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The Effect of Learning Cycle Models on Achievement of Students: A Meta-Analysis Study

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Abstract: In the study, a meta-analysis was conducted to determine the effect of the use of the learning cycle model on the achievements of the students. Doctorate and master theses, made between 2007 and 2016, were searched using the keywords in Turkish and English. As a result of the screening, a total of 123 dissertations, which used learning cycle models to increase the achievement of students, were included in the analysis. As a result of this study, it is confirmed that the effect of learning cycle models on students' achievement is positive and the determined effect size was found out as 1.164 (% 95 CI, SE = .071) according to random effects model.. In the study, moderator analysis was made according to the learning cycle models, type of the dissertations, disciplines, and education levels of students. The analyses showed that among the learning cycle models, the highest effect size was determined in the 4E Model (2.659), among the dissertations the highest effect size was in master thesis (ES = 1.231), among the disciplines the highest effect size was in the other lessons (ES = 1.637) and among the educational levels the highest effect size was in the high school students (ES = 1.237).

Keywords: *Academic achievement, constructivist approach, learning cycle model, meta-analysis.*

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Introduction

Ministry of National Education (MoNE) has put into practice a teaching plan which is the foreground of the constructivist approach as a result of the increase in the importance given to individual differences in education since 2004-2005 education period (Tonbuloglu, 2014). The constructivist learning approach is based on the idea that instead of transferring knowledge directly to individuals, it should be structured by associating it with prior knowledge that individuals possess (Akpinar, & Ergin, 2005). The constructivist approach generally answers the following these questions; "*How does information from the outside get in our minds*?", "*How does this information work in our minds and cost us ourselves?*", and "*What changes do we have in our minds when new information contradicts our previous knowledge?*" (Baker, & Piburn, 1997).

The implementation of the constructivist approach in the educational process is through learning cycle models (Ozmen, 2004). In researches conducted in science education, it is emphasized that learning cycle models are effective models in terms of knowing knowledge of learners, understanding the content of learned information and applying scientific processes. (Wilder, & Shuttleworth, 2004). The learning cycle is a flexible model. Accordingly, the form of learning stages can be changed, but the order can not be changed and none of the stages can be skipped. The stages of the learning cycle model allow students to discuss and test new situations that allow them to test their preliminary knowledge (Renner, Abraham, & Birnie, 1998).

The learning cycle model initially started out as a 3-stage model of *discovery*, *terminology recognition* and *concept implementation*, and then expressed as a 4E learning cycle model in the form of *engage, exploration, explanation* and *extension* (Bybee, 2003). In the following years, the 5E has been developed as a learning cycle model by adding an additional evaluation stage by science education researchers (Boddy, Watson, & Aubusson, 2003; Bybee, 2003). Eisenkraft (2003), who is studying learning cycle models later, has re-interpreted the 5E learning cycle model as a 7E learning cycle model. Eisenkraft, in addition to the 5E model; first add the "*elicit*" stage and finally the "*extend*" stage. The stages of the 5E learning cycle model are based on Bybee (2003), *engage, explore, explain, elaborate* and *evaluate*.

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The stages of the 7E learning cycle model are based on Eisenkraft (2003), preliminary information is in the form of, *elicit, engage, exploration, explanation, elaboration, evaluation* and *extend*.

The teaching materials prepared according to the learning cycle models in the literature; the effects of the students on the learning outcomes (Coruhlu, & Cepni, 2016; Kucuk, & Calik, 2015; Meseci, & Karamustafaoglu, 2015; Turgut, Colak, & Sala, 2016; Sarac, 2015), the contribution to the teaching material development process (Balim, Turkoguz, Aydin, & Evrekli, 2012; Kanli, 2009; Sadoglu, & Akdeniz, 2015), the effect on the interest, skills and attitudes of the lesson (Demir, & Maskan, 2012; Sasmaz Oren, & Tezcan, 2009; Temel, Ozgur, & Yilmaz, 2012), opinions about learning cycle models of the teacher, the candicate teachers and students (Bilgin, Ay, & Coskun, 2013; Demir, & Maskan, 2014), and the literature search (Keles, 2010; Ozmen, 2004; Turkmen, 2006) were studied. In addition, it is available content analysis studies on "*Constructivist approach 7E learning cycle model: Content analysis study*" (Sarac, & Kunt, 2016), and "*Written resources regarding 5e model in science education*" (Ergin, 2012).

In the literature, a number of studies have been conducted on academic achievement in the learning outcomes using meta-analysis within the scope of national education researches (Aktamis, Higde, & Ozden, 2016; Ayaz, 2015; Ayaz, Sekerci, & Oral, 2016; Balta, & Sarac, 2016; Basol, & Erbay, 2017; Batdi, 2015; Bozdemir, Cevik, Altunoglu, & Kurnaz, 2017; Guzeller, & Ustunel, 2016; Sarac, 2017; Ulubey, & Toraman, 2015). It is also available about on learning cycle models "*Factors effecting academic achievement of students in Turkey*" (Sarier, 2015) in the form of meta-analysis. The results obtained from these studies are shown in Table 1 in general.

Table 1. Meta-analysis studies in the area of educational researches

Researchers	**Subject of Research**	**Learning Outcomes**	**Effect Size Value**	**Effect Size Level***
Sarac (2017)	Smart Board	Academic Achievement	1.009	Large Level
Balta and Sarac (2016)	7E Learning Model	Academic Achievement	1.245	Very Large
Ayaz, Sekerci and Oral (2016)	Teaching Technologies	Academic Achievement	0.973	Large Level
Guzeller and Ustunel (2016)	Mobil Learning	Academic Achievement	0.849	Large Level
Bozdemir, Cevik, Altunoglu and Kurnaz (2017)	Astronomy Teaching	Academic Achievement	0.816	Large Level
Aktamis, Higde and Ozden (2016)	Research-Question Based Learning	Academic Achievement	1.029	Large Level
Batdi (2015)	Computer Based Instruction	Academic Achievement	1.130	Very Large
Basol and Erbay (2017)	Portfolio Usage	Academic Achievement	0.831	Large Level
Ayaz (2015)	Probing Based Learning	Academic Achievement	1.206	Very Large
Ulubey and Toraman (2015)	Creative Drama Method	Academic Achievement	1.255	Very Large

* According to Thalheimer and Cook (2002) classification

In the literature, there has been no meta-analysis study on the effect of learning cycle models on academic achievement of students. Therefore, it is thought this study will contribute to the literature.

The purpose of the study, a meta-analysis was conducted to determine the effect of the use of the learning cycle model on the achievements of the students. Accordingly, the question "*What is the effect of learning cycle models on students' achievement?*" is tried to be answered. The sub-problems identified for this meta-analysis study is as follows.

- Is there any effect of learning cycle models on the achievement of students?
- Does the effect of learning cycle models on students' achievement vary according to the type of the learning cycle models?
- Does the effect of learning cycle models on students' achievement vary according to the type of the dissertations?
- Does the effect of learning cycle models on students' achievement vary according to the type of the disciplines?
- Does the effect of learning cycle models on students' achievement vary according to the education levels of the students?

Method

Research Model

In the study, meta-analysis was used to determine the effectiveness of constructivist approach to learning cycle models in the educational process. Meta-analysis is the calculation of the effect of the independent variable on the dependent variable by comparing, quantifying and combining the quantitative data obtained from the experimental-quasi-experimental studies using statistical methods (Cohen, Manion, & Marrison, 2007).

There are two types of meta-analysis; group comparison and correlation. In this study, meta-analysis of transaction effectiveness, which is one of group comparison meta-analysis methods, is used. Transaction effectiveness meta-analysis is a comparison of effect size values obtained by converting data belonging to independent studies used in multiple studies into a common measurement system (Sahin, 2005).

Collection of Data

The studies included in the study consist of doctorate and master theses with the necessary quantitative data on the published statistical evaluation made using the learning cycle models in the national education process between 2007 and 2016. Dissertations are not allowed to be achievemented by the researcher have not been included in the research.

The screening of dissertations conducted in the national was conducted between 1 April 2017 and 1 July 2017 from the National Thesis Center website in Turkish and English. During the screening, the theses including the words "*Learning cycle model*", "*3-stage Model*", "*4E Model*", "*5E Model*" and "*7E Model*" in the names and keywords of the dissertations were taken in Turkish and English.

A total of 187 dissertations were found after the screening. When the identified dissertations are appropriately reviewed for the purpose of research, 123 national dissertations have been included in the search according to the required criteria in the national. In the study, the effect size value of 123 different students (Appendix-1), totaling 54 from the doctorate thesis and 69 from the master thesis were calculated for the academic achievements of the students.

Inclusion Criteria for Research

1. The study to be done between 2007 and 2016, in Turkey

2. The study has been carried out in the national territory and the achievement permits have

3. The study should be published in the national doctorate thesis and master thesis

4. Use of experimental or quasi-experimental methods in study

5. Using materials prepared according to learning cycle models for experimental groups and using traditional methods for control groups.

6. Examination of the academic achievements of the students in the study

7. Presenting the statistical data necessary to calculate the effect size in the study

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 features of the form are as follows; The quantitative data of the study and the study data are given in the order of the name of the study, the type of study, the learning cycle used in the study, the goal of the learning outcomes, the discipline of the study, the year the study was published, the duration of the study, the level of education of the participants, obtained statistical information etc...

Filling in the coding form created for the purposes of meta-analysis is very important 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 95% 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

The effect sizes calculated for the academic achievement of the students constitute the dependent variable of the study. The independent variable of the study is lesson method (use of materials prepared according to learning cycle models and traditional teaching methods). Accordingly, the use of learning-cycle models and the effects of traditional teaching methods (independent variable) on students' academic achievements (dependent variable) are examined in this study.

Analysis of Data

In the meta-analysis study, the results of the investigations should be statistically combined. First, which statistical model of using 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 study, 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). Hedges' g calculation is used in this study. 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 in a wide scale, the level classifications specified by Thalheimer and Cook (2002) are used. 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 outcome 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 study, various sub-groups were determined in which the effectiveness of the cycle learning models in the educational process could change. These groups are; learning cycle model types, dissertations types, disciplines, and the education levels of the students. Analyses of the identified subgroups were made and the results were reported.

Findings

In this study, the effect size values obtained from 123 dissertations were calculated. 54 effect sizes were obtained from doctoral theses and 69 from master's theses. There are 4688 students in the experimental groups and 4614 students in the control groups in the meta-analysis study. When the researhes are divided into subgroups; Seven on the 3E model, three on the 4E model, ninty-seven on the 5E model, and sixteen on the 7E model; 56 in science, 19 in physics, 19 in chemistry, 12 in biology, 8 in mathematics, 5 in social sciences and 4 in other lessons; 8 in primary schools, 42 in secondary schools, 61 in high schools and 12 in universities. Table 2 shows that the effect sizes of the 123 studies are detected homogeneous.

Table 2. Findings of academic achievement effect sizes of researches

Model	N	ES	df	(Q)	Std. Error	Z	p	I^2	% 95 confidence intervals	
									Lower Limit	Upper Limit
FEM	123	0.998	122	1166.214	.022	44.402	.000	89.539	.954	1.042
REM	123	1.164			.071	16.441	.000		1.025	1.303

The homogeneity of the academic achievement of the students was found to be Q = 1166.214 and p = 0.00 according to the fixed effect model (FEM). Value of the p was less than 0.05 level according to the 95% significance level, it shows that there is a statistically significant difference between the independent variables. For this reason, it is seen that the effect size values of academic achievement of students are heterogeneous. The mean effect size was found to be 1.164 with a standard error of 0.071 as a result of the analysis based on the random effects model (REM). This effect has a very large level on the Thalheimer and Cook (2002) classification. A forest chart showing the distribution of the students' effect size values for academic achievement is shown in Figure 1.

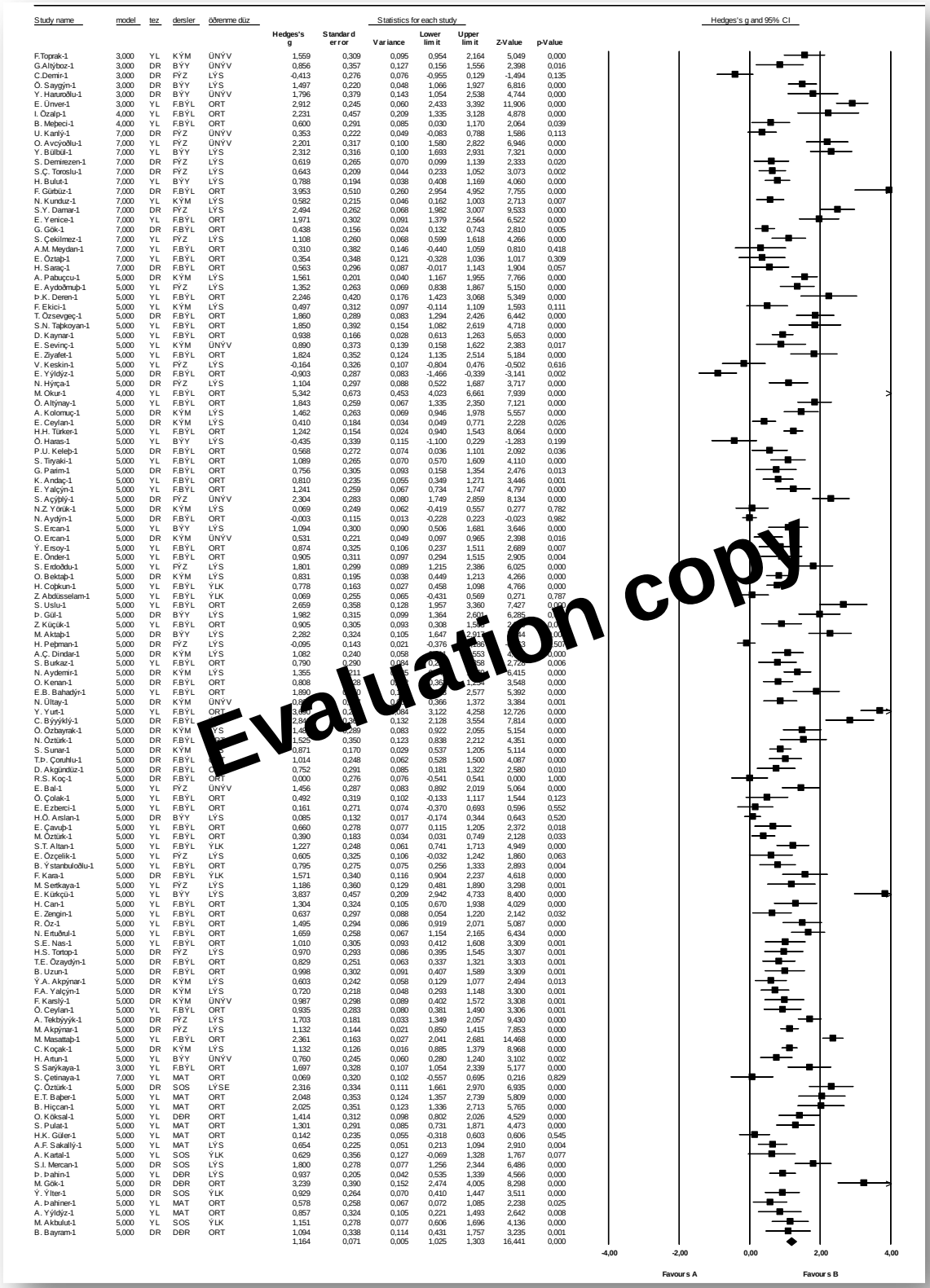

Figure-1 Forest chart of the academic achievements' effect size values

In the graph, the position of the black squares with respect to the mid-vertical line shows the effect size value of the search, and 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 value of the investigations they belong to within the overall effect size. The figure with the lowest quadrangle shows the magnitude of the overall effect according to the random effects model of the study.

When the effect sizes of the researches are examined; the smallest effect size value is -0.916 (Yildiz, 2008) and the highest effect size value is 5.450 (Okur, 2009). The 123 effect size values of the study have 117 positive effect and six have negative effect.

One of the issues that should be considered in meta-analysis study is publication bias. It was determined that the required number of runs with effect sizes 0 (zero) was 8892 to reduce the value of effect size 1.164 obtained as a result of the analysis by Orwin method to 0 (zero) effect size value. This is a very high number and shows that the publication bias is low. In addition to this, it can be interpreted as Funnel Plot in Fig-2.

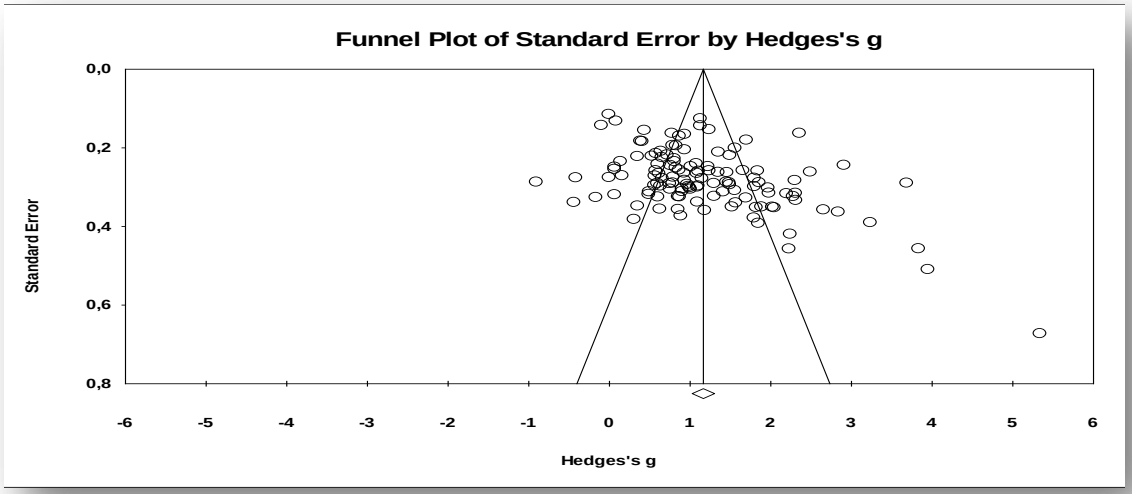

Figure-2 Funnel graph of the researches included in the study

In case of publication 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 researches show an almost symmetrical structure. Accordingly, it can be said that there is no publication bias in the study.

The effect sizes obtained in the meta-analysis are divided into subgroups according to various classifications. The results of the analysis are shown in Table 3.

Table 3. Statistical analyzes according to classified subgroups

Operating Characteristics	Homogeneity between groups (QB)	p	N	Effect Size (ES)	ES (%95 CI)		Standard Error(S)
					Lower	Upper	
Learning cycle model	2.032	0.566					
3-stage Model			7	1.417	0.603	2.232	0.416
4E Model			3	2.659	0.246	5.072	1.231
5E Model			97	1.120	0.973	1.268	0.075
7E Model			16	1.131	0.720	1.543	0.210
Dissertations	1.150	0.284					
Doctorate			54	1.080	0.878	1.283	0.103
Masters			69	1.231	1.044	1.418	0.095
Disciplines	8.587	0.198					
Biology			12	1.372	0.805	1.938	0.289
Others			4	1.637	0.733	2.542	0.462
Science			56	1.237	1.004	1.469	0.119
Physics			19	1.067	0.696	1.438	0.189
Chemistry			19	0.916	0.730	1.101	0.095
Math			8	0.932	0.446	1.419	0.248
Social Sciences			5	1.365	0.807	1.922	0.285
Education levels	1.209	0.751					
Primary school			8	1.120	0.644	1.595	0.243
Middle school			42	1.068	0.854	1.243	0.109
High school			61	1.237	1.012	1.462	0.115
Universty			12	1.196	0.821	1.570	0.191

p<.05

In the subgroup analyzes made; there was no statistically significant difference in the type of learning cycle models used (QB = 2.032, p> .05), the type of dissertations (QB = 1.150, p> .05), the type of disciplines (QB = 8.587, p> .05), and the type of education levels of the students (QB = 1.209, p> .05). In other words, among the academic achievement effect sizes of the students, there is no statistically significant difference between the type of learning cycle model, the type of dissertations, the type of of disciplines, and the the type of education levels of the students.

Discussion, Conclusions and Recommendations

In the study, the dissertations on the effect of the use of learning cycle models in the educational process on students' academic achievement were combined with meta-analysis. According to the REM in the study, a positive result of 1.164 was reached in favor of experimental groups on a very large level. This result is in agreement with the results obtained from the meta-analyzes carried out within the scope of educational researches in the literature (Aktamis, Higde, & Ozden, 2016; Ayaz, 2015; Ayaz, Sekerci, & Oral, 2016; Balta, & Sarac, 2016; Basol, & Erbay, 2017; Batdi, 2015; Bozdemir, Cevik, Altunoglu, & Kurnaz, 2017; Guzeller, & Ustunel, 2016; Sarac, 2017; Ulubey, & Toraman, 2015).

When the results of the meta-analysis obtained from the research are examined according to the learning cycle models used in the study; it has been found out that there is no statistically significant difference between the effects of the academic achievement in the students and the type of learning cycle models used in the educational process (Q = 2.032 and p = 0.566). When the studies examined were evaluated according to the model of the learning cycle model, the highest effect size value was found to be excellent in the 4E Model (ES = 2.659). In addition, it has been found out that the studied studies are very large with 7E Model effect size value (ES = 1.131), 3-stage Model effect size value (ES = 1.417) and 5E Model effect size value (ES = 1.120).

When the results of the meta-analysis obtained from the research are examined according to the dissertations used in the study; it has been found out that there is no statistically significant difference between the effects of the academic achievement in the students and the type of dissertations used in the educational process (Q = 1.150 and p = 0.284). When the researches examined were evaluated according to the dissertations, the highest effect size value was found to be very large in the master theses (ES = 1,231). In the literature, it is seen that the highest effect size value of the dissertations type within the scope of the education researches is in the master thesis research with 1.307 in the study performed by Balta and Sarac (2016). According to this result, the result obtained according to the dissertations types in the meta-analysis study performed by Balta and Sarac (2016) and the academic achievement effect of the students using the learning cycle models in the study period in the research are similar according to the master thesis. In addition, within the scope of the researches, the highest effect size value in the dissertations type was 0.919 in the study of Sarac (2017), 1.598 in the study of Ayaz (2015), 1.247 in the study of Ayaz, Sekercici and Oral (2016) and 1.213 in the study of Ulubey and Toraman (2015) were found to be in doctoral theses. According to the meta-analysis studies performed by Sarac (2017), Ayaz (2015), Ayaz, Sekerci and Oral (2016) and Ulubey and Toraman (2015), results obtained according to the type of dissertations and learning cycle models the effect of using academic achievement on students' achievement according to the dissertation does not overlap.

When the results of the meta-analysis obtained from the research are examined according to the disciplines used in the study; it has been found out that there is no statistically significant difference between the effects of the academic achievement in the students and the type of disciplines used in the educational process (Q = 8.587 and p = 0.198). It is seen that the highest effect size value in the science studies is excellent in the Biology (ES = 1.372), in the Social science (ES = 1.365) and in the other lessons (ES = 1.637). In the literature, it is seen that Sarac (2017) in the scope of educational researches has the highest effect size value in the disciplines with 1,324 in the other lessons. Ayaz, Sekerci and Oral (2016), Batdi (2015) and Ulubey and Toraman (2015) were found to be in the Social sciences. In this case, meta-analysis studies of Sarac (2017), Ayaz, Sekerci and Oral (2016), Batdi (2015) and Ulubey and Toraman (2015) and the results obtained by the area of discipline and the use of learning cycle models the result obtained according to the disciplines of the academic achievement effect in the students is partially similar. In addition, Ayaz (2015) and Balta and Sarac (2016) found that the highest effect size values in the disciplines were in Chemistry lessons with 1.432 and 2.066. In this case, the results obtained by disciplines in the meta-analysis of Ayaz (2015) and Balta and Sarac (2016) and the results of the use of learning cycle models in the study in academic research do not overlap according to the disciplines of academic achievements.

When the results of the meta-analysis obtained from the research are examined according to the education levels of the study groups; it has been found out that there is no statistically significant difference between the effects of the academic achievement in the education levels of the study groups (Q= 1.209 and p= 0.751). When the studies examined were evaluated according to the education levels of the study group, it was seen that the highest effect size value was very large in high school students (ES = 1.237) and university students (ES = 1.196). In the literature, in the study conducted by Sarac (2017) within the scope of educational research, it was seen that the effect size value of the study groups was 1,024 in university students and in the study performed by Balta and Sarac (2016), 1.419 in high school students. In this case, the results obtained according to the education levels of the study group in the meta-analysis study that Sarac (2017) and Balta and Sarac (2016) did and the result obtained according to the educational level of the academic achievement effect of the students in the educational process. In addition, Ayaz (2015) showed that the

highest effect size was 1,727 in primary school students according to the learning level of studying groups. It is seen that the highest impact size value in the studies of Batdi (2015) and Ulubey and Toraman (2015) is in the middle school students according to the education levels of studying groups. In this case, the results obtained by education levels in the meta-analysis of of Ayaz (2015), Batdi (2015) and Ulubey and Toraman (2015) and the result of the use of learning cycle models in the study in academic research does not overlap according to the education levels of academic achievements.

When we look at the results of the research in general; it has been determined that the use of learning cycle models in the educational process has a very large effect on students' academic achievements. There is no statistically significant difference between the learning cycle model used in the educational process and the academic achievement effect of the learning cycle models, the disciplines, the dissertations, and the education levels of the study groups.

In this meta-analysis study, the use of learning cycle models in the educational process was examined academic achievements on students, and the remaining effects were excluded from the scope of the study. After that, researchers who will work on these topics will be able to use learning cycle models in the educational process; gender and anxiety on factors such as the effect on different topics can perform meta-analysis studies. Moreover, it has been revealed that this meta-analysis gives more effective results on the courses of Biology and Social sciences. A comprehensive study of the causes of these outcomes can be made. The research was conducted in all disciplines. A similar study can be applied specifically at Science, Social sciences and Mathematics. In addition, meta-analysis studies can be done in different categories for the effects of learning cycle models on learning outcomes.

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Appendix-1. The dissertations included in the Meta analysis study

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