies was "high". Cooper, Hedges, and Valentine (2009) stated that the I^2 value of about 25% indicated a low level, the value of about 50% indicated medium level, and the value of about 75% indicated a high level of heterogeneity. Therefore, it was decided to conduct a categorical moderator analysis to determine the variables that contribute to heterogeneity.

Table 3. Average Effect Size and Confidence Interval Upper and Lower Values according to Effects Model

Model Type	**k**	**Z**	**p**	**Q**	I^2	**df**	**g**	**SE**	**% 95 CI**	
									Lower	**Upper**
Fixed Effects	40	13.897	0.000	144.916	73.088	39	0.489	0.035	0.420	0.558
Random Effects	40	7.375	0.000	47.114		39	0.523	0.071	0.384	0.662

Note. k=number of effect sizes; Q=Homogeneity Value; df=degrees of freedom; g=Hedges' g; SE=standard error; CI=confidence of interval for the average value of ES.

As can be understood from Table 3, the value of the Hedges' g was found to be 0.523. This value was evaluated according to Thalheimer & Cook's (2002) effect size classification, and it was found to correspond to the moderate effect size. Therefore, it can be stated that CSCL is effective and has a positive effect on academic achievement.

The forest plot displaying the distribution of Hedges' g effect sizes of the studies included in the research is presented in Figure 2.

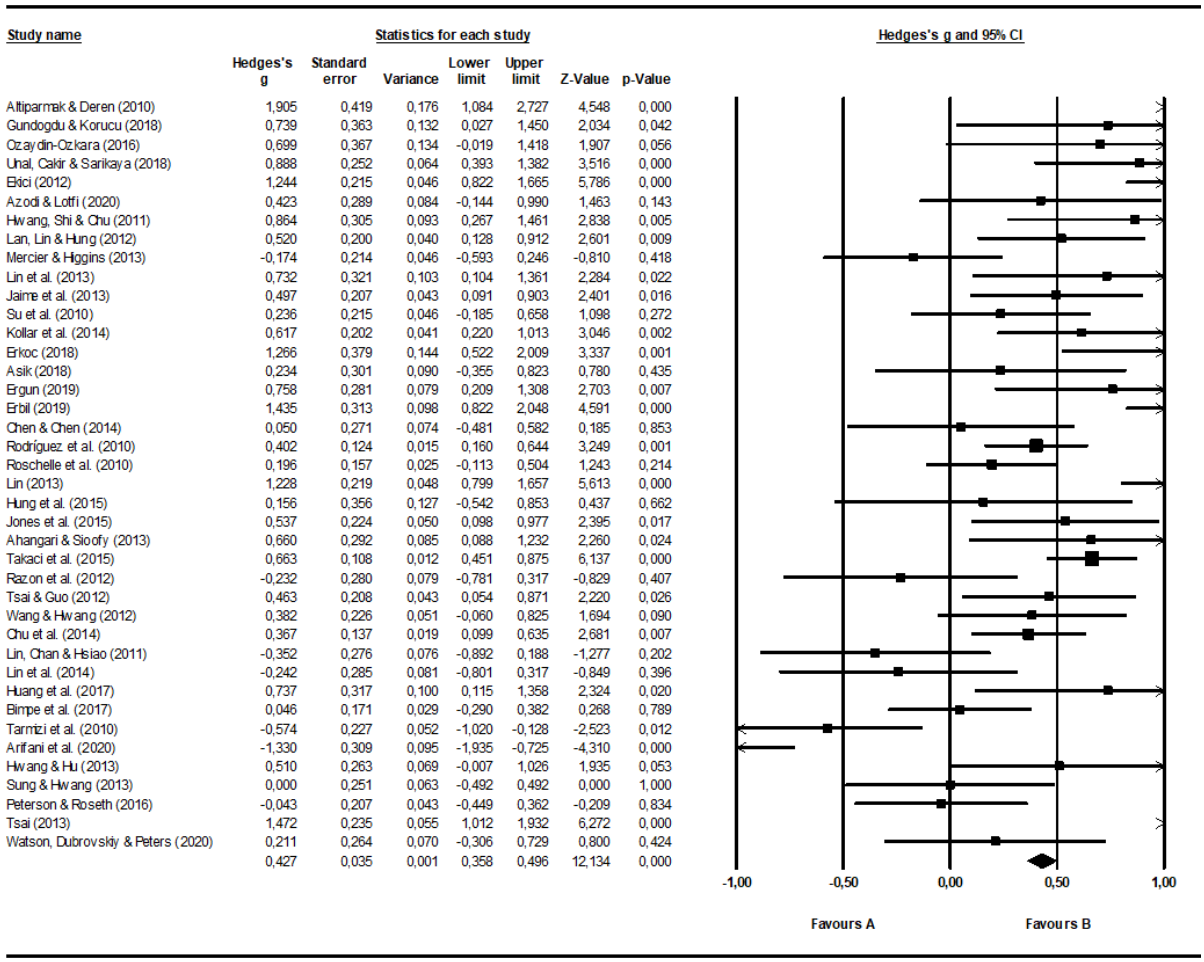

Figure 2. Forest Plot

Considering the forest plot of the studies, the diamond symbol, which indicated the effect size, was observed to have a value greater than zero. This indicated that the difference was greater than zero in favor of CSCL in terms of its effect on student's academic achievement. Considering the studies separately, the maximum effect size was observed to be 1.905 (Altıparmak & Deren, 2010) while the minimum effect size was observed to be -1.330 (Arifani et al., 2020). Also, the lower and upper limits of the effect sizes of the studies were found to range between -1.935 (Arifani et al., 2020) and 2.727 (Altıparmak & Deren, 2010). The p-value was found to be statistically significant ($p < .05$) in 23 studies included in the study while it was not statistically significant in 17 studies ($p > .05$).

Publication Bias

Three methods, namely, the Funnel Plot, Rosenthal FSN value, and Egger test methods were used to determine whether there was a bias in favor of studies with significant differences among the studies included in the research. The results of the funnel plot of the studies are given in Figure 3. In cases where there is no publication bias, the studies are expected to be distributed symmetrically around the overall effect size in this graph (Borenstein et al., 2013).

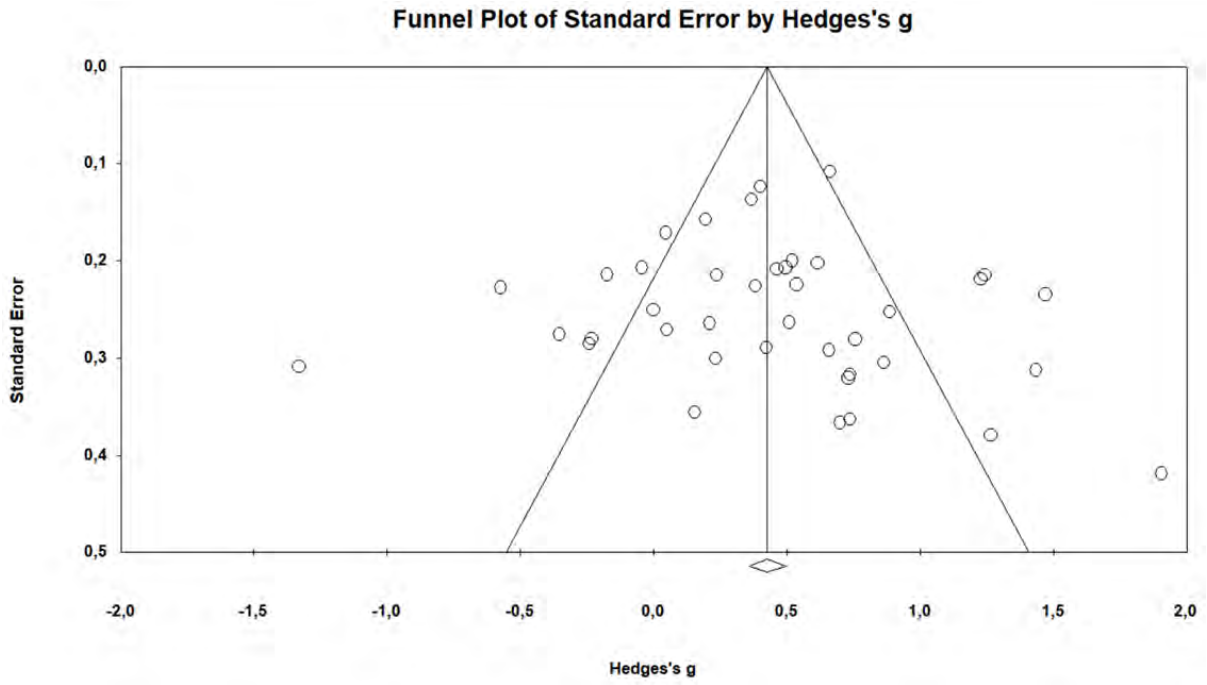

Figure 3. Funnel Plot

Figure 3 reveals that the studies do not show an asymmetric distribution around the overall effect size. In other words, the distribution is not concentrated on one side. Most of the studies included in the analysis were observed to be at the upper part of the plot, and they approached the combined effect size. Although some of the studies extended beyond the pyramid, these studies were located in the middle and upper parts of the plot. If there had been a publication bias in the research, most of the studies would have been concentrated at the bottom of the funnel shape, and on only one side of the vertical line. The fact that the distribution was not asymmetric and the studies did not accumulate around a specific point revealed that the study sample was not biased in favor of the CSCL method.

The interpretation of the funnel plot is highly subjective (Borenstein et al., 2013; Rothstein, Sutton & Borenstein, 2005). Therefore, the Rosenthal FSN value was calculated to determine the bias more precisely and support the result obtained. The findings obtained from this test are presented in Table 4. According to the table, the safe N number is 1954. It can be stated that the significant effect can be reduced to zero if at least this number of studies with negative or neutral significant differences are included in the analysis. Comparing the FSN value with the number of studies included in the analysis, the FSN value is found to be quite high and

unreachable. These findings show that the results of the meta-analysis are reliable. Egger test is another publication bias test for the results of the meta-analysis. The results of this test are given in Table 5.

Table 4. Rosenthal's Fail-safe Number Calculations

Z-value for observed studies	13.83577
p-value for observed studies	0.00000*
Alpha	0.05000
Tails	2
Z for alpha	1.95996
Number of observed studies	40
Fail-safe Number	1954

*Note. *p <.05*

As seen in Table 5, the intercept value (B_0) for the variable of academic achievement was calculated as 1.03192. Considering the significance level of the intercept value calculated for this variable, it is observed that it is not significant at the confidence level of 95% ($p > .05$). This result also proves that there is no publication bias in the research.

Table 5. The Results of the Egger Test

Intercept (B_0)	1.03192
Standard Error	0.95470
95% Lower Limit (2 tailed)	-0.90077
95% Upper Limit (2 tailed)	2.96461
t-value	1.08089
sd	38.00000
p-value (1 tailed)	0.14328
p-value (2 tailed)	0.28656

The Effect Sizes of Studies According to Moderators

One of the reasons for the difference between effect sizes may be the moderator variables of the studies included in the meta-analysis. Therefore, it was aimed to examine whether the effect sizes of the studies varied according to these variables. Table 6 presents the results of the moderator analysis of the studies included in the meta-analysis in terms of the variables of learning stage, intervention duration, domain subject, and sample size. According to Table 6, the average effect size of studies on academic achievement is 0.479 at the primary school stage; it is 0.656 at the secondary school stage; it is 0.291 at the high school stage, and it is 0.533 at the university stage. According to the results of the homogeneity test conducted to determine whether there is a significant difference between the effect sizes of the studies included in the meta-analysis in terms of the learning stage, no significant difference was found between the effect sizes of the studies (Q_B=2.435; $p > .05$). According to these findings, the academic achievement levels of the students at different learning stages do not

show a statistically significant difference after CSCL applications.

Table 6. The Overall Effect Sizes of the Studies according to Moderator Analyses

	Variables	k	g	95% CI		Q_B	Z	df	p
				Lower	Upper				
Learning Stage	Primary School	7	0.479	0.099	0.858	2.435	7.063	3	0.487
	Secondary School	11	0.656	0.339	0.974				
	High School	4	0.291	-0.055	0.637				
	University	18	0.533	0.332	0.734				
	Sum	40	0.510	0.368	0.651				
Intervention Duration	1-4	7	0.567	0.165	0.970	12.063	6.873	5	0.034
	5-6	6	0.709	0.238	1.179				
	7-8	4	0.714	0.330	1.099				
	9-+	12	0.624	0.383	0.866				
	Other	7	0.289	-0.034	0.612				
	Not mentioned	4	0.128	-0.134	0.390				
	Sum	40	0.457	0.327	0.588				
Domain Subject	Computer	9	0.660	0.390	0.930	1.699	7.717	4	0.791
	Maths	7	0.437	0.193	0.680				
	Medical Science	2	0.590	-0.655	1.836				
	Science	11	0.523	0.297	0.748				
	Social Sciences	11	0.429	0.030	0.828				
	Sum	40	0.521	0.388	0.653				
Sample Size	Small	12	0.643	0.356	0.930	1.668	7.354	2	0.434
	Medium	19	0.427	0.210	0.644				
	Large	9	0.587	0.340	0.834				
	Sum	40	0.532	0.390	0.674				

According to Table 6, the effect size of applications with a duration of 1-4 weeks is 0.567; the effect size of the applications with a duration of 5-6 weeks is 0.709; the effect size of the applications with a duration of 7-9 weeks is 0.714, and the effect size of the applications with a duration of 9 weeks and longer is 0.624. On the other hand, the effect size obtained from the studies reporting the intervention duration in minutes, hours, days, and sessions is 0.289. Also, the effect size obtained from the studies that did not report the intervention duration is 0.128. A heterogeneity test was conducted to determine whether there was a significant difference between the effect sizes in terms of the intervention duration. The results of this test revealed that the distribution was heterogeneous (Q_B=12.063; $p < .05$). In this case, it can be stated that the effect of CSCL on academic achievement varies according to the intervention duration.

Table 6 reveals the following effect sizes of CSCL according to different domain subjects: Computer, 0.660; Mathematics, 0.437; Medical Science, 0.590; Science, 0.523; Social Sciences, 0.429. According to the results of

the heterogeneity test conducted to determine whether there was a significant difference between these effect sizes, it was found that there was no significant difference between the average effect sizes of the studies in terms of academic achievement (Q_B=1.699; p > .05). According to these results, it can be stated that the effect of CSCL on academic achievement does not change by the domain subject.

According to the results of the analysis, the effect size of the studies with a small sample (1 < n ≤ 49) is 0.643 while it is 0.427 for the studies with a medium sample (50 ≤ n ≤99), and it is 0.587 for the studies with a large sample (n > 99). According to the results of the homogeneity test conducted to determine whether there was a significant difference between the effect sizes, it was found that there was no statistically significant difference between the groups according to their sample sizes (Q_B = 1.668, p > .05). According to this finding, it could be stated that academic achievement levels obtained after CSCL learning applications with different sample sizes did not show a statistically significant difference.

Discussion

In the present research, studies in the literature were subjected to meta-analysis to determine the effectiveness of CSCL on academic achievement. Therefore, a total of 40 studies conducted between 2010 and 2020 were included in the meta-analysis. Within the scope of the research, in the beginning, the data of the studies included in the meta-analysis were examined. According to the results of the research, it was found that the studies were usually conducted in the domain subjects of sciences and social sciences at the learning stage of the university and the publishing type of article. On the other hand, it was determined that the intervention duration of the studies was particularly longer than 9 weeks and they were carried out with a medium sample.

According to the results of the heterogeneity test, it was concluded that the distribution of the effect size of the studies was heterogeneous. The analysis revealed that CSCL had a moderately positive significant effect on academic achievement. This result indicates that CSCL positively affects the students' academic achievement. As a matter of fact, several studies in the literature report that CSCL positively affects the academic achievement of students (Aşık, 2018; Ergün, 2019; Gündoğdu & Korucu, 2018; Huang, Su, Yang & Liou, 2017; Lin, 2013; Sioofy & Ahangari, 2013; Takači, Stankov & Milanovic, 2015; Tsai & Guo, 2011; Watson, Dubrovskiy & Peters, 2020). In this case, it can be stated that the result of the study is consistent with the relevant literature and that this method positively affects the academic achievement of students. Moreover, the positive effects of CSCL on students' learning outcomes and processes were widely reported in meta-analysis studies (Chen, Wang, Kirschner & Tsai, 2018; Chen, Wang, Kirschner & Tsai, 2019; Sung, Yang & Lee, 2017). On the other hand, some studies indicate that no significant improvement was obtained in academic achievement after CSCL application or that no significant differences were found compared to other methods (Lin, Chan & Hsiao, 2011; Lin, Hsiao, Tseng & Chan, 2014; Peterson & Roseth, 2016; Razon et al., 2012). The reason for obtaining different results in these studies in the literature may be due to different CSCL applications, the type and nature of technological tools used during the application, and the differences in learning activities used during the class. Another reason for this difference may be because the teacher conducting the application managed and planned the process differently. Besides, the process of participants' adoption of CSCL, their

attitudes toward the course, and their motivations may also cause obtaining different results. The learning techniques used in CSCL (such as peer learning, Jigsaw, team games tournaments) may also be the reason for different results. Therefore, it can be stated that the courses designed according to CSCL should be planned well.

CSCL positively affects academic achievement because it provides permanent and easy learning, concretizes abstract concepts, increases interest in the course, and solves the examples using an application (Kağızmanlı, 2015; Sümer, 2015). With the development of technology, CSCL environments offer various tools that also facilitate communication. Moreover, these environments improve social interaction and facilitate in-depth learning (Francescato et al., 2006). Online discussions, where social interaction is performed at the highest level, increase interaction between participants and facilitate structuring he knowledge (Öztürk & Deryakulu, 2011; Topçu, 2006).

According to the results of the funnel plot, no publication bias was found on the calculation of the overall effect size. Also, Rosenthal FSN was calculated and the Egger test was conducted to clarify the publication bias of the research. As a result, all three analyses revealed that there was no publication bias in the meta-analysis study. This information demonstrated that the results of the meta-analysis were reliable.

In the study, it was also examined whether the effect of CSCL on academic achievement differs by the learning stage, intervention duration, domain subject, and sample size by conducting a moderator analysis. Considering the results of this test, it was found that the effect of CSCL on academic achievement did not change by the learning stage, domain subject, the sample size but it changed by the intervention duration. As a result, it can be stated that the effect of CSCL on academic achievement differs by the intervention duration. Similar to the present research, the study conducted by Chen, Wang, Kirschner, and Tsai (2018) also concluded that no significant difference was found between the different "educational levels" and between the different "subject areas". On the other hand, significant differences were found between the different "sample sizes" and between the different "intervention durations" in the same study (Chen, Wang, Kirschner & Tsai, 2018). Moreover, Sung, Yang and Lee (2017) also reported that no statistically significant difference was found between the different "learning stages" and between the different "domain subjects"; however, the differences detected between the different "intervention durations" were found to be statistically significant. On the other hand, Chen, Wang, Kirschner and Tsai (2019) did not find any significant difference between the different "educational levels"; however, they found a significant difference between the different "subject areas".

In the literature, there are also some meta-analysis studies on the effects of CSCL using several technologies on learning outcomes and processes. For example, Sung, Yang and Lee (2017) examined the overall effects of mobile CSCL on learning performance in their meta-analysis study. They determined that 48 studies published between 2000 and 2015 were consistent with the inclusion criteria of their research. According to the results of the analysis, they found the overall effect size of the mobile CSCL on learning performance to be 0.516, corresponding to a moderate level. They concluded that the mobile CSCL had a positive effect on learning performance. Similarly, Chen, Wang, Kirschner and Tsai (2018) examined 425 empirical studies published

between 2000 and 2016 to investigate the effect of CSCL on education by conducting a meta-analysis. In this study, it was determined that CSCL had significant positive effects on 'knowledge gain' (ES = 0.42), 'skill acquisition' (ES = 0.64), and 'student perceptions' (ES = 0.38). Also, Jeong, Hmelo-Silver and Jo (2019) presented a meta-analysis study on the effects of CSCL on STEM education. The researchers aimed to determine the overall effect size by gathering 143 scientific studies on CSCL conducted between 2005 and 2014. According to the results of the analysis, the overall effect size of CSCL on STEM was found to be 0.51. Calculated effect size revealed that CSCL had a moderate positive effect, which was statistically significant.

Conclusions

The present study tried to determine the effectiveness of CSCL on the academic achievement of students by using the meta-analysis method, and it excluded other factors from the scope of the study. In future studies, its effects on social skills, motivation, and knowledge retention can be examined, and subgroup analyses can be conducted according to the domain subject, intervention duration, sample size, age, and gender. Thus the practicality and effectiveness of CSCL can be examined in-depth. As the number of studies on the subject has been increasing each passing day, more studies are needed in this field to better understand the effectiveness of CSCL. Therefore, significant contributions can be made to the literature by conducting more comprehensive meta-analysis studies in the future by observing the change in the effect sizes over time. Accordingly, the results of the changes in the effect size can be examined considering their different aspects. Only studies presenting quantitative data were included in the present research. As a complementary study to this research, qualitative studies on the domain subject area can be examined, and more comprehensive results can be obtained. It was also determined that the studies included in the analysis were concentrated at university and secondary school levels. Increasing the number of studies on other learning stages, on which the number of studies is quite low, will be more determinant to view the overall situation.

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