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Effect of 5E Learning Model on Academic Achievement, Attitude and Science Process Skills: Meta-analysis Study

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Abstract

Today, with the development of science and technology and its rapid progress, the importance attached to science education has increased. This increase in interest has led to the development of the methods, techniques, and approaches that enable the students to be active, question and construct knowledge. The 5E learning model is one of them, and many studies have been conducted in literature related to this model. These independent studies have been carried out in different study areas, with different study groups, and different results have been achieved. In order to evaluate these results in general, it is necessary to make use of as many studies as possible. Meta-analysis was considered to work to reveal how each work has impacted the situation and make a generalization. From this point of view, a meta-analysis study was planned in this study to evaluate the effect of the 5E learning model on academic achievement, retention and scientific process skills. For this purpose, all the Master's, doctoral theses and articles in Turkish and English languages which were carried out in Turkey between 2006 and 2016 and which are suitable for the research problem have been scanned and included in the scope of the study. In order to limit studies and conduct meta-analysis in this context, studies had to be planned with semi-experimental design with experiment and control groups; there had to be quantitative data such as mean, standard deviation, and sample size and they had to be applied only in science courses. The data obtained from the articles and theses were meta-analyzed and it was determined that the 5E learning model had an effect on the students' academic achievement, attitude towards science and science process skills. In this context, studies should be conducted in order to limit the studies and to perform the meta-analysis, in which semi-experimental design with experimental and control groups is planned, t-test is applied only in science courses. By analyzing the data obtained from the articles and theses, a general evaluation was made about the effect of the 5E learning model on academic achievement, attitude toward science and science process skills. As a result of the study, the effect of the method applied for each dependent variable was found to favor the experimental group.

Keywords: 5E learning model, meta-analysis

1. Introduction

Today, it has become more difficult for individuals to follow fast and continuous information exchange around the world. Individuals realized that they need to learn the ways to attain information rather than knowing it so that they can overcome this difficulty, facilitate their daily life and work in developing and changing work environments. It was also thought that education should teach individuals how to construct information. For this reason, many countries took science education programs into consideration and they began new structuring. To examine some of these programs;

Science_A Process Approach: S_APA I was developed by Gagne and this program aims to ensure that students learn by practicing during their education and that they obtain and improve science process skills by doing experiments (Padilla, Okey & Garrard, 1984; Kaptan, 1999). It was later revised and changed to S_APA II (Science_A Process Approach II). This program differed from the previous one in that students did not have books and were involved in the learning process by participating directly in the activities (Kaptan, 1999).

In the Elementary Science Study (ESS) program, the teacher assumes the role of guide. The students, on the other hand, plan everything and organize their own learning. Students need to talk, discuss and perform the activities according to their interests and speeds. They seek answers to questions and evaluate the results of research in a discussion environment while doing so (Kaptan, 1999).

The Science Curriculum Improvement Study (SCIS) program aims to help children achieve science process skills and become scientifically literate individuals. Piaget's developmental periods were taken into consideration in the construction of the program. The main aim of the program is to enable students to discover, search for and find scientific knowledge in classrooms (Kratochvil & Crawford, 1971, Kaptan, 1999, Kaptan, Yetisir & Demir, 2007). Learning cycle defined by JMyran Atkin and Robert Karplus (1962) was used in this program (Bybee, 2006). Learning cycle is based on research and constructivist approach.

If we look at the basics of all of these programs, it is noteworthy that students are active and construct the knowledge themselves in these programs.

These recently developed programs, science education standards published by the National Research Council (NRC) in 1995 and rapidly changing science and technology have made it necessary to restructure the science course program in our country in order to train qualified individuals. In light of these developments, Ministry of National Education restructured the Science Lesson in 2004 and changed its name to Science and Technology Lesson (MoNE, 2005). A structured approach was adopted in the new program and the program was designed with a spiral structure. Later revisions were made to the program (MoNE, 2005; MoNE, 2013) and finally, draft program was developed in 2017. However, the basis of the program is the constructivist approach (MoNE, 2017). The main aim of the program is to educate science-literate individuals. The main feature of science literate individuals is they construct information themselves. Many methods, techniques, and models have been developed to reveal the constructivist approach in the program. One of these models is 5E learning model. The model can be used in science courses to increase the quality of practices and to design science courses based on structural approach and cognitive psychology (Bybee, 1997). Furthermore, Bybee (1997) argues that the use of this approach helps students redefine, organize, examine, and change the ideas they already have through interacting with their peers and environment. According to Duran (2004), the 5E learning model helps and serves teachers in that it provides an example of the application of the structuralist approach in course processing and provides good reform-based instruction. He also stated that the model could help to develop the curriculum. Senan (2013) reported that the technology-enriched 5E learning model is a good tool for students to acquire 21st-century skills as well as for teachers to teach a specific concept. In his study on the 5E learning model, Prokes (2009) observed that the students in this model were more active and motivated than the students in lecture-based classrooms and that these students could find opportunities to share their knowledge and experiences. According to the 5E learning model, students' prior knowledge is identified and a research question is put forth about the concept or event to be learned, the first-hand experience and information are reached in the solution of the existing question through teacher’s guidance and the concept or event is transferred to a different field and evaluated. When its steps are examined in general;

Introduction: the purpose of this step is to capture the attention and interest of students. A problem, situation or event is given for the ability and concept intended to be constructed in the students. It is aimed that the students focus on this situation. The most prominent feature of this step is that a short demonstration, problem situation or event is given in order to evaluate and reveal the preliminary knowledge of students. The teacher gets students’ attention to the question or event at the beginning of the lesson.

Discovery: At this stage, students experience firsthand the experience they need to solve the question put forth in the introduction stage.

Description: Students are allowed to explain and organize the lacking part in their preliminary knowledge in a clear and understandable manner with the information they just acquired.

Expanding: It includes the ability to transfer the concepts or situations students learn to new situations.

Assessment: Students receive adequate feedback on the concepts, explanations, and skills they acquire. Teachers have to evaluate learning outcomes at this stage (Bybee, 2006, Campbell, 2006).

Since the concepts in the field of science are abstract concepts in general, these concepts are often difficult to construct in students' minds. Thus, misconceptions are widespread in science. The 5E learning model emerges as an important model in the elimination of misconceptions since it allows students to determine the misconceptions, to eliminate them through first-hand experiences and to evaluate themselves (Ayas, 1998; Ceylan & Geban, 2009; Cepni, et al., 2001; Saka, 2006; Sahin & Cepni, 2012; Turgut & Gurbuz, 2011; Yıldız Feyzioglu, Ergin & Kocakulah, 2012). There are also many studies examining the effect of the 5E learning model on the achievement (Acıslı, 2014; Acıslı &Turgut, 2011; Aksoy & Gurbuz, 2013; Aktas, 2013a; Aydın & Yılmaz, 2010; Ayvacı & Yıldız, 2015; Bıyıklı & Yagcı, 2015; Cepni & Sahin, 2012; Cepni, Sahin & İpek, 2010; Cetin Dindar, 2012; Dasdemir, 2016; Devecioglu, 2016; Dikici, Turker & Ozdemir, 2016; Er Nas, Coruhlu & Cepni, 2010; Guzel, 2016; Lai, Lai, Chuang & Wu, 2015; Ozsevgec, Cepni & Bayri, 2007; Ozturk Geren & Dokme, 2015; Pabuccu & Geban, 2015; Sahin & Cepni, 2012; Temel, Dincol, Ozgur & Yılmaz, 2012; Tiryaki, 2009), attitude (Acıslı, Turgut, Yalcın & Gurbuz, 2009; Acıslı & Turgut, 2011; Akar; 2005; Altun Yalcın,

Acıslı & Turgut, 2010; Aktas, 2013b, Aydın & Yılmaz, 2010; Bıyıklı & Yagcı, 2015; Guzel, 2016; Hırca, Calık & Seven, 2011; Ozbudak & Ozkan, 2014) and science process skills (Acıslı, 2014; Acıslı, Turgut, Yalcın & Gurbuz, 2009; Acıslı & Turgut, 2011; Altun Yalcın, Acıslı & Turgut, 2010; Bıyıklı, 2013; Ozturk Geren & Dokme, 2015;) of students. These studies in science have been realized at many levels from primary education (first (primary) and second (secondary) levels) to university. However, no research has been carried out that indicates a clear result showing how effective this model is on attitude, achievement and science process skills when compared with traditional teaching methods in the field of science. These independent studies were carried out in different study areas and with different study groups and different results were achieved. In order to evaluate these results in general, it is necessary to make use of as many studies as possible. Meta-analysis has been conducted in the study in order to monitor how each study has affected the situation and to make a generalization. This study aims to determine the effect of the 5E learning model on academic achievement, attitude towards lesson and science process skills compared to the traditional teaching method. To this end, answers to the following questions were sought:

1. What is the effect of the 5E learning model on the academic achievement of students?
2. What is the effect of the 5E learning model on students' attitude towards lesson?
3. What is the effect of the 5E learning model on students' science process skills?

2. Method

2.1 Research Model

In the study, meta-analysis was used to determine the effect of the 5E learning model on students' academic achievement, attitudes toward science, and science process skills. Although meta-analysis is described as reviewing in health sciences and research in social sciences, it is basically a quantitative technique which aims to combine the results of several published and complete individual studies in terms of various variables and make a general evaluation. It is a literature search technique in scientific research and helps to reach a general judgment by compiling quantitative research results (Bailar, 1995, Christensen, Johnson & Turner, 2015; Finley, 1995; Hunter & Schmidt, 2004).

2.2 Data Collection

The sources from which the research data was obtained are articles and master's and doctoral dissertations published and unpublished about the "5E learning" model in Turkey between 2006 and 2016, designed with quantitative design and published in refereed journals with essential statistical data.

When scanning;

The website of YOK (Council of Higher Education) National Dissertation Center has been used for thesis. When scanning, keywords including both Turkish and English "5E learning model", "Structural approach", "5E" were typed in the study title and both the Turkish and English theses were reached. A total of 74 dissertations were reached, but the number of theses reached from the dissertation center and from the researchers is 21. 11 of these theses are master's degree and 10 of them are doctorate theses. Only theses written for science courses were included in the study. 10 theses were excluded from the study because of the use of a single group pattern or the use of more than one teaching method in some theses, or because some theses did not have some values required for analysis or because some of them had been published in journals. The articles of the theses published have been included in the study. 10 theses on the effect of the 5E learning model on the academic achievement of students, 6 theses on the students' attitude towards lesson and 1 thesis on the science process skills of students have been included in the meta-analysis study.

EBSCO, Google Scholar, Ulakbim, and other prestigious scientific refereed journals were scanned in order to reach the articles published in Turkey. All the Turkish and English publications whose sampling was Turkey have been scanned. Some articles have not been included in the study because they had more than one teaching method used together and they did not indicate some values required for analysis. As regards to the articles included, 23 articles on the effect of the 5E learning model on the academic achievement of students, 16 articles on the students' attitude towards lesson and 5 articles on the science process skills of students have been included in the meta-analysis study.

As there were several studies on attitudes and academic achievement in some theses and articles, these were considered as separate studies. Furthermore, the reports on the 5E learning model were difficult to reach, so they have not been included in the study.

Criteria for Being Included In the Study

The following criteria were taken into account when determining the studies to be included in the meta-analysis study:

- Studies should be conducted between 2006 and 2016,

- The articles should be published in master and doctoral theses and in refereed journals written in English and Turkish,
- Studies should include experimental and control groups and pre-test post-test experimental study;
- Studies should be applied in the field of science and technology,
- In the studies, the traditional teaching approach should be applied to the control group while the 5E learning model to the experimental group.
- In the studies, there should be arithmetic mean and standard deviation values of study groups related to academic achievement, attitude towards lesson and science process skills.
- In the studies, the sample sizes of the study groups should be included.

2.3 Data Code

The coding has been done so that the meta-analysis of the scanned and obtained works can be done. The coding process has been done to include the contents and the publication information of the study. Codes consist of the author, type and publication year of the study, the level of education of the student group to which the study was applied, the type of the course the study was applied to, the statistical data and dependent variables in the study. The statistical data used in the study are the sample size, arithmetic mean and standard deviation values of the study. The dependent variables, on the other hand, are the effect size of the academic achievement, attitude towards the course and science process skills. The effect size is a standard value used in the analysis of each study (Bernard et al., 2004; quoted by: Aktamıs, Higde & Ozden, 2016).

2.4 Data Analysis

Meta-analysis method has been used in the study. In addition, descriptive analyses have been made as to by whom, in what year and in which publication type the studies were performed. Comprehensive Meta-Analysis (CMA) program has been used for meta-analysis. Cohen (1977) defined the Cohen's d shown in the meta-analysis as the difference between the averages of the two groups as the resulting value from dividing the two groups into a common standard deviation combined (quoted by: Cohen, 1980). There is also Hedge's g in meta-analysis studies and the same formula is utilized here too and Cohen assumes that the variances here are not equal to the difference (Dincer, 2014). Thanks to the d and g values calculated here, the results of more than one independent study are translated into a common measuring system, which helps us to make a right comparison (Dincer, 2014, Ustun, Eryılmaz, 2014).

Cohen (1988) used a classification for interpreting the effect sizes and overall effect size obtained from the meta-analysis. According to this;

- $-0.15 \leq d \leq 0.15$ was interpreted as insignificant level;
- $0.15 \leq d \leq 0.40$, minor level;
- $0.40 \leq d \leq 0.75$, medium level;
- $0.75 \leq d \leq 1.10$, broad level;
- $1.10 \leq d \leq 1.45$, very broad-level;
- $1.45 \leq d$ perfect level.

Before calculating the effect sizes in the meta-analysis, it is necessary to perform a homogeneity test to measure the effect sizes and the homogeneity of the population sample in the study. Thus, the model to be applied is determined according to the study. There are 2 models; one is the fixed effects model and the other is the random effects model. The fixed effect model states that all studies have only one effect size and that the resulting differences are due to sampling error. The random effects model, on the other hand, implies that the actual effect size may vary from work to work due to variables such as age, education of participants and sampling size. Thus, it tells the effect size is distributed around some averages (Ustun & Eryılmaz, 2014). The model is determined according to whether or not the Q value exceeds the critical value and whether the p values are less or more than 0.05. If the Q value exceeds X^2 value for a specific df value and if $p<0.05$, there is heterogeneity and the random effects model is used. If the Q value does not exceed X^2 value for a specific df value and if $p>0.05$, there is homogeneity and the fixed effects model is used. The effect size is calculated according to these models (Borenstein, Hedges, Higgins & Rothstein, 2009; Dincer, 2014).

3. Results

A total of 38 studies have been used in the study comparing 5E learning model with traditional teaching in the field of science. 22 articles and 10 theses on the dependent variable of academic achievement; 14 articles and 7 theses on the dependent variable of attitude towards lesson and 5 articles and 1 thesis on the dependent variable of science process

skill have been included in the study. In the studies about the dependent variable of academic achievement, a total of 1202 students in the experimental group and 1054 students in the control group; in the studies about the dependent variable of attitude towards lesson, a total of 725 students in the experimental group and 722 students in the control group and in the studies about the dependent variable of science process skills, a total of 177 students in the experimental group and 169 students in the control group have been analyzed.

Table 1. Meta-Analysis included works

	Academic Achievement		Attitudes Towards Science		Science Process Skills	
Included works	Article	Thesis	Article	Thesis	Article	Thesis
Acıslı, 2014	x				x	
Acıslı, Turgut, Yalcın & Gurbuz, 2009			x		x	
Acıslı & Turgut, 2011	x		x		x	
Ozturk Geren & Dokme, 2015	x				x	
Aksoy & Gurbuz, 2013	x					
Aktas , 2013a/b	x		x			
Ayvacı & Yıldız, 2015	x		x			
Bıyıklı & Yagcı, 2015	x		x			
Cardak, Dikmen & Sarıtas, 2008	x					
Cepni & Coruhlu, 2014	x					
Ergin, 2009	x					
Ergin, Kanlı & Tan, 2007	x					
Ergin, Unsal & Tan, 2006	x		x			
Ersoy, Sarıkoc & Berber, 2013	x					
Guzel, 2016	x		x			
Guzel, 2016			x			
Guzel, 2016			x			
Hırca, Calık & Seven; 2011	x		x			
Ozbudak & Ozkan, 2014	x		x			
Ozsevgec, 2006	x		x			
Saygın, Altınboz & Salman, 2006	x					
Yıldız Feyzioglu, Ergin & Kocakulah	x					
Turgut & Gurbuz, 2011	x		x			
Aggul, Yalcın & Bayrakceken, 2010	x					
Altun Yalcın, Acıslı & Turgut, 2010			x		x	
Bıyıklı, 2013		x		x		x
Akar, 2005				x		
Ceylan, 2008		x		x		
Ekici, 2007		x		x		
Erdogdu, 2011		x				
Erdogdu, 2011				x		
Zengin, 2016		x				
Onder, 2011		x				
Coskun, 2011		x				
Aydemir, 2012		x		x		
Ozturk, 2013				x		
Keskin, 2008		x		x		
Bilgin, Ay & Coskun, 2013	x					
Total (n:38)	22	10	14	7	5	1

The findings of the study have been evaluated in 3 sub-categories. Analyses have been performed for each dependent variable and the findings were listed respectively.

3.1 Findings Related to the Effect of 5E Learning Model on Academic Achievement of Students

The findings of the homogeneity test and the findings as to which model is to be used are given in Table 2 below in order to determine the effect of the 5E learning model on the academic achievement of the students when compared with the traditional teaching model.

Table 2. Findings Related to Homogeneity and General Effect Size

Model	ES	df	Q	X^2	SE	ES (%95 CI)	
						Min.	Max.
SEM	1.189	30	215.652	43.77	0.047	1.098	1.280
REM	1.268	30	215.652	43.77	0.128	1.017	1.518

When the Table 2 above is examined, the Q value according to the homogeneity test is calculated as 215.652. In the X^2 table, the critical value was found to be 43.77 with 30 degrees of freedom at 95% significance level. According to these results, it can be said that the distribution of effect sizes is heterogeneous because Q value (215.652) is larger than the critical value of 43.77 and p-value ($p < 0.05$) is small. According to the test results, the analysis was performed by the random effects model. Accordingly, the combined effect sizes, variance and working weights of the studies included in the study are shown in Table 3.

Table 3. Effect Size Findings of Studies Included in the Research

Researcher	ES	p	Working weight
Acıslı, 2014	1.312	0.000	3.23
Ozturk Geren & Dokme, 2105	1.554	0.000	2.96
Acıslı & Turgut, 2011	2.326	0.000	3.23
Aksoy & Gurbuz, 2013	1.119	0.000	3.23
Aktas, 2013a	2.315	0.000	3.07
Ayvacı & Yıldız, 2015	0.759	0.000	3.49
Bıyıklı & Yagcı. 2015	2.878	0.000	2.92
Cardak, Dikmenli & Sarıtas, 2008	0.990	0.004	3.01
Cepni &Coruhlu, 2014	1.025	0.000	3.35
Ergin, 2009	2.179	0.000	3.27
Ergin, Kanlı &Tan, 2007	2.179	0.000	3.72
Ergin, Unsal & Tan, 2006	1.703	0.000	3.34
Ersoy, Sarıkoc & Berber, 2013	0.890	0.007	3.06
Guzel, 2016	1.105	0.000	3.27
Hırca, Calık &Seven, 2011	1.101	0.001	3.06
Ozbuda & Ozkan, 2014	0.907	0.000	3.67
Ozsevgec, 2006	1.127	0.000	3.34
Saygın, Altınboz & Salman, 2006	1.217	0.000	3.11
Yıldız Feyzioglu, Ergin & Kocakulah, 2012	-0.916	0.002	3.21
Turgut & Gurbuz, 2011	1.578	0.000	2.88
Aggul Yalcın & Bayrakceken, 2010	1.306	0.000	3.04
Ceylan, 2008	2.669	0.000	3.35
Ekici, 2007	0.944	0.002	3.17
Erdogdu a, 2011	1.821	0.000	3.17
Erdogdu b, 2011	1.105	0.000	3.27
Zengin, 2016	0.648	0.032	3.17
Onder, 2011	0.921	0.004	3.11
Coskun, 2011	0.783	0.000	3.62
Aydemir, 2012	1.365	0.000	3.48
Keskin, 2008	-0.167	0.616	3.05
Bilgin, Ay & Coskun, 2013	0.786	0.000	3.62
Effect size	1.268		

As a result of the analysis made according to the random effects model, the upper limit was calculated as 1.518, the lower limit was 1.017 and the effect size was 1.268 for a standard error of 0.128 and a confidence interval of 95%. When statistical significance was examined, it was found that $Z = 9.931$ and $p = 0.000$. This is statistically significant according to the results obtained. In addition, the fact that the mean effect size is positive (+1.268) shows that the effect of the applied method was in favor of the experimental group and has a wide range of effects according to the Cohen (1988) classification. When the effect sizes of the studies are examined, it is seen that 29 studies have positive effects and 2 works have negative effects. The smallest effect size was calculated as -0.916 and the highest effect size as 2.878.

The Funnel Plot was used to determine if there was a publication bias, and calculations were made according to the Rosenthal method.

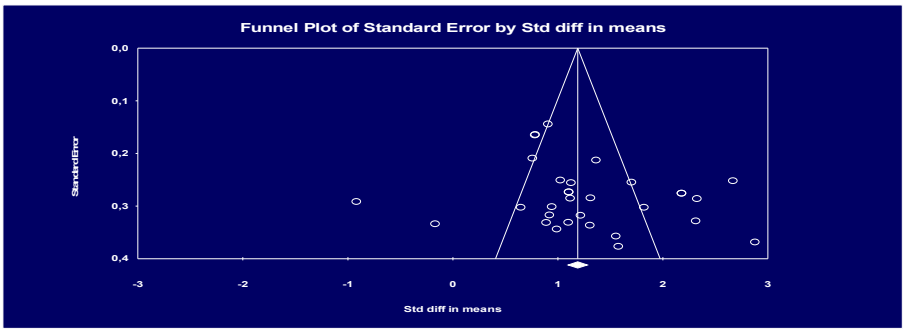

Figure 1. Effect Size Funnel Plot

It will be seen that in the event of publication bias in the funnel plot, the effect sizes will be distributed asymmetrically and vice versa. When Figure 1 is examined, it is seen that it is distributed in a structure close to the symmetric structure. This shows that the publication bias is not high. The value obtained as a result of the Rosenthal method is 13.270 and if the value is more than 1, it shows that there is resistance against publication bias.

3.2 Findings Related to the Effect of 5E Learning Model on Students' Attitudes towards the Lesson

The findings of the homogeneity test and the findings as to which model is to be used are given in Table 2 below in order to determine the effect of the 5E learning model on students' attitudes towards the lesson when compared with the traditional teaching model.

Table 4. Findings Related to Homogeneity and General Effect Size

Model	ES	df	Q	X^2	SE	ES (%95 CI)	
						Min.	Max.
SEM	0.584	19	79.697	30.14	0.054	0.477	0.691
REM	0.583	19	79.697	30.14	0.115	0.358	0.808

As indicated in Table 4 above, the Q value according to the homogeneity test was calculated as 79.697. In the X^2 table, the critical value was found to be 30.14 with 19 degrees of freedom at 95% significance level. These results show that the distribution of effect sizes is heterogeneous because Q value (215.652) is larger than the critical value of 30.14 and p-value ($p < 0.05$) is less. Furthermore, the test results indicate that the analysis was performed by the random effects model. Accordingly, the combined effect sizes, variance and working weights of the studies included in the study are shown in Table 5.

Table 5. Effect Size Findings of Studies Included in the Research

Researcher	ES	p	Working Weight
Acıslı. Turgut, Yalcın & Gurbuz. 2009	2.547	0.000	3.60
Acıslı & Turgut.2011	0.893	0.000	5.33
Aktas, 2013b	0.815	0.002	5.00
Ayvacı &Yıldız. 2015	0.694	0.001	5.57
Bıyıklı & Yagcı. 2015	1.115	0.000	4.87
Ergin, Unsal & Tan, 2006	0.521	0.019	5.43
Guzel a, 2016	0.213	0.403	5.10
Guzel b, 2016	-0.546	0.035	5.06
Guzel c, 2016	1.105	0.000	4.91
Hırca, Calık & Seven, 2011	0.986	0.003	4.39
Ozbudak & Ozkan. 2014	0.960	0.000	6.15
Ozsevgec, 2006	0.067	0.779	5.27
Turgut & Gurbuz, 2011	0.074	0.822	5.37
Altun Yalcın, Acıslı & Turgut, 2010	0.023	0.930	5.07
Akar, 2005	0.068	0.800	4.97
Ceylan,. 2008	0.413	0.026	5.79
Ekici, 2007	0.637	0.030	4.72
Aydemir, 2012	0.630	0.001	5.68
Keskin, 2008	0.230	0.492	4.31
Oztruk, 2013	0.697	0.031	4.42
Effect Size	0.583		

The analysis performed according to the random effects model indicate that the upper limit was calculated as 0.808, the

lower limit was 0.358 and the effect size was 0.583 for a standard error of 0.115 and a confidence interval of 95%. When statistical significance was examined, Z = 5.088 and p = 0.000 were found. This is statistically significant according to the results obtained. In addition, the fact that the mean effect size was positive (+0.583) shows that the effect of the applied method is in favor of the experimental group and has a medium range of effects according to the Cohen (1988) classification. The effect sizes of the studies point out 19 studies had positive effects while only 1 study had negative effects, and the smallest effect size was calculated as -0.546 and the highest effect size as 2.547.

The Funnel Plot was used to determine if there was a publication bias, and calculations were made according to the Rosenthal method.

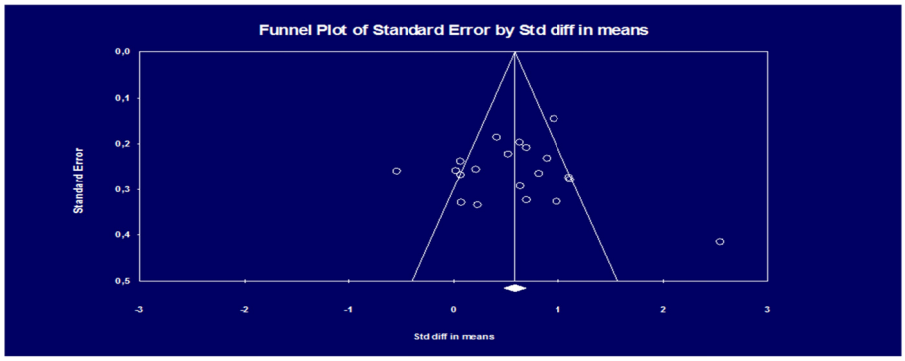

Figure 2. Effect Size Funnel Plot

It will be seen that in the event of publication bias in the funnel plot, the effect sizes will be distributed asymmetrically and vice versa. Figure 2 proves that it was distributed in a structure close to the symmetric structure. This shows that the publication bias is not high. The value obtained as a result of the Rosenthal method was 12.583 and if the value is more than 1, it shows that it is resistant against publication bias.

3.3 Findings Related to the Effect of 5E Learning Model on Students' Science Process Skills

The findings of the homogeneity test and the findings as to which model is to be used are demonstrated in Table 6 below in order to determine the influence of the 5E learning model on students' science process skills when compared with the traditional teaching model.

Table 6. Findings Related to Homogeneity and General Effect Size

Model	ES	df	Q	X^2	SE	ES (%95 CI)	
						Min.	Max.
SEM	1.586	5	23.797	11.07	0.126	1.340	1.832
REM	1.669	5	23.797	11.07	0.278	1.124	2.214

As indicated in Table 6 above, the Q value according to the homogeneity test was calculated as 23.887. In the X^2 table, the critical value was found to be 11.70 with 5 degrees of freedom at 95% significance level. These results prove that the distribution of effect sizes was heterogeneous because Q value (23.797) is larger than the critical value of 11.70 and p-value ($p < 0.05$) is less. Furthermore, the test results indicate that the analysis was performed by the random effects model. Accordingly, the combined effect sizes, variance and working weights of the studies included in the study are shown in Table 7.

Table 7. Effect Size Findings of Studies Included in The Research

Researcher	ES	p	Working Weight
Acıslı, 2014	1.472	0.000	17.30
Acıslı, Turgut, Yalcın & Gurbuz, 2009	0.927	0.004	16.53
Ozturk Geren & Dokme; 2015	1.892	0.000	15.35
Acıslı & Turgut, 2011	1.643	0.000	18.09
Altun Yalcın, Acıslı & Turgut. 2010	1.131	0.000	17.59
Bıyıklı, 2013	3.134	0.000	15.14
Effect Size	1.669	0.000	

As a result of the analysis performed according to the random effects model, the upper limit was calculated as 2.214, the lower limit was 1.124 and the effect size was 1.669 for a standard error of 0.278 and a confidence interval of 95%. When statistical significance was examined, Z = 6.002 and p = 0.000 were found. This is statistically significant according to the results obtained. In addition, the fact that the mean effect size is positive (+1.669) shows that the effect

of the applied method is in favor of the experimental group and has a perfect range of effects according to the Cohen (1988) classification. When the effect sizes of the studies are examined, it is seen that all studies have positive effects, the smallest effect size was calculated as 0,927 and the highest effect size was 3.134.

The Funnel Plot was used to determine if there was a publication bias, and calculations were made according to the Rosenthal method.

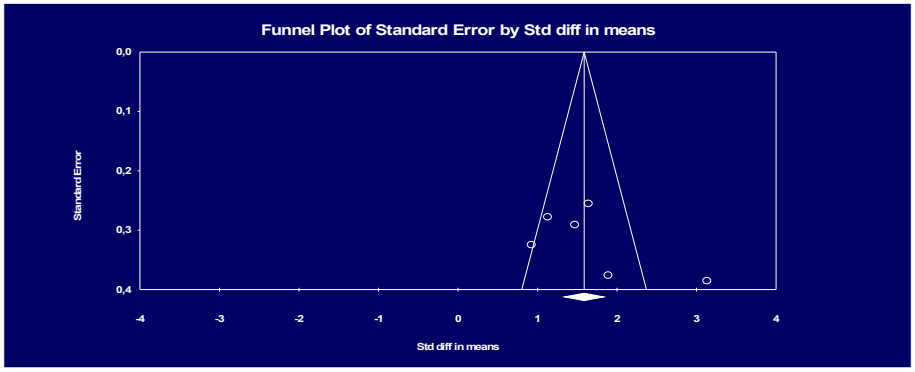

Figure 3. Effect Size Funnel Plot

It will be seen that in the event of publication bias in the funnel plot, the effect sizes will be distributed asymmetrically and vice versa. Figure 3 shows that it is distributed in a structure close to the symmetric structure. This shows that the publication bias is not high. The value obtained as a result of the Rosenthal method is 8.65 and if the value is more than 1, it shows that it is resistant against publication bias.

4. Discussion

On the effect of 5E learning model on the academic achievement compared with the traditional teaching method, a total of 31 studies which were published or unpublished nationally or internationally between 2006 and 2016, which were applied in science lessons, designed in experimental design, with quantitative data (arithmetic average, sample size and average) have been combined. The total number of samples in the studies used to determine its effect on academic achievement was 2256. According to random effects model, it has been determined that the overall effect size of the studies was found to be 1,017 and ES=1,268 (%95 CI, SE=0,128) at a confidence interval of 1,518 and that it has a very broad level of effect according to Cohen (1988) classification. According to this finding, it can be said that the 5E learning model is very effective on academic achievement compared with the traditional teaching method. Besides this, studies showing that it has negative effects have also been found (Keskin, 2008; Yıldız Feyzioglu, Ergin & Kocakulah, 2012). The negative consequences of these studies may be due to small sample groups and physics topics that are difficult to understand. This result of the study shows a parallelism with the studies conducted in parallel with the studies carried out between 2003 and 2014 but researched the effect of constructivist approach on academic achievement (including studies involving the 5E learning model) and with no specific field application limit (Ayaz & Sekerci, 2015) and the studies with no specific field application limit that researched the effect of 5E learning model on the academic achievement between 2008 and 2014 (Anıl & Batdı, 2015).

On the effect of 5E learning model on students' attitude towards the lesson compared with the traditional teaching method, a total of 20 studies which were published or unpublished nationally or internationally between 2006 and 2016, applied in science lessons, designed in experimental design with quantitative data (arithmetic average, sample size and average) have been combined. The total number of samples in the studies used in determining its effect on attitudes towards the lesson is 1447. According to random effects model, it has been determined that the overall effect size of the studies was found to be 0,358 and ES=0,583 (%95 CI, SE=0,115) at a confidence interval of 0,808 and that it has a very broad level of effect according to Cohen (1988) classification. This finding reveals that the 5E learning model is moderately effective on the attitude towards the lesson compared with the traditional teaching method. Besides this, 1 study showing that it has negative effects was found (Guzel, 2016). The reason for the negative outcome of these studies has not been determined. This result of the study shows a parallelism with the studies conducted in parallel with the study between 2003 and 2014 but researched the effect of constructivist approach on students' attitude towards lesson (including the studies involving the 5E learning model) and with no specific field application limit (Ayaz & Sekerci, 2015) and the studies with no specific field application limit that researched the effect of 5E learning model on students' attitude towards lesson (Anıl & Batdı, 2015) and the studies that researched the effect of 5E learning model on students' attitude towards lesson and that covered the years between 2004 and 2014 and with no specific field application limit (Ayaz, 2015).

On the effect of 5E learning model on the science process skills compared with the traditional teaching method, a total of 6 studies which were published or unpublished nationally or internationally between 2006 and 2016, applied in science lessons, designed in experimental design with quantitative data (arithmetic average, sample size and average) have been combined. The total number of samples in the studies used in determining the effect on science process skills is 346. According to random effects model, it has been determined that the overall effect size of the studies was found to be 1,124 and ES=1,559 (%95 CI, SE=0,278) at a confidence interval of 2,214 and that it has a perfect level of effect according to Cohen (1988) classification. According to this finding, it can be said that the 5E learning model is effective at a perfect level on the attitude towards the lesson compared with the traditional teaching method. Besides this, no studies showing negative effects have been identified.

In general, it can be said that the 5E learning model is more effective on students' academic achievement, attitude towards lesson and science process skills than the traditional teaching method.

The following suggestions can be given in line with the study.

- It has been determined that the 5E learning model has a moderate effect on the attitudes of the students. In other studies, Ayaz (2015) determined a small scale of effect; Anıl and Batdi (2015) a medium scale of effect, Saraç (2017) a medium scale of effect, Ural and Bumen (2016) a medium scale of effect and Ayaz and Sekerci (2015) a medium scale of effect. These results indicate that it can be investigated what needs to be done in order to increase this effect.
- The 5E learning model has been found to have a broad effect on the academic achievement of students. In other studies; Anıl and Batdi (2015) determined a very broad scale of effect, Saraç (2017) a very broad scale of effect, Ural and Bumen (2016) a very broad scale of effect and Ayaz and Sekerci (2015) a very broad scale of effect. Teachers can be encouraged to apply the 5E learning model in lessons, and the necessary in-service practices can be given to eliminate the application difficulties.
- Since this teaching model is efficient, it can be emphasized more in the curriculum.
- Meta-analysis studies that investigate with which course content and at which level of learning the applications prepared according to the 5E learning model are more effective can be performed.

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Notes

Note 1. The items used in the study are marked with "*"

Note2. This article presented as a video presentation at International Conference on New Horizons in Education. But this article is not printed in full text.