The Effect of Science, Technology, Engineering and Mathematics-Stem Educational Practices on Students' Learning Outcomes: A Meta-Analysis Study

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ABSTRACT
In the study, a meta-analysis study was conducted in order to determine the effects of STEM educational practices on the learning outcomes of the students in the education-training process. The articles were made in national and international context with statistical data that could be included in the meta-analysis study in accordance with the research problem between 2010-2017, literature review was conducted using Turkish and English key words. As a result of the survey, 23 articles on the effect of STEM educational practices on the learning products of students and 2 postgraduate theses meta-analyses were included and a total of 58 effect size values were obtained. A total of 6535 students in the experimental groups and a total of 6373 students in the control groups were included in the meta-analysis included studies. As a result of the study, it was determined that the effects of STEM educational practices on students' academic achievement were 0.442, the attitude effect was 0.620 and the effect on scientific process skills was 0.820. These results are middle effect on students' academic achievement and attitude towards the course according to the effect size classification and a large level of effects on scientific process skills. Of the 58 effect size values obtained in the study, 56 have a positive effect and 2 have a negative effect. Moderator analyses were carried out according to the researches examined, the academic achievement of the learning outcomes, the attitude towards the course and the scientific process skills subscale, the lesson types in which the research was conducted, and the learning levels of the students participating in the research.

Keywords: STEM, Meta-analysis, Learning outcomes

INTRODUCTION
In the present century, on the one hand, technological changes are affecting education, on the other hand, increasing knowledge accumulation affects education (Williams & Kingham, 2003). It would not be wrong to state that education researchers and scientists are in a consensus on the need to use technology in education to achieve permanent and effective learning in individuals by increasing the quality of education (Komis, Ergazakia & Zogzaa, 2007). Use of technology in education; incorporating computers for teaching purposes, or bringing technology products to class, and using technological products in the teaching process (Isman, 2002). The use of technology in education should not be perceived only as computer use or internet access. Technology should at the same time be seen as a means of enhancing the professional productivity of teachers and enhancing the learning of students (Hernandez-Ramos, 2005). In terms of education, technology can be defined as a phenomenon of information exchange and human interaction, which is used in a purposeful way that includes all sorts of systems, techniques, and help to improve the learning process beyond the use of technology as a tool (Girginer & Ozkul, 2004).

The area in which technology-based education is inevitable is waiting for the individuals to be producers and inventors; this suggests that they can bring together the knowledge in the fields of Science, Technology, Engineering and Mathematics (STEM) to enable individuals to demonstrate their productivity (Akgunduz, Ertepinar, Ger, Kaplan Sayi & Turk, 2015). STEM is an abbreviation of the initials of the words Science, Technology, Engineering and Mathematics. This technology-based education, termed STEM in the United States, is understood to be an integral part of math and science courses at school level, but it is also understood to be teaching engineering and technology with in-class and out-of-class activities (Sahin, Ayar & Adiguzel, 2014). STEM is an abbreviation of the initials of the words Science, Technology, Engineering and Mathematics. All the disciplines that make up the STEM play an important role in the development of twenty-first century skills such as adaptability, communication, social skills, problem solving, creativity, self-control and scientific thinking (NRC 2012). The aim of STEM education is to achieve an approach that focuses on the integration of learning by establishing a relationship between the disciplines, rather than being separate from each other (Guzey, Harwell & Moore, 2014). All the disciplines that make up STEM; It also plays an important role in the development of twenty-first century skills such as critical thinking, problem solving, co-operation, leadership ability, scientific thinking, adaptability, entrepreneurship, curiosity and imagination, communication, access to information and use (Bybee, 2010).

STEM; science, technology, engineering and mathematics as a field of work that bridges the disciplines (Meng, Idris & Kwan, 2014). Technology and engineering design-based STEM foresees the integration of knowledge and skills related to these areas in teaching mathematics and science subjects (Bybee, 2010; Guzey, Harwell & Moore, 2014). STEM; is an educational approach aimed at providing students with the ability to communicate in an inter disciplinary way, to do team work, to think creatively, to research, to produce and to solve problems, focusing on the integration of knowledge and skills of science, technology, mathematics and engineering on an engineering design based teaching (Dugger, 2010). STEM education; is important because it is a method by which students gain knowledge and skills by approaching problems from a multidisciplinary point of view and also provide opportunities for students to gain twenty-first century skills and opportunities for these four field specializations. For this reason, if the method is applied, it will serve to close the qualified labor force in the labor market, production, AR-GE, innovation, technical infrastructure and process development (TUSIAD, 2014). STEM education in general; engineering, and mathematics disciplines by establishing a relationship between a unit or lesson of real life problem and content (Altan, Yamak & Kirikkaya, 2016; Moore, Stohlmann, Wang, Tank & Roehrig, 2013; Riechert & Post, 2010).

In many developed and developing countries, particularly in the USA, the STEM education model has begun to be implemented in curricula, standards and in-school and out-of-school activities. In 2014, the Turkish Industrialists' and Businessmen's Association (TUSIAD) organized the "*STEM Summit*" in order to emphasize the importance of STEM education and the need for STEM workforce. This meeting was attended by researchers, teachers and students, as well as lucrative companies that have shown progress in the field of industry. It is argued at this meeting that STEM education practices can increase the level of economic and welfare of the community, as is the case in the US and other countries. Researchers who advocate an integrated approach in STEM education argue that with the topics that present problems in current life, learners will be able to increase the interest, motivation and achievement of the course and thus increase the number of students planning a career related to STEM (Honey Pearson & Schweingruber, 2014). The aims of our country's 2023 vision and the strategic documents of the Ministry of National Education (MoNE) indicate that science-technology-engineering-mathematics (STEM) education should be defined on the scale of our country (Corlu, Capraro & Capraro, 2014). However, work done in this area is still in its infancy. Therefore, to develop a generation capable of innovation, the scope, theory and practice of science-technology-engineering and mathematics education, which is at the center of reforms, should be studied at the level of schools and universities (Cavas, Bulut, Holbrook & Rannikmae, 2013; Marulcu & Sungur, 2012). The integration of the STEM areas, which are understood as the result of the international literature search, and that many studies have been conducted and the education of the schools has begun to be started, has not been wide spread in Turkey yet (Gulhan & Sahin, 2016).

The aim of the research is to determine the effect of the use of STEM educational practices on the academic achievement of the students, on the related course and on the development of scientific process skills by meta-analysis. For this, the effect sizes of studies using STEM educational practices in the national and international education and training process have been analysed.

According to this research; The question was searched "*How is STEM Educational Practices Affecting Students' Learning Outcomes*?" Sub-problems identified in this direction are as follows.

- Is there any effect on the academic achievement of students using STEM educational practices?
- Is there any effect on the attitude of students using STEM educational practices?
- Is there any effect on the scientific process skills of students using STEM educational practices?

Literature Review

As a result of the national literature review on the integration of STEM educational practices, it appears that the work on STEM, which has a central position in educational reform movements in recent years, is on the rise (Akaygun & Aslan-Tutak, 2016; Aslan-Tutak, Akaygun & Tezsezen, 2017; Ayar, 2015; Ayar & Yalvac, 2016; Baran, Bilici & Mesutoglu, 2015; Bozkurt, Yamak, Bulus Kirikkaya & Kavak, 2013; Buyruk & Korkmaz, 2016; Cinar, Pirasa, Uzun & Erenler, 2016; Haciomeroglu & Bulut, 2016; Yamak, Bulut & Dundar, 2014; Yildirim & Altun, 2015). In the international of integration of STEM educational practices, it is observed that STEM activities are mainly concentrated at primary and secondary level, and higher education is mostly coding and software based projects, where laboratory activities are mainly developed (Apedoe, Reynolds, Ellefson & Schunn, 2008; Barnett, Connolly, Jarvin, Marulcu, Rogers, Wendell & Wright, 2008; Brophy, Klein, Portsmore

& Rogers, 2008; Bybee, 2010; Meng, Idris & Kwan, 2014; Strong, 2013). The use of robotic applications in education has provided significant gains to students and rapid development in robotic technologies has led to an increase in the number of such studies both nationally and internationally (Daugherty, 2012; Ercan, 2014; Felix, 2010; Harkema, Jadrich & Bruxvoort, 2009; Householder & Hailey, 2012; Hynes, Portsmore, Dare, Milto, Rogers, Hammer & Carberry, 2011; Kucuk & Sisman, 2017).

Within the context of the use of technological materials in science and mathematics education, as a national and international meta-analysis study; Work on smart board use, use of instructional technologies, computer based and assisted instruction, dynamic geometry software, mobile learning and project based learning in science teaching (Ayaz & Soylemez, 2015; Ayaz, Sekerci & Oral, 2016; Batdi, 2015; Dikmen & Tuncer, 2017; Dincer, 2015; Gunhan & Acan, 2016; Guzeller & Ustunel, 2016; Kablan, Topan & Erkan, 2013; Sarac, 2017; Yesilyurt, 2011). The results obtained from these studies are shown in Table 1 in general.

Table 1. Meta analysis studies in the field of technology in science and mathematics education

Researchers	Research Content	Learning Outcomes	Effect size value	Effect size level *
Sarac (2017)	Use Smart Boards	Academic achievement	1.009	Large
		Attitude	0.809	Large
Dikmen & Tuncer (2017)	Using Computer Aided Animation	Academic achievement	1.073	Largel
Ayaz, Sekerci & Oral (2016)	Use of Teaching Technologies	Academic achievement	0.950	Large
Gunhan & Acan (2016)	Dynamic Geometry Software	Academic achievement	0.849	Large
Guzeller & Ustunel (2016)	Mobil Learning	Academic achievement	0.849	Large
Ayaz & Soylemez (2015)	Project Based Learning in Science Teaching	Attitude	0.997	Large
Batdi (2015)	Computer Based Instruction	Academic achievement	1.130	Very Large
Dincer (2015)	Computer Aided Instruction	Academic achievement	1.210	Very Large
Kablan, Topan & Erkan (2013)	Use of Classroom Technological Material	Academic achievement	1.270	Very Large
Yesilyurt (2011)	Computer Aided Instruction	Academic achievement	3.170	Excellent

* According to Thalheimer and Cook (2002) classification

In the literature, there was no meta-analysis study about the effect of students' learning products (academic achievement, attitudes and scientific process skills) using STEM educational practices. It is believed that this work will contribute to the literature, will shed light on the researchers about STEM education in terms of researchers, and will reinforce the importance of developing STEM educational practices.

METHOD

Research Model

The meta-analysis method was used to determine the effectiveness of STEM educational practices in the national-international and in the education-training process. The meta-analysis method is the calculation of the effect of independent variables on the dependent variable by using statistical methods to evaluate, compare and combine the quantitative data obtained from experimental-quasi-experimental studies made in any area. (Cohen, Manion & Marrison, 2007).

Collection of Data

The studies included in the study consist of published and statistically evaluated articles and post-graduate theses with necessary quantitative data made using STEM educational practices in the national-international education process between 2010-2017. Postgraduate theses without permission are not included in the search.

Scanning of work done on the national subclause and internationally conducted studies from ASOS, Journel Park Academic, Google Academic, ULAKBIM and National Center for Higher Education websites in Turkish and English Academic Search Complete, Elsevier, ERIC, Google Scholar, ProQuest Desertions and Thesis and Web of Science from 1 September 2017 to 31 October 2017. During the screening, the names and keywords of the graduate theses as Turkish; "*FeTeMM*", "*FeTeMM eğitimi*", "*FeTeMM etkinlikleri*" and "*FeTeMM uygulamalari*" and as English;"*STEM*", "*STEM education*", "*STEM events*" and "*STEM applications*" were taken into consideration.

As a result of the survey, 74 articles in the national, 72 articles in the international, 8 thesis in the national and 2 theses in the national were found. 14 national articles, 1 master's thesis, 9 international articles and 1 doctoral thesis were included in the national subdivision in accordance with the criteria when they were examined for the purpose of the investigations (Appendix 1). In the study, a total of 58 effect size values were calculated, totaling 52 from 23 national-international articles and 6 from 2 national-international postgraduate theses. 27 effect sizes were obtained from national articles, 25 effect sizes from international articles, 4 effect sizes from national theses and 2 effect sizes from international theses.

A total of 6535 students in the experimental groups and a total of 6373 students in the control groups were included in the meta-analysis included studies. When the studies are divided into subgroups, in the area of learning outcomes; In the area of discipline in which the STEM educational practices were applied in the area of academic achievement, 27 in the area of the attitude effect, 13 in the area of scientific process skills, 23 in the science area, 17 in the area of mathematics, 3 in the area of technology, 13 in the general sense in which scientific process skills are examined, and 2 in other areas; there were 27 studies in the primary and secondary schools, 25 in the secondary school, and 6 in the higher education university.

Coding of Data

The appropriate coding form for the purpose of the study was developed by the researcher in order to examine the inclusion of the studies found in the research into the meta-analysis method and its suitability, to compare the studies, and to determine the statistical information used in the research.

The filling of the coding form created for the purpose of the meta-analysis method is crucial for coding reliability. In the area of studies determined for this, at least two experts must be examined and the coding forms must be filled in (Acikel, 2009). In the study, the coding forms of the studies were filled by two experts who completed the doctorate in the area of educational sciences. After coding, the forms of both experts were evaluated mutually. As a result of the evaluation, the credibility of the codes was calculated to be 90% according to the security level formula developed by Miles and Huberman (2002). According to the reliability level formula, results of 70% or more are sufficient for reliability (Yildirim & Simsek, 2011). According to this, it can be said that the coding made for the studies determined for the purpose of the research is reliable.

Dependent and Independent Variables

In the studies included in the meta-analysis method in the study, the calculated effect sizes for the learning outcomes constitute the dependent variable of the study. The independent variable of the research is lecture method (use of materials prepared according to STEM educational practices and traditional teaching methods).

Analysis of Data

The quality problem was tried to be solved by considering the published national and international publications and postgraduate theses in the research. Effective size values obtained in the field of learning outcomes were analysed by SPSS in terms of academic achievement, attitude to the course and scientific process skills. In the meta-analysis method, the results of the identified studies must be statistically combined. First, which statistical model should be used should be decided. For this, Q statistics developed by Hedges and Olkin (1985) are used. According to the Q statistics, there are two models; Fixed Effect Model (FEM) and Random Effect Model (REM). In FEM, there is one actual effect size for each run. REM is a model that estimates the average of the magnitude of the effects of studies participating in the study (Borenstein, Hedges, Higgins & Rothstein, 2013).

In the meta-analysis method, which statistical model is used, it is checked whether the effect sizes are homogeneous. If the p value of the homogeneity test Q is greater than .05, then the random effect model (REM) is used if the distribution is homogeneous and the fixed effect model (FEM) is below .05 (Ellis, 2010).

The effect sizes of the studies determined in the meta-analysis method are calculated as Cohen's d suggested by Thalheimer and Cook (2002) and Hedges' g proposed by Hedges and Olkin (1985). Classification is used when the magnitudes of effect sizes calculated in the meta-analysis method are interpreted. When the scale of the effect size values obtained in the research is large, the level classifications specified by Thalheimer and Cook (2002) are used. If According to this, if the effect size value is less than 0.15, it is insignificant, between 0.15 and

0.40 is at a small level, between 0.41 and 0.75 is at medium level, between 0.76 and 1.10 is at large level, between 1.11 and 1.45 is at very large level, if it is bigger than 1.45, it is excellent.

Positive effect size values indicate that the assessed performance dimension is in favor of the experimental group, and a negative effect size value indicates that the assessed performance dimension is in favor of the control group (Wolf, 1988).

The Orwin method and the funnel graph method are used to determine the publication bias of the studies identified in the meta-analysis method. In the Orwin method, the number of runs with a mean effect size of zero is calculated to reduce the value of the general effect size to zero (Lipsey & Wilson, 2001). Funnel Plot can also be used to get an idea of broadcast bias. The funnel graph is constructed to show the magnitude of the effect of each work participating in the X-axis survey, and the sample size, variance, or standard error on the Y-axis. If the studies participating in the survey according to the graph show a symmetrical distribution according to the general effect size, it is decided that the study is reliable, that is, the publication bias does not exist (Ustun & Eryilmaz, 2014).

Finally, in the meta-analysis method, various sub-groups were identified in which the effectiveness of the use of STEM educational practices in the education-training process could change. These groups are; the types of publications of the studies, the discipline of the study, and the level of learning of the students involved in the study. Analyses of these subgroups were made and their results reported.

FINDINGS

Firstly, the appropriateness of the normal distribution of the data obtained in order to assess whether the aggregation of the effect sizes of the identified studies is appropriate is examined. The results of SPSS-Shapiro-Wilk normal distribution analysis showing the normal distribution suitability of the effect sizes of the studies are given in Table 2.

Table 2. Shapiro-Wilk normal distribution analysis results

Learning Outcomes	N	Mean	Ss	p*
Academic achievement	27	.51	.43	.254
Attitude	18	.61	.42	.195
Scientific process skills	13	.83	.62	.101

*p< .05

As seen in Table 1, the results obtained from the effect sizes obtained in the field of learning outcomes (p> .05) are within the normal distribution. According to this, it is determined that the studies that are determined have a normal distribution. In this case, as mentioned in Rosenberg et al., (2000), it can be said that the combination of meta-analysis-forming studies is statistically appropriate if the distribution is normal. The results of the study were examined in the field of learning outcomes at the level of sub-problems where the effect size values of the 58 studies were homogeneous.

Findings of the first subproblem

The first subproblem of the research is; "*Is there any effect on the academic achievement of students using STEM educational practices?*" The findings of the questionnaires were first investigated. It is shown in Table 3 that the effect size values of the 27 detected workers are homogeneous.

Table 3. Findings of academic achievement impact sizes of studies

Model	N	ES	Df	(Q)	Std. Error	Z	p	I^2	% 95 confidence intervals	
									Lower Limit	Upper Limit
FEM	27	.217	26	143.709	0.021	9.954	.00	81.908	.176	.259
REM	27	.442			0.061	6.804	.00		.322	.561

The homogeneity of the studies included in the study was Q = 143.709 and p = 0.00 according to the fixed effect model (FEM). The *p* value was found to be statistically significant between the 95% significance level and the independent variables, which were less than 0.05. For this reason, it is seen that the effect size values of the studies are heterogeneous. Therefore, the analyses in this study are based on the random effects model (REM).

The mean effect size was found to be 0.442 with a standard error of 0.061 as a result of the analysis based on the random effects model (REM). In the 95% confidence interval, the lower limit of the effect size is 0.322, and the upper limit is calculated as .561. The positive effect of the mean effect size value indicates that academic achievement is more effective than traditional methods in the courses taught using STEM educational practices. This effect has moderate effect on the Thalheimer and Cook (2002) classification. The forest chart showing the distribution of the impact size values of the academic achievements included in the studies is shown in Figure 1.

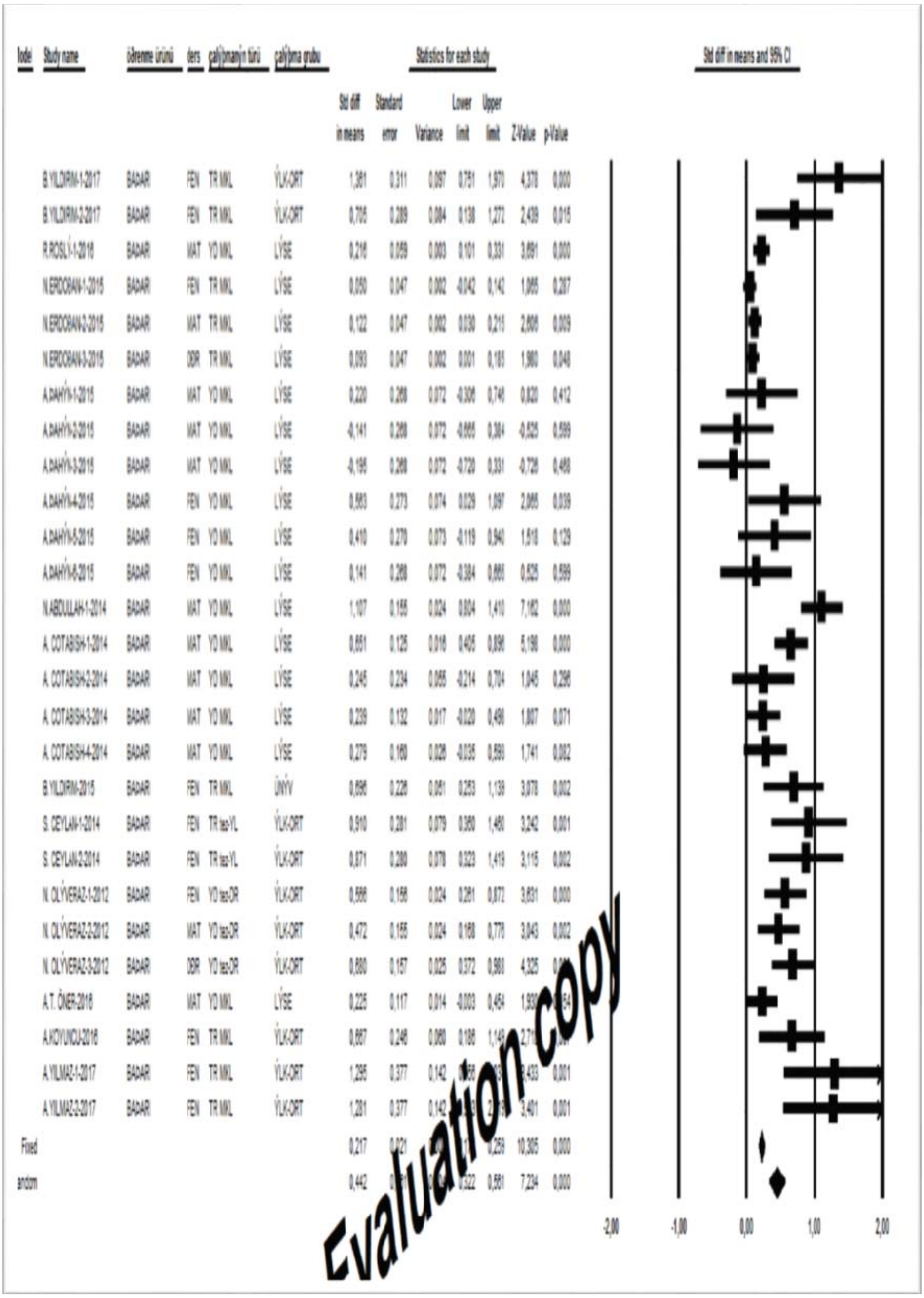

Figure 1. Forestry chart of the academic achievement effect studies included in the survey

The position of the black squares in the graph relative to the vertical vertical line shows the magnitude of the effect of the academic achievement studies, the lines on both sides of the squares indicate the upper and lower limits of the 95% confidence interval. The size of the squares reflects the weight of the studies they belong to within the overall magnitude of effect. The diamonds at the bottom of shaplin, the rhombus, show the magnitude of the overall effect according to the random effects model of work (REM).

When the effect sizes of the academic achievement studies are examined, it is determined that the smallest effect size value is -0.195 (Sahin, 2015) and the highest effect size value is 1.361 (Yildirim, 2017). Given the magnitude of the effects of the studies, 25 of the 27 effect sizes have a positive value and 2 have a negative effect value.

One of the issues that should be considered in meta-analysis studies are publication bias. It was determined that the required number of works with effect sizes 0 (zero) is 1202 to reduce the value of 0.442 effect size obtained by the Orwin method to zero effect size value. This is normally a high number and shows that the bias is low. However, whether or not the broadcast bias exists can be interpreted by the Funnel Plot (REM) given in Figure 2.

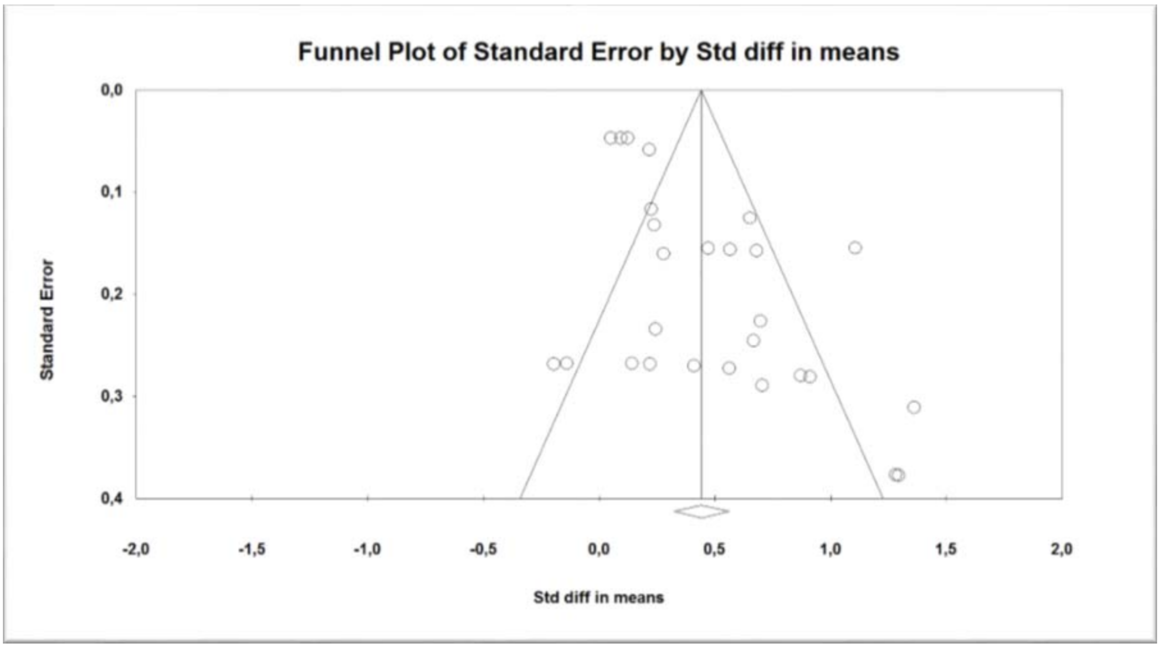

Figure 2. Funnel graph of the academic achievement studies included in the research-REM

In case of broadcast bias in the funnel graph, the effect sizes will be asymmetrically. In the case of no publication bias, they show a symmetrical distribution. As seen in figure-2, the funnel obtained from the works shows an almost symmetrical structure. Accordingly, it can be said that there is no bias in the study. The effect sizes obtained in the area of academic achievement were subdivided according to the various characteristics of the studies and the analysis results are shown in Table 4.

Table 4. Statistical analysis according to study characteristics in academic achievement area

Operating Characteristics	Homogeneity between groups(Q_B)	p	N	Effect Size (ES)	ES (%95 CI) Lower	ES (%95 CI) Upper	Standard Error(SE)
Publication Type	8.289	0.040	3				
National Article			9	0.441	0.253	0.629	0.096
National Thesis			2	0.891	0.505	1.279	0.198
International Article			13	0.331	0.157	0.505	0.089
International Thesis			3	0.572	0.395	0.748	0.090
Lesson Type	5.180	0.075	2				
Science			13	0.689	0.408	0.969	0.143
Math			12	0.315	0.156	0.474	0.081
Other			2	0.367	-0.207	0.941	0.293
Level of Education	23.049	0.000	2				
Basic Teaching			10	0.766	0.588	0.943	0.090

(Primary/Secondary School)					
Secondary education (High school)	16	0.272	0.145	0.379	0.060
Higher Education (University)	1	0.696	0.253	1.139	0.226

$p<.05$

There was a statistically significant difference in the publication type (QB = 8.289, p <.05) and the level of education (QB = 23.049, p <.05). This difference is in the form of the publication type in which the study was conducted, with nationally articles, international postgraduate theses, basic education and higher education students. In other words, it is seen that the academic achievements of STEM educational practices are more effective in publications published in national and in postgraduate theses published internationally and in students of basic education and higher education level. There was no statistically significant difference in the sub-dimension of the lesson types (QB = 5.180, p> .05) of the studies carried out in the subgroup analyses. In other words, there is no statistically significant difference between the academic achievement effect sizes of the courses studied using STEM educational practices.

Findings from the second subproblem

The second subproblem of the research is; "*Is there any effect on the attitude of students using STEM educational practices?*" The findings of the questionnaires were first investigated. It is shown in Table 5 that the effect size values of the 18 detected workers are homogeneous.

Table 5. Findings related to the effects of the attitudes of the studies on the course

Model	**N**	**ES**	**Df**	**(Q)**	**Std. Error**	**Z**	**p**	**I^2**	**% 95 confidence intervals**	
									Lower Limit	**Upper Limit**
FEM	18	.595	17	73.722	0.049	11.193	.00	76.940	.498	.692
REM	18	.620			0.111	5.217	.00		.403	.836

The homogeneity of the studies included in the study was Q 73.722 and p = 0.00 according to the fixed effect model (FEM). The *p* value was found to be statistically significant between the 95% significance level and the independent variables, which were less than 0.05. For this reason, it is seen that the effect size values of the studies are heterogeneous. Therefore, the analyses in this study are based on the random effects model (REM).

The mean effect size was found to be 0.620 with a standard error of 0.111 as a result of the analysis based on the random effects model (REM). In the 95% confidence interval, the lower limit of the effect size is 0.403, and the upper limit is calculated as .836. The positive effect of the mean effect size value indicates that attitude is more effective than traditional methods in the courses taught using STEM educational practices. This effect has middle effect on the Thalheimer and Cook (2002) classification. The forest chart showing the distribution of the impact size values of the attitudes included in the studies is shown in Figure 3.

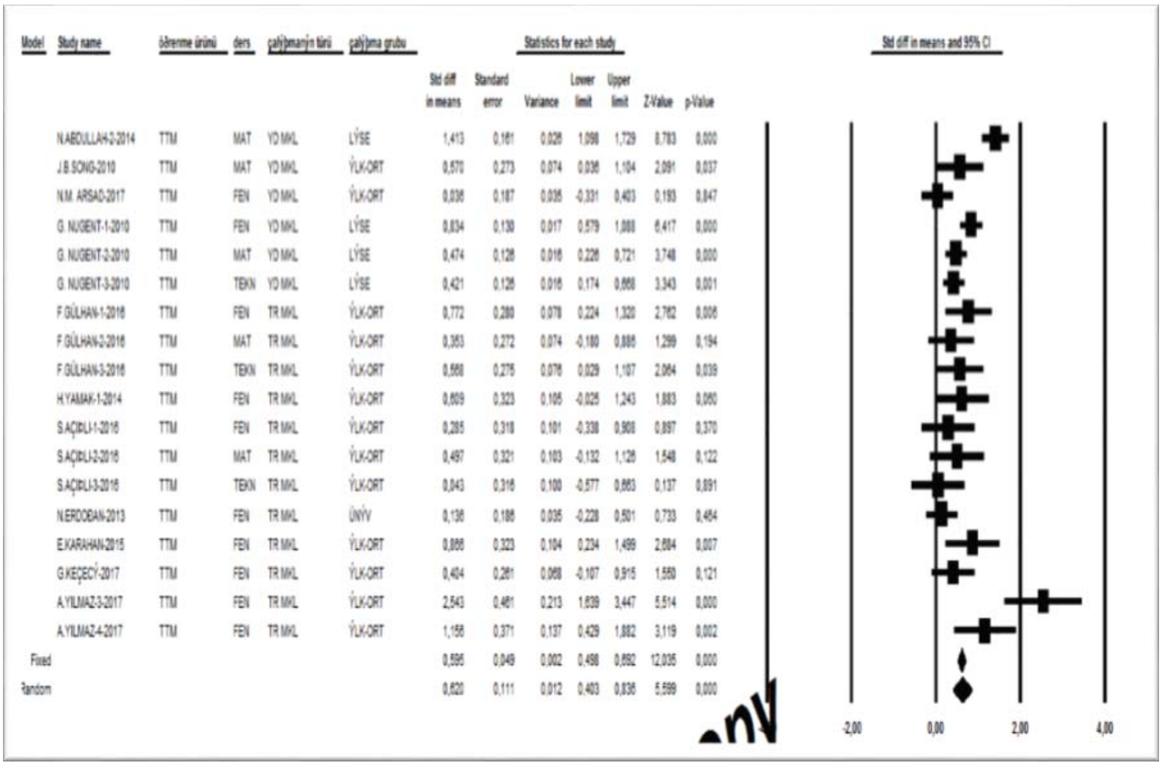

Figure 3. Forestry chart of the attitude effect studies included in the survey

The position of the black squares in the graph relative to the vertical vertical line shows the magnitude of the effect of the attitudesstudies, the lines on both sides of the squares indicate the upper and lower limits of the 95% confidence interval. The size of the squares reflects the weight of the studies they belong to within the overall magnitude of effect. The diamonds at the bottom of Shaplin, the rhombus, show the magnitude of the overall effect according to the random effects model of work (REM).

When the effect sizes of the attitudestudies are examined, it is determined that the smallest effect size value is 0.036 (Arsad, 2017) and the highest effect size value is 2.543 (Yilmaz, 2017). All of the 18 effect sizes have a positive impact value when the effect sizes of the studies are examined.

One of the issues that should be considered in meta-analysis studies are publication bias. It was determined that the required number of works with effect sizes 0 (zero) is 602 to reduce the value of 0.620 effect size obtained by the Orwin method to zero effect size value. This is normally a high number and shows that the bias is low. However, whether or not the broadcast bias exists can be interpreted by the Funnel Plot (REM) given in Figure 4.

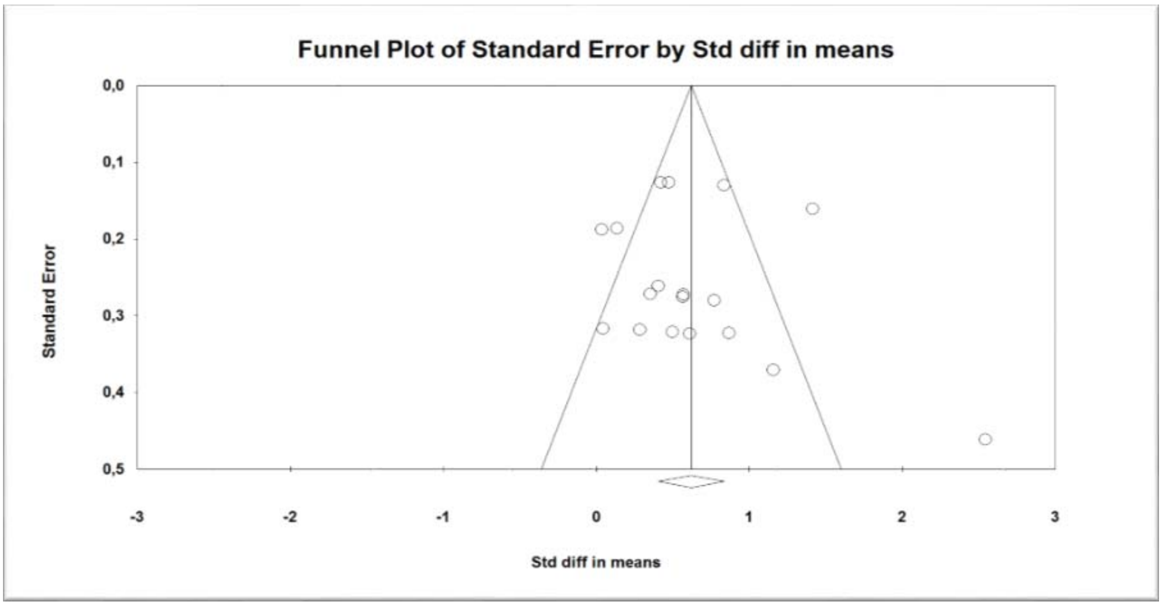

Figure 4. Funnel graph of the attitudes to the course included in the study-REM

In case of broadcast bias in the funnel graph, the effect sizes will be asymmetrically. In the case of no publication bias, they show a symmetrical distribution. As seen in figure 4, the funnel obtained from the works shows an almost symmetrical structure. Accordingly, it can be said that there is no bias in the study. The effect sizes obtained in the area of attitude were subdivided according to the various characteristics of the studies and the analysis results are shown in Table 6**.**

Table 6. Statistical analysis according to study characteristics in attitude area

Operating Characteristics	Homogeneity between groups(Q_B)	p	N	Effect Size (ES)	ES (%95 CI) Lower	ES (%95 CI) Upper	Standard Error(SE)
Publication Type	0.004	0.949	1				
National Article			12	0.615	0.329	0.901	0.146
International Article			6	0.630	0.276	0.983	0.180
Lesson Type	2.598	0.273	2				
Science			10	0.681	0.347	1.014	0.170
Math			5	0.683	0.224	1.142	0.234
Other			3	0.400	0.189	0.611	0.108
Level of Education	6.101	0.047	2				
Basic Teaching (Primary/Secondary School)			13	0.600	0.329	0.871	0.138
Secondary education (High school)			4	0.777	0.368	1.185	0.209
Higher Education (University)			1	0.136	-0.228	0.501	0.186

p<.05

In the subgroup analyses, there is a statistically significant difference between the attitude effect sizes in the relevant lesson in the learning level of the educations (QB = 6.101, p <.05). This difference is favored by students with basic education and secondary education. In other words, it is seen that STEM educational practices are more effective in the attitudes of the elementary education and secondary education students towards the relevant course. There was no statistically significant difference between publication type (QB = 0.004, p> .05) and lesson types (QB = 2.598, p> .05) subscales. That is to say, there is no statistically significant difference between the type of publication done in the lessons that are processed using STEM educational practices and the attitude effect sizes in the lesson types where the work is done.

Findings from the third subproblem

The third subproblem of the research is; "*Is there any effect on the scientific process skills of students using STEM educational practices?*" The findings of the questionnaires were first investigated. It is shown in Table 7 that the effect size values of the 13 detected workers are homogeneous.

Table 7. Findings related to the effects of the scientific process skills of the studies on the course

Model	N	ES	df	(Q)	Std. Error	Z	p	I^2	% 95 confidence intervals	
									Lower Limit	Upper Limit
FEM	13	.756	12	165.766	0.045	16.737	.00	92.760	.667	.844
REM	13	.820			0.172	4.760	.00		.482	1.157

The homogeneity of the studies included in the study was Q 165.766 and p = 0.00 according to the fixed effect model (FEM). The p value was found to be statistically significant between the 95% significance level and the independent variables, which were less than 0.05. For this reason, it is seen that the effect size values of the studies are heterogeneous. Therefore, the analyses in this study are based on the random effects model (REM).

The mean effect size was found to be 0.820 with a standard error of 0.172 as a result of the analysis based on the random effects model (REM).In the 95% confidence interval, the lower limit of the effect size is 0.482, and the upper limit is calculated as 1.157. The positive effect of the mean effect size value indicates that scientific process skills are more effective than traditional methods in the courses taught using STEM educational practices. This effect has large level effect on the Thalheimer and Cook (2002) classification. The forest chart showing the distribution of the impact size values of the scientific process skills included in the studies is shown in Figure 5.

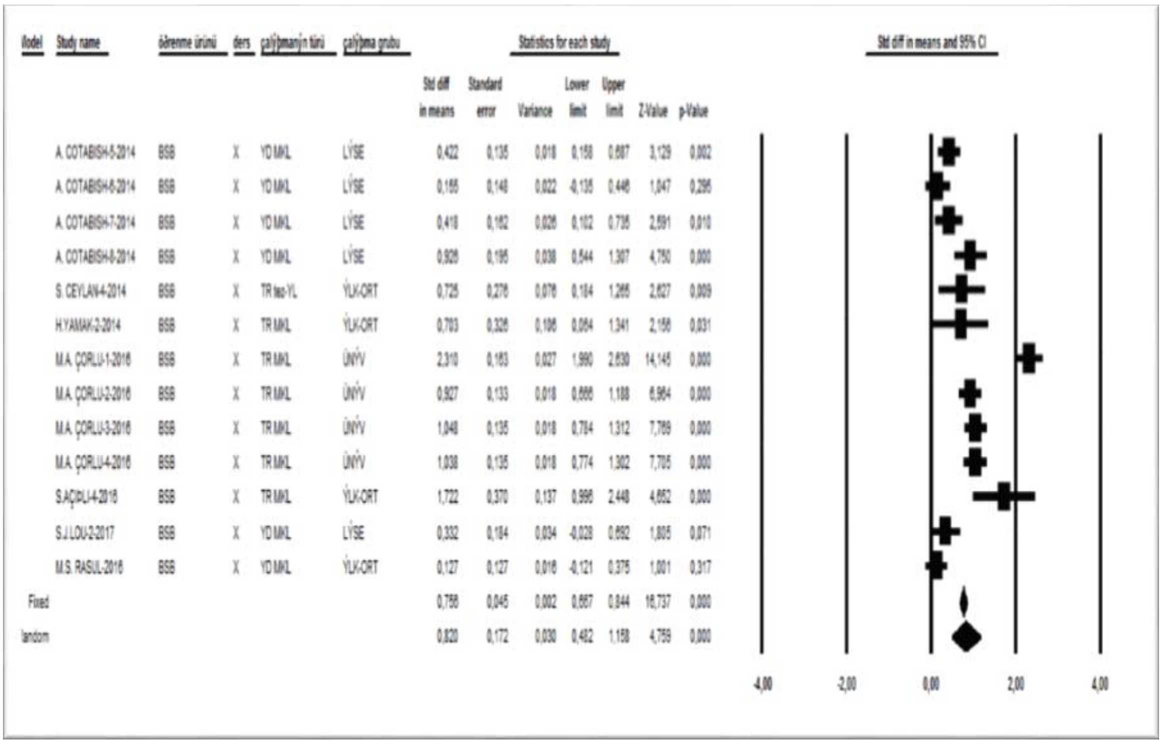

Figure 5. Forestry chart of the scientific process skills effect studies included in the survey

The position of the black squares in the graph relative to the vertical vertical line shows the magnitude of the effect of the scientific process skillsstudies, the lines on both sides of the squares indicate the upper and lower limits of the 95% confidence interval. The size of the squares reflects the weight of the studies they belong to within the overall magnitude of effect. The diamonds at the bottom of Shaplin, the rhombus, show the magnitude of the overall effect according to the random effects model of work (REM).

When the effect sizes of the scientific process skillsstudies are examined, it is determined that the smallest effect size value is 0.127 (Rasul, 2016) and the highest effect size value is 2.310 (Corlu, 2016). All of the 13 effect sizes have a positive impact value when the effect sizes of the studies are examined.

One of the issues that should be considered in meta-analysis studies are publication bias. It was determined that the required number of works with effect sizes 0 (zero) is 935 to reduce the value of 0.820 effect size obtained by the Orwin method to zero effect size value. This is normally a high number and shows that the bias is low. However, whether or not the broadcast bias exists can be interpreted by the Funnel Plot (REM) given in Figure 6.

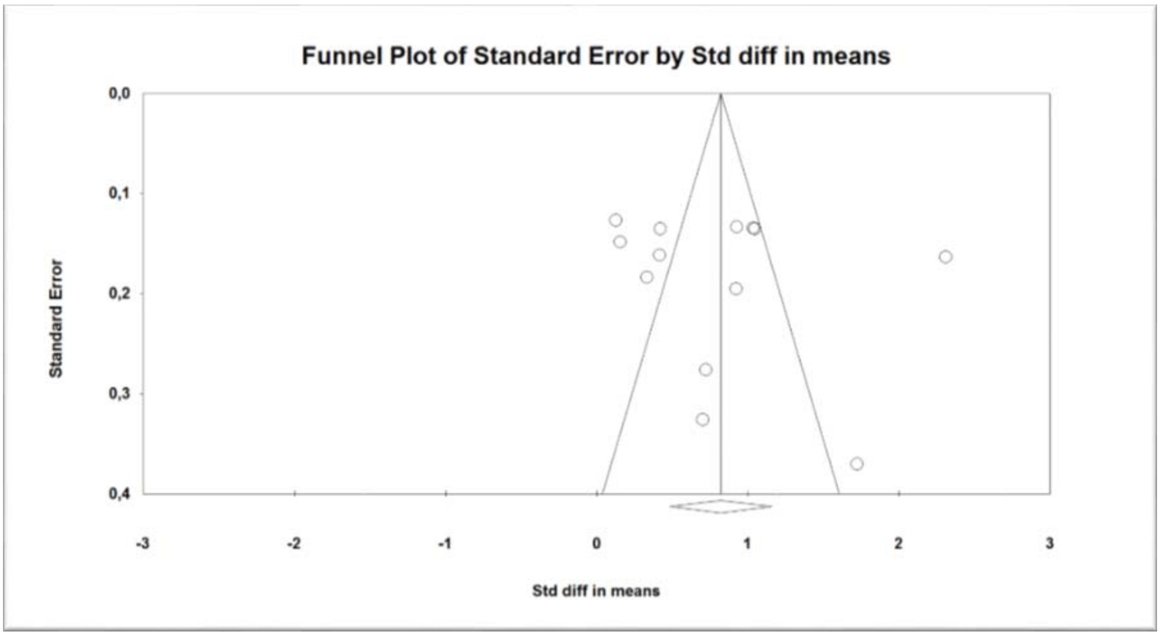

Figure 6. Funnel graph of the scientific process skills to the course included in the study-REM

In case of broadcast bias in the funnel graph, the effect sizes will be asymmetrically. In the case of no publication bias, they show a symmetrical distribution. As seen in figure 6, the funnel obtained from the works shows an almost symmetrical structure. Accordingly, it can be said that there is no bias in the study. The effect sizes obtained in the area of scientific process skillswere subdivided according to the various characteristics of the studies and the analysis results are shown in Table 8.

Table 8. Statistical analysis according to study characteristics in scientific process skills area

Operating Characteristics	Homogeneity between groups(Q_B)	p	N	Effect Size (ES)	ES (%95 CI)		Standard Error(SE)
					Lower	Upper	
Lesson Type	12.397	0.002	2				
Science			6	1.288	0.814	1.763	0.242
Math			1	0.725	0.184	1.265	0.276
Other			6	0.376	0.167	0.884	0.106
Level of Education	8.281	0.016	2				
Basic Teaching (Primary/Secondary School)			4	0.765	0.118	1.412	0.330
Secondary education (High school)			5	0.434	0.207	0.661	0.116
Higher Education (University)			4	1.325	0.747	1.903	0.295

p<.05

There was a statistically significant difference in the lesson types (QB = 12.397, p <.05) and the level of education (QB = 8.281, p <.05). This difference is in the form of the lesson types in which the study was conducted, with science and math lesson, basic education and higher education students. In other words, it is seen that the scientific process skills of STEM educational practices are more effective in lesson types in science and in math and in students of basic education and higher education level.

DISCUSSION

In the study, the academic achievement of the students was reached to a middle level with a positive score of 0.442, with a middle level of 0.620 in the positive direction of the students' attitude towards the course, and a large level effect size of 0.820 in the positive process in the students' scientific process skills.

In meta-analysis studies in which the use of technological materials in science and mathematics education is investigated, the effects of smart board use (Sarac, 2017), use of instructional technologies (Ayaz, Sekerci & Oral, 2016; Kablan, Topan & Erkan, 2013), computer-based and assisted instruction (Batdi, 2015; Dikmen & Tuncer, 2017; Dincer, 2015; Yesilyurt, 2011), dynamic geometry software (Gunhan & Acan, 2016) and mobile learning (Guzeller & Ustunel, 2016) are generally broad. The results obtained from the above studies and the results obtained from this study partially overlap in the literature. When the results obtained from the meta-analysis method in the study are examined at the level of sub-dimensions of the effects of STEM educational practices on academic achievement, it was found that there was a statistically significant difference between the publication types and the level of educationand no statistically significant difference was found among the lesson types where the studies were conducted. This difference is favored by university students with higher education level, primary school and secondary school which are the basic teaching level and postgraduate theses made in the national.

When the studies examined were evaluated according to the publication type in academic achievement, it was seen that the highest effect size value was small in the master's thesis (ES = 0.891) in the national and the smallest effect size value was small in the international study (ES = 0.331). Within the scope of researches on the use of technological materials in science and mathematics education in the literature; the highest effect size values in publication types were found to be broad at 0.919 in the study of Sarac (2017), broad at 1.073 in the study conducted by Dikmen and Tuncer (2017), Ayaz et al., (2016) were found to be in a very broad range of work with 1.247, and in the study of Gunhan and Acan (2016), they were in a very broad range of doctoral studies with 1,335. In this case, according to the results obtained in the meta-analyses carried out by Sarac (2017), Ayaz et al., (2016) and Gunhan and Acan (2016), the results obtained according to the types of publications and the results of the study using STEM educational practices the result obtained is similar.

In the academic achievement, the studies examined are evaluated according to the type of lesson; it is seen that there is no statistically significant difference between the effect sizes of the lesson types. In the literature, in the type of lesson in which studies are carried out within the scope of researches on the use of technological materials in science and mathematics education; it was found that there was no statistically significant difference between the use of smart board (Sarac, 2017), the use of instructional technologies (Ayaz, Sekerci & Oral, 2016), the use of computer-based teaching (Batdi, 2015), the use of computer-assisted teaching (Dincer, 2015) and the use of in-class technological material among students (Kablan, Topan & Erkan, 2013). In this case, the meta-analysis results (Ayaz, Sekerci & Oral, 2016; Batdi, 2015; Dikmen & Tuncer, 2017; Dincer, 2015; Kablan, Topan & Erkan, 2013; Sarac, 2017) obtained from the type of lesson and the academic achievement of the use of STEM educational practices in the study are similar to the results obtained according to the lesson type of the study.

When the studies examined are evaluated according to the level of educationin academic achievement; it is seen that the highest effect size value is small in elementary and secondary school students (ES = 0.766), which is the basic education level, and the smallest effect size value is in the high school students (ES = 0.272), which is the secondary education level. Within the scope of researches on the use of technological materials in science and mathematics education in the literature; the highest effect size value of the level of educationwas found to be very wide at the level of 1.057 in the study conducted by Ayaz et al., (2016) and at the level of 1.327 in the study conducted by Kablan et al., (2013) work. In this case, the meta-analysis of Ayaz et al., (2016) and Kaban et al., (2013) shows that the results obtained according to the students' learning levels and the use of STEM educational practices in this research are obtained according to the learning levels of students' the result is similar. It was seen that the highest effect size value of the students at the learning levels was found to be wide in the high school students whose education level was 1,024 with Sarac (2017), university students with higher education level and 1,014 with Gunhan and Acan (2016) study. According to this, the results of the meta-analyses carried out by Sarac (2017) and Gunhan and Acan (2016) according to the level of education and the results obtained according to the level of education effects on the academic achievement of the students using STEM educational practices in this research do not overlap.

In the meta analysis studies in which the use of technological materials in science and mathematics education has been investigated, the effect of using intelligent board (Sarac, 2017) and project based learning (Ayaz & Soylemez, 2015) in science teaching is wide. The results obtained from the above studies (Ayaz & Söylemez, 2015; Sarac, 2017) and the results obtained from this study partially overlap in the literature. When the results obtained from the meta-analysis method in the study are examined at the level of the subordinate effects of STEM educational practices on the relevant course, it was found that there was a statistically significant difference between the level of educationand no statistically significant difference between the types of publications and lesson fields where the studies were made. This difference is favored by the primary school, primary school and secondary school, and high school students with secondary education.

When the studied studies are evaluated according to the publication type in the attitude of the related course, it is seen that there is no statistically significant difference between the effect sizes of the publication types. In the literature, it is seen that there is no statistically significant difference between the size of Sarac's (2017) smart board use and the effect of the students' attitude effect on the related course within the scope of researches on the use of technological materials in science and mathematics education. In this case, the result obtained according to the publication type in Sarac's (2017) meta-analysis study and the result obtained according to the publication type of the study effect of the use of STEM educational practices in this research are similar.

When the studies examined are evaluated according to the lesson fields in the field of attitude which is the lesson, it is seen that there is no statistically significant difference between the effect sizes of the lesson field types. Within the scope of researches on the use of technological materials in science and mathematics education in the literature; There is no statistically significant difference student's attitude effect sizebetween the size of Sarac's (2017) smart board usage and Ayaz and Soylemez's (2015) science-based project-based. In this case, the result obtained according to the lesson fields in Sarac (2017) and Ayaz and Soylemez (2015) and the result obtained according to the study of the study effect of using the STEM educational practices in the study are similar.

When the studies examined are evaluated according to thelevel of education in the area of attitudes to the lesson, it is seen that the highest effect size value is at a high level in secondary school students (ES = 0.777) and the smallest effect size value is at a small level in university students with higher education level (ES = 0.136). Within the scope of researches on the use of technological materials in science and mathematics education in the literature; it was seen that the value of the highest effect size in the level of education was in the middle school students with Sarac's (2017) study at 1.057 and university students with Ayaz and Sekerci (2015) at 0.844. In this case, the results obtained according to the the level of educationin the meta-analysis studies that Sarac (2017) and Ayaz and Soylemez (2015) did have do not agree with the level of education in the study on the effect of using the STEM educational practices in this study.

When the results obtained from the meta-analysis method in the study are examined in terms of the effects of STEM educational practices on scientific process skills at sub-dimensions, it was found that there was a statistically significant difference between the types of publications and the level of education. This difference is in favor of primary school and junior high school students with university education and basic education level with university studies and master's theses and higher education level. When the studies are evaluated according to the publication type, it is seen that the highest effect size value is small in the nationally published articles (ES = 1.288) and the smallest effect size value is small with the internationally published articles (ES = 0.376). When the scientific process skills are evaluated according to the level of education, it is seen that the studies are moderate with the university students with higher education level (ES = 1.325) and the smallest effect size value with the secondary education students with secondary education level (ES = 0.434).

SUGGESTIONS

In this meta-analysis study, the effects of STEM educational practices on the learning outcomes of students were examined in the categories of academic achievement, course attitude and scientific process skills and the remaining effects were excluded from the study. After that, the researchers who will work on these topics will be able to learn STEM education practices during the education period; gender and anxiety on factors such as the effect on different topics can perform meta-analysis studies. Moreover, studies conducted in this meta-analysis have been mostly focused on students' academic achievement and the effect of course attitude. It is suggested that STEM education practices in researchers should focus more on the effect of learned knowledge on permanence.

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APPENDIX 1.
STEM Educational Practices Investigations Included In The Meta Analysis Study

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