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The Effect of Using Technology in Education on Academic Achievement of Students: The Case of Geographical Information Systems

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Abstract

The objective of this study was to determine the effect of Geographic Information Systems, one of the educational technologies, on the academic performance of students. In accordance with this purpose, to combine the results of independent experimental studies, the meta-analysis method was put into use. Within this context, as a result of the literature review, in the meta-analysis, 17 experimental studies conducted between the years 2007 and 2020 were included. The total sample size of the mentioned studies was 620 in the experimental group and 607 in the control group. Thalheimer and Cook's (2002) classification was used in calculating the effect size values in the study in which the random effects model was used. Publication bias in research; Funnel Plot was tested with Rosenthal Fail Safe N value, cut and fill method of Duval and Tweedie and Begg-Mazumdar statistics, and studies included in meta-analysis were found to be heterogeneous. The effect of moderator variables, which are thought to influence academic achievement, was examined. Q and p significance tests were used to calculate the effect of moderator variables. According to the results of the study, it has been determined that GIS has a very wide (+1,193) effect on academic achievement. Positive average effect size indicates a change in favour of the experimental group. It was concluded that among the moderator variables, the study type, class level and sample size did not create a significant change in the effect size, and the year variable created a significant difference in the effect size.

Keywords: Academic Achievement, Geographic Information Systems, Meta-Analysis

1. Introduction

Rapid change and transformation in the world have been effective in education as well as in all areas. One of the main factors causing this change is the developments in technology. In today's world where the information age is experienced and ways to reach information are more important than obtaining information, it is aimed to train individuals to have these qualities. The education system in Turkey has made innovations in many areas, especially the programs prepared based on the constructivist approach, to achieve the determined goals (Akkus, 2014). In

particular, one of the important developments at the point of technology and education integration is the FATİH (Increasing Opportunities and Technology Improvement Movement) project (Coskunserce & Isciturk, 2019; Cavus & Yorganci, 2020). With the FATİH project, which was put into practice in 2010, efforts were made to improve schools as hardware infrastructure, to make education programs compatible with information technologies, and to develop educational e-contents (Keser & Yayla, 2021). With this project, it was aimed to reduce the difference between the metropolitan and rural schools and to provide equal opportunity in education by making the investments required for the integration of education and technology (Gokmen & Aygun, 2016). In addition to the investments made for educational technology projects to be successful, there is a need for teachers and students who can use information communication technologies effectively and adapt to technology (Ayvaci, Ozbek & Sevim, 2018; Yilmaz, 2020). Accordingly, it is necessary to know the technology options to be used in teaching and to benefit from them effectively. There are different technology options to be used in accordance with the purpose of teaching and Geographical Information Systems (GIS) is one of them.

Geographical Information Systems is known as one of the active learning methods that make students active in lessons and at the same time bring technology to the classroom and bring them together with students (Artvinli, 2009). According to Burrough (1998), GIS is used to collect, query, display and transmit data of any location on earth for specific purposes. Parker (1988) defines GIS as storing, analysing, and displaying data belonging to the location or not. According to some researchers, GIS is defined as a scientific concept or a tool that transfers spatial information to the computer system, which includes spatial information systems and geographic information, and for some, GIS is a database and management system that helps the organization of information (Balciogullari, 2011). GIS is a method with a unique methodology that continues to collect, store, process and present information obtained through location-based observation (Yomralioglu, 2002). Since GIS is generally described as a methodology, it is used by branches of science and professional groups, whose subjects are human, space and time, and include variables related to them (Aladag, 2007). GIS, which was named for the first time by Tomlinson (1968), started to be used in Canada in the 1960s as the use of spatial data in a computer environment (Kokturk, 2004). GIS, which is used by many disciplines, has started to be used in educational settings as a result of the developments in computer, software and hardware systems, especially in the last 30 years or so (Ertogral, 2019). In Turkey, GIS took its place in the curriculum with the 2005 Geography Secondary Education program which was prepared in accordance with the constructivist approach (Ministry of National Education, (MEB) 2005). Thus, for the first time officially, applications related to GIS at the high school level took their place in the official program. GIS enables students to develop many skills including analytical thinking, spatial perception, problem-solving, computer literacy, communication, and presentation skills (Aladag, 2007; Audet & Ludwig, 2000). Therefore, in educational settings, the use of GIS has been included in many stages of the education-teaching process, including primary education, secondary education and university (Baker, 2002; Keiper, 1996). Contrary to the frequent use of GIS by developed countries today, its use is not at the desired level in Turkey (Artvinli, 2010; Baker, 2005; Demircioglu & Karaburun, 2011; Mennecke & West, 2001). In secondary schools and high schools, although the use of GIS is recommended by the Ministry of National Education for some gains, the use of GIS in schools is limited (Kapluhan, 2014). The reason for this is that the number of educators who are qualified to use GIS is low, the physical conditions of schools are inadequate, and also GIS software is expensive (Simsek, 2008; Tastan, 2021). When CBS is used effectively, it activates students by removing them from their passive position and gives them various skills (Aladag, 2007). The most well-known of these skills are spatial perception, using information communication technologies, geographic analysis, and cartographic skills (Tabanli, 2014). Thanks to these skills, students improve their attitude, motivation, and success towards the lessons, especially in the Geography and Social Studies course, in a positive way. When the relevant literature is reviewed, it can be observed that there are many studies that have reached the conclusion that GIS affects academic success positively (Aladag, 2007; Arrasyid, Iwan & Sugandi, 2019; Artvinli, 2010; Aydin & Coskun, 2011; Aydogmuş, 2010; Baker, 1996; Baker & White, 2003; Balciogullari, 2011; Baloglu- Ugurlu, 2007; Cin & Tabanli , 2015; Covey & Cobb, 2003; Degirmenci & Altas, 2016; Demirci & Atalay, 2014; Ertogral, 2019; Gunes, Arikan & Cetin, 2020; Inec, 2012; Kaya, 2011; Keskin, 2018; Koca & Dasdemir, 2016 ; Koca, Gokdemir & Dasdemir, 2017; Oner & Aydın, 2014; Oner, 2020; Ozgen, 2009; Ozgen & Cakicioglu, 2009; Singh, Rathakrishnan, Sharif, Talin & Eboy, 2016; Sonmez & Akbas, 2019; Simsek, 2011 ; Tabanli, 2014; Unal & Sari, 2012; Unlu & Yildirim, 2016; Vincent, 2004). While there are reviews in the literature to summarize the effects of the studies, no meta-analysis study has been found. Meta-analysis studies are needed to combine the results of similar studies and to interpret the accumulation.

Therefore, the purpose of the study is to examine the effect of GIS on students' academic achievement. In this sense, the sub-problems in the study were determined as follows:

- Do Geographical Information Systems, one of the educational technologies, affect the academic success of students?
- Does the average effect size differ regarding the type of study, the moderator variables, year of publication, class level and sample size?

2. Method

In the present study, the method of the meta-analysis was put into use because the objective was to determine the effect of GIS on the academic achievement of students by using the quantitative findings of experimental studies. Meta-analysis is called a statistical process allowing to make a common inference by combining the quantitative findings of previous research on a specified topic (Tatsioni & Ioannidis, 2017). The meta-analysis method is accepted as one of the most common ways to synthesize research (Schulze, 2007). In the most general sense, meta-analysis can be described as analysing the analysis (Cohen, Manion & Morrison, 2007). Durlak (1995) divides meta-analysis types into two as group comparison and correlational meta-analysis. In the current study, the group comparison process effectiveness model, which is one of the meta-analysis types, was used. In the process efficiency model, the standardized effect size which is indicated by the letters "d" and "g" is used and the result is obtained by dividing the difference between the experimental-control groups by the standard deviation (Sahin, 2005).

2.1 Data Collection

In parallel with the aims determined in the study, all the studies including the effect of GIS on the academic achievement levels of students were scanned in YOK (Council of Higher Education) National Thesis Center, Proquest, Google Scholar, Web of Science, Scopus, ULAKBIM TR Index, EBSCOhost databases. To decide on the studies to be meta-analysed, Turkish keywords “başarı,” “Coğrafi Bilgi Sistemleri,” “CBS,” “erişim” and English keywords “competence,” “achievement,” “Geographic Information Systems,” “GIS” and “competence” were determined. The following criteria were used while determining the studies to be analysed within the scope of the research.

- The research to be used should be done between 2007-2020.
- The researches should be selected from among the master's and doctoral thesis written in Turkish or English, or articles published in peer-reviewed journals.
- The sample of the research should include the primary, secondary and high schools, university and graduate students, and teachers.
- Research to be included should be carried out in an experimental design to reach the effect size.
- The validity and reliability analysis of the measurement tools which were used in the research should be done.
- Studies should have variables (sample size, arithmetic mean, standard deviation, t, F, etc.) required for meta-analysis statistics.
- The path followed in the selection of scientific research to be applied meta-analysis is given in Figure 1.

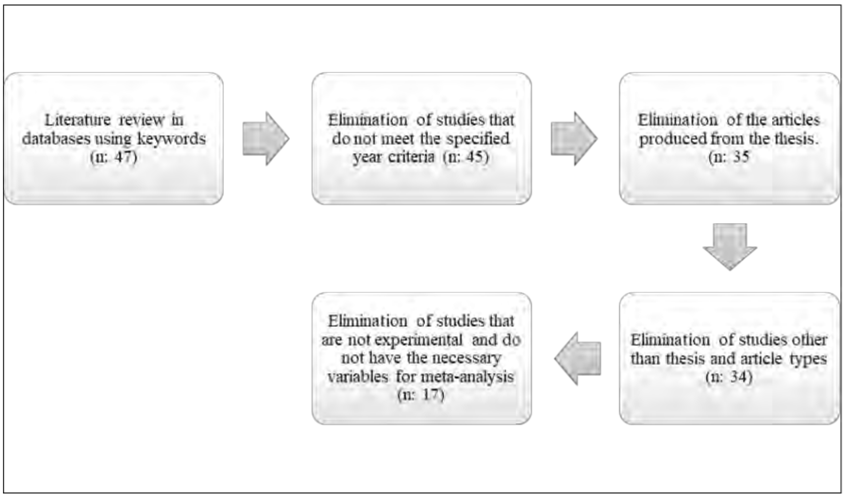
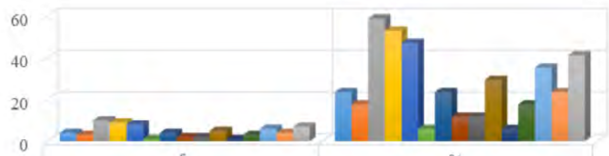


Figure 1: The Path followed in the selection of scientific research to be applied to meta-analysis

According to the determined criteria, the literature review was made and a total of 47 studies were reached. Two studies before 2007 that did not meet the year criteria were eliminated, and it was concluded that 10 studies were produced from the thesis. One study was excluded on the grounds that it was in the form of a paper abstract. After eliminating 17 studies whose method was non-experimental or experimental and did not have the necessary variables (sample size, standard deviation, arithmetic mean, t, F, etc.) to calculate the effect size, analyses were made over 17 studies that were finally reached.

2.2 Data Coding

The included studies were coded in line with the determined criteria, and the effect size was tried to be calculated. While coding the selected studies, the variables of author information, the year in which the study was published, the type of the study, and the sample information were included. Therefore, coding was done by two experts in the field and tested with Miles and Huberman's (1994) method of congruence percentage and the result was found to be 94.44% (Agreement / (Agreement + Disagreement) x100) in order to ensure the reliability of the coding. Studies in which consistency was not ensured were re-examined by the researchers and the consensus was raised to 100%. Descriptive data of the data obtained according to the last screening result dated December 31, 2020, is also given in Figure 2.



	f	%
Master Theses	4	23,53
PhD	3	17,65
Article	10	58,82
2007-2012	9	52,94
2013-2020	8	47,06
5th grade	1	5,88
6th grade	4	23,53
7th grade	2	11,76
9th grade	2	11,76
10th grade	5	29,41
11th grade	1	5,88
Teacher Candidate	3	17,65
25-50	6	35,29
51-75	4	23,53
76 and above	7	41,18

Figure 2: Descriptive statistics regarding the data included in the study

When the descriptive data of Figure 2 were examined, it was found that 58.82% of the studies in the dimension of study type variable are articles, 23.53% are master theses and 17.65% are doctoral dissertations. 52.94% of the studies were published between 2007-2012, and 47.06% were published between 2013-2020. When the studies in the class-level dimension were examined, it was found that studies at the 10th grade (29.41%) and 6th grade (23.53%) were conducted at most and that 41.18% of the sample consists of 76 and above, and 35.29% consists of 25-50 people.

2.3 Investigation of Publication Bias

In meta-analysis studies, one of the ways to increase the validity of the study is to ensure that there is no publication bias. Publication bias is that not all studies on a particular subject can be included in the analysis. Mostly, analysing through the studies with meaningful results causes the calculated effect size to deviate and diverge from the actual result (Borenstein, Hedges, Higgins & Rothstein, 2009). Publication bias in research; Funnel Plot was analyzed using four different statistics: Rosenthal Fail Safe N value, Duval and Tweedie's cut and fill method and Begg-Mazumdar Statistics. The Funnel Scatter Plot for the studies which were included in the meta-analysis is given in Figure 3.

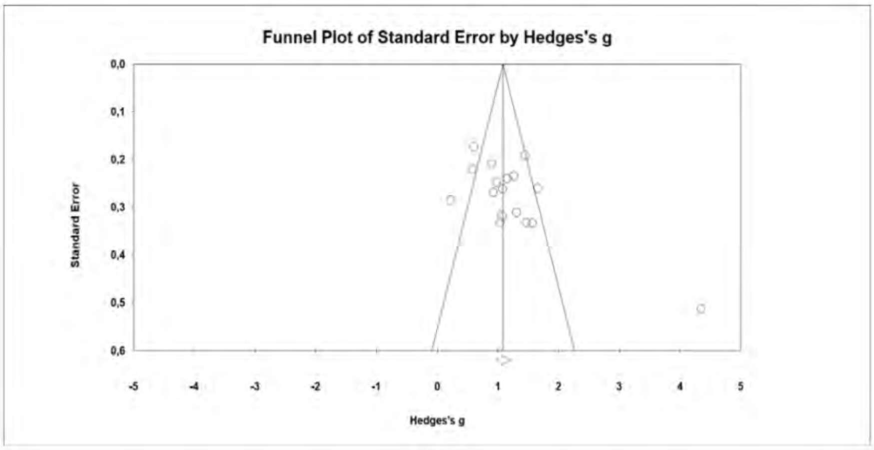


Figure 3. Funnel scatter plot regarding the bias of the studies

According to Figure 3, it can be said that Hedges g values of the studies show a symmetrical distribution. The symmetrical distribution of the studies in the funnel plot shows that the standard error value is strong in the clustered analysis in the middle or upper part of the graph. Except for the Funnel Scatter Plot, the publication bias was supported by the Rosenthal Fail-Safe N value. The data for the Rosenthal Fail-Safe N table are as follows.

Table 1: Study bias according to Rosenthal FSN Value

Bias Condition	
Z Value for Observed Studies	18,25726
P Value for Observed Studies	0,00000
Alpha	0,05000
Direction	2
Z Value for Alpha	1,95996
Observed Number of Studies	17
Number of Missing Studies	1459

According to the Rosenthal FSN table, there is no limit to the FSN value to be able to say that there is no publication bias, but Rosenthal (1979) states that the FSN value found should be ten times more than the study (FSN> 5k +

10). In Table 1, when the analysis results are examined, the number of studies to be reached in order to eliminate publication bias is 1459. This value is approximately 86 times higher than the number of studies that were included in the study. To avoid publication bias in the research, 1442 more studies are needed. Since it is not possible to reach this value, the result achieved is accepted as an indication that there is no publication bias. In addition to the analyses made to test publication bias, Begg-Mazumdar Statistics and Duval and Tweedie's Trim-Fill Method statistics were used. The results of the analyses made are as in Table 2.

Table 2: The Bias of Studies in Terms of Begg-Mazumdar Statistics and Duval and Tweedie's Trim-Fill Method Values

Begg-Mazumdar Rank Correlation					
Tau	0,27941				
Z Value	1,56532				
P Value (Double Tailed)	0,11751				
Trim and fill method by Duval and Tweedie					
	Excluded Study	Effect size	Lower Lim	Upper Lim.	Q Value
Observed Values		1,193	0,921	1,464	77,032
Corrected Values	4	0,96	0,657	1,266	138,398

When examined, it can be said that there is no publication bias according to the result of the Begg-Mazumdar Rank Correlation test in Table 2 (Tau = 0.279; z = 1.565; p = 0.117; p> 0.05). According to Begg and Mazumdar (1994), to be able to say that there is no publication bias, the p-value should be greater than 0.05. According to the Trim and Fill Method of Duval and Tweedie, the observed effect size value is 1.193 and the corrected effect size value is 0.96. According to the results, 4 studies should be added to the meta-analysis to eliminate the asymmetry. The effect size will decrease by 0.233, while the value of Q will increase in this case. The results of the analysis show that the values reached are not at a level that may threaten publication bias. The results obtained in the conducted four analysis show that no publication bias affects the validity of this study, and the results obtained support each other.

2.4 Data Analysis

Analysis of the data was conducted with the comprehensive Meta-analysis (CMA) program, and the Hedge's g coefficient was used instead of Cohen’s d to calculate the impact dimensions of those given for reasons of small sample size (Borenstein et al., 2009). The Cohen’s d form is preferred for studies with a sample size is greater than 20 (Lipsey and Wilson, 2001). The Thalheimer and Cook’s (2002) level was used to calculate the size of the effect (-0,15- 0,15: Negligible level; 0,15- 0,40: Small level; 0,40- 0,75; Medium level; 0,75- 1,10: Large level; 1,10- 1,45: Very Large level; 1,45- Huge level).

In the meta-analysis method, it should be decided which statistical model to choose first to bring the study results together in a statistically meaningful way. Cumming (2012) states that a model of random effects should be made in studies in the field of social science. While it is assumed that the effect sizes of the studies included in the random effects model are different; In the fixed effects model, meta-analysis of all the studies that are included in the standard deviation of the mean is zero (Bakioglu & Goktas, 2018). Heterogeneity and Q-value are examined to decide which effect model to use in the meta-analysis studies. For the distribution to be heterogeneous, the p-value must be less than 0.05. If this value is less than 0.05, it indicates that the distribution is heterogeneous, and in this case, the random-effects model should be preferred. Q value indicates heterogeneity in the case where it is greater than the value corresponding to the df value in the chi-square table (Dincer, 2020). Another criterion for determining heterogeneity in meta-analysis studies is the I2 statistic. If the values found in the I2 statistic are 25% and below, it means low, between 50% and 75% is medium, and 75% and above indicates a high level of heterogeneity (Higgins, Thompson, Deeks & Altman, 2003). One of the important factors affecting validity and reliability in the analyses made is the detection of publication bias. Publication bias shows the power of studies to represent the universe. Selecting the results of the selected studies from statistically significant studies increases

the possibility of publication bias and negatively affects the validity and reliability of the study (Rothstein, Sutton & Borenstein, 2005). In the current study, publication bias was examined with various tests and the results were presented in tables. Finally, analogue ANOVA statistics were made to analyse subgroups and moderators in the study (Bakioglu & Goktas, 2019). First, subgroups (study type, year, class level and sample size) that the use of the GIS method can be effective were determined and it was tried to determine to what extent the moderators could explain the variance.

3. Results

In the study, the effect size of each of a total of 17 studies was calculated individually and the total effect size value was tried to be found. The number of students in the experimental group of the studies included in the meta-analysis is 620, and the number of students in the control group is 607.

3.1 Findings Regarding the First Sub-Problem

The first sub-problem of this study was determined as "Does Geographical Information Systems, which is one of the educational technologies, affect the academic success of the students?". In this sense, the total effect size was calculated by determining the effect size of the studies. The effect size and heterogeneity statistics of the studies are given in Table 3.

Table 3: Analysis results regarding the effect of geographical information systems on students' academic achievement

Model	Average Effect Size Value (ES)	95% Confidence for Effect Size Lower L	L- Upper L	Standard Error (SE)	Homogeneity Value (Q)	Degree of Freedom	I2	p
Constant	1,083	0,963	1,204	0,062	77,033	16	79,23	),000
Random	1,193	0,921	1,464	0,139				

In the study, firstly, heterogeneity statistics were examined, and it was decided which effect size to use. An I2 value of 75% and above shows a high level of heterogeneity (Higgins et al., 2003). The fact that the I2 value is 79.23% and the p-value is less than 0.05 in the study shows that the distribution is heterogeneous (Q = 77.033; p <0.05; I2 = 79.23). It was decided to use the random-effects model according to the heterogeneity test results. In the current study, the average effect size value was 1.193, the standard error was 0.139, and the minimum and maximum values were 0.921 and 1.464. According to the classification of Thalheimer and Cook (2002), a value of 1,193 shows that the effect of GIS on academic achievement is very large level. The positive average effect size (+1,193) indicates that the operations performed are in favour of the experimental group. The forest graph, which reveals the effect size of the studies carried out, is shown in Figure 4.

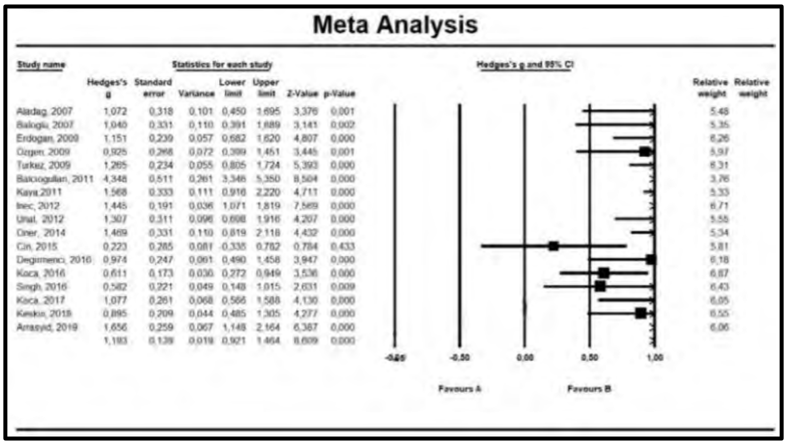


Figure 4. Forest graph regarding the effect sizes of the studies

When Figure 4 is examined, it was found that the effect sizes of all studies included in this study were positive. In other words, academic success increased significantly in the experimental group in which GIS was applied. The highest effect size belongs to the study of Balciogullari (2011), the lowest effect size belongs to the study of Cin and Tabanli (2015). When the confidence intervals of the studies are examined, it is seen that they vary between 6.87% and 3.76%, but they generally have close intervals. The highest confidence interval is the study of Koca and Dasdemir (2016) with the highest number of participants (n = 139), while the lowest confidence interval is the study of Balciogullari (2011) with a smaller number of participants (n = 51).

3.2 Findings Regarding the Second Sub-Problem

The second sub-problem of the study was determined as "Does the average effect size differ according to the moderator variables, type of study, years of publication, class level and sample size?". Moderator variables analysis is an analysis that is used to determine the average effect size difference and direction between specified subgroups (Littel, Corcoran & Pillai, 2008). Q and p significance tests were used to determine the effect of moderator variables. The effect of GIS on academic achievement level according to the type of study, which is one of the moderator variables, is shown in Table 4.

Table 4: The effect of geographical information systems on academic achievement regarding the type of study moderator

Variable		Q Homogeneity Between Groups	p	n	Effect Size (ES)	Standard Error	95% Confidence Interval for Effect Size Lower L.	Upper L.
	Total	3,081	0,214	17	1,183	0,091	1,005	1,361
Study Type	Master Thesis			4	1,279	0,117	1,050	1,509
	Doctoral Disssertations			3	2,032	0,854	0,359	3,705
	Article			10	1,010	0,145	0,725	1,295

According to Table 4, it can be said that GIS does not have a significant effect on academic achievement according to the type of study (Q = 3.081; p> 0.05). When the effect sizes of the subgroups are examined, it is seen that the studies with the highest effect size are in the doctoral dissertations (ES = 2.032), and the studies with the lowest effect size (ES = 1.010) are in article type. The effect of the year moderator variable on the academic achievement level is given in Table 5.

Table 5: The impact of geographical information systems on academic achievement regarding the year moderator

Variable		Q Homogeneity Between Groups	p	n	Effect Size (ES)	Standard Error	95% Confidence Interval for Effect Size Lower L.	Upper L.
	Total	4,480	0,034	17	1,104	0,124	0,861	1,346
Year	2007-2012			9	1,468	0,212	1,052	1,214
	2013-2020			8	0,915	0,152	0, 617	3,705

Table 5 shows the distribution of the experimental studies including the effect of GIS on academic achievement by years. The studies conducted were grouped between 2007-2012 and 2013-2020. When the effect sizes of the subgroups are examined, the effect sizes of the studies between 2007-2012 are 1,468, and the effect sizes of the studies conducted between 2013-2020 are 0,915. According to the results of the research, studies conducted by years have a significant effect on academic achievement, and this effect is in favour of studies conducted between

2007-2012 (Q = 4.480; p <0.05). The effect of the grade level variable on academic achievement level is given in Table 6.

Table 6: The effect of geographical information systems on academic achievement regarding the class level moderator

Variable		Q Homogeneity Between Groups	p	n	Effect Size (ES)	Standard Error	95% Confidence Interval for Effect Size Lower L.	Upper L.
Grades	Total	10,875	0,092	18	1,149	0,085	0,983	1,316
	5			1	1,307	0,311	0,698	1,916
	6			4	1,037	0,215	0,615	1,458
	7			2	0,636	0,424	0,196	1,468
	9			2	1,333	0,191	0,958	1,708
	10			5	1,681	0,429	0,839	2,522
	11			1	1,656	0,259	1,148	2,164
	Preservice Teachers			3	0,927	0,137	0,658	1,196

Table 6 shows the analysis results and it is seen that the class level where the most research is done is at the level of 10th Grade (n = 5) and 6th Grade (n = 4). When the effect sizes are examined according to the class level, it was found that the highest effect level belongs to the studies at the 10th grade (EB = 1,681) and the lowest effect belongs to the studies at the 7th grade (EB = 0.636). However, when the difference between the groups was examined, it was observed that there was no significant difference (Q = 10.875; p> 0.05). The effect of the sample size variable on academic achievement is as in Table 7.

Table 7: The effect of geographical information systems on academic achievement regarding the sample size moderator

Variable		Q Homogeneity Between Groups	p	n	Effect Size (ES)	Standard Error	95% Confidence Interval for Effect Size Lower L.	Upper L.
Sample Size	Total	1,393	0,498	17	1,114	0,122	0,875	1,354
	25-50			6	1,097	0,210	0,686	1,509
	51-75			4	1,735	0,542	0,673	2,798
	76 and over			7	1,072	0,156	0,765	1,379

According to Table 7, it is seen that there is no statistically significant difference between the mentioned groups which were formed according to the sample size variable (Q = 1,393; p> 0.05). The sample size with the highest effect size (EB = 1.735) varies between 51-75 people, while the sample size with the lowest effect size (EB = 1,072) is 76 and over.

4. Conclusion, Discussion and Suggestions

The individual and general effect size of 17 experimental studies were calculated in this study, which aims to examine the effect of Geographical Information Systems, one of the educational technologies, on the academic achievement level of students with the meta-analysis method. In addition, it was examined whether the GIS differs

according to the moderator variables (study type, years, class level and sample size), which is thought to influence academic achievement.

Regarding the research types, 10 of the 17 studies published between the years 2007 and 2020 are article, 4 are master's thesis, and 3 are doctoral thesis, and the most researched grade level is at the 10th and 6th grade. Almost half of the sample consists of 75 or more people.

In this study, funnel plot, Rosenthal Fail-Safe N value, cut and fill method of Duval and Tweedie and Begg-Mazumdar statistics were used to test publication bias, and it was found that publication bias was low. Before calculating the effect sizes of the studies which were included in the meta-analysis, the homogeneity test was performed and it was determined that the studies showed heterogeneous distribution and accordingly, the random-effects model was used. The classification made by Thalheimer and Cook (2002) was used to evaluate the effect sizes of the analyses.

The first finding of the study shows that the effect of GIS on academic achievement is very broad and positive. This result of the study is in line with the meta-analysis findings of Inel and Sezer (2017). When the relevant literature is examined, no study directly tries to determine the effect of GIS on academic achievement. However, Inel and Sezer (2017) examined the effect of material using on teaching Geography subjects in their study and found a moderate, positive relationship. Since some of the studies included in the meta-analysis include the effect of GIS on academic achievement, it can be said that the results of the research are similar. When the effect sizes of all studies included in the study were examined individually, it was concluded that all of them were positive. Accordingly, in all conducted studies, a significant increase was achieved in the experimental group in terms of academic achievement. When the confidence intervals of the studies were examined, it was found that there were studies with close intervals in general and they changed in parallel with the number of participants.

The studies conducted to examine the effect of the type of research on the effect size are divided into three categories as article, master thesis and doctoral dissertation. When the average effect size is examined according to the study type, it has been determined that all studies have a large effect size and above. However, when the effect sizes of the studies were examined in terms of differentiation between groups, no significant difference was found ($Q = 3.081$; $p > 0.05$). Although it is concluded that the study type does not make a significant difference in academic achievement, it is seen that the effect size (2.032) of the studies conducted in the doctoral thesis type is higher.

When the distribution of the studies including the effect of GIS on the academic achievement level by years was examined, it was concluded that there was a significant difference, and this difference was in favour of the studies conducted between 2007-2012 ($Q = 4.480$; $p < 0.05$). When the effect sizes of the subgroups were examined, the effect size of the studies conducted between 2007-2012 was excellent (1,468), while the effect size of the studies conducted between 2013-2020 (0.915) was wide. It has been stated that GIS technologies should be included in the Geography Course Secondary Education Program (9th-12th Grade) which has been prepared according to the constructivist approach since 2005 (MEB, 2005). However, GIS has not been used sufficiently due to problems such as the number of teachers who can use GIS technology, expensive software and infrastructure problems in schools (Artvinli, 2009; Dolek & Demir, 2011). This has led to the lack of experimental studies on GIS technologies. Thus, when the distribution of the studies in the last thirteen years is examined, the number is not at the desired level.

According to the level of the class in which the studies are conducted, it can be seen that the largest effect size value is at the 10th class (1,681) and the lowest effect size value is at the 7th class (0.636). It is thought that the fact that GIS is not included in the primary and secondary school level programs is effective in the occurrence of this situation. However, various studies indicate that the use of GIS in earlier periods has many benefits (Aladag, 2007; Baker, 2002; Keiper, 1996). It was concluded that there was no significant difference when it was examined whether there was a significant difference between the specified grade levels. When the curriculum is examined, the fact that only high school level gains are found for GIS may have made it difficult to accurately compare the effect sizes between the groups.

When the effect sizes related to the sample size of the studies are examined, it is seen that the largest effect size (1.735) is in the groups between 51-75 people, and the lowest effect size (1,072) is in the groups between 76 and above. However, it was concluded that there was no significant difference between the specified groups. In meta-analysis studies, enlarging the sample helps to obtain more reliable and accurate results (Dincer, 2013). In this sense, more studies are needed in the field to determine the significance between moderator variables more accurately. Regarding the results obtained from the study, the suggestions below have been made. These are given as in the following.

- The study shows that GIS affects academic achievement positively at a very large level. The study is important in terms of showing how important GIS is especially in affecting students' success in the Geography and Social Studies course. So, it is thought that increasing the use of GIS in lessons will make a great contribution to increasing the success of students.
- In the study, study type, class level and sample size are determined as moderator variables. In future studies, different moderators can be determined, and the number of variables can be increased.
- When the studies using GIS are examined, it is seen that there are fewer studies conducted at the secondary school level and there are almost no studies at some grade levels. Considering the benefits of using GIS at the secondary school level, it is thought that more emphasis should be placed on practical studies at these grade levels.
- While determining the sample of the research, the studies conducted in Turkey and abroad were examined. While reviewing the relevant literature, it was observed that the number of experimental studies was small and some studies did not have the necessary variables (sample size, mean, standard deviation, t, F, etc.) for meta-analysis statistics. Since this situation affects the results of the meta-analysis studies, it is thought that it is significant to include the relevant details in the studies.

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