JOURNAL OF BALTIC SCIENCE EDUCATION
ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

EFFECTS OF LEARNING CYCLE MODELS ON SCIENCE SUCCESS: A META-ANALYSIS

Süleyman Yaman,
Şadiye Karaşah

Abstract. *This meta-analysis has two objectives: (a) to address the main effects of learning cycle models on students' success in science; and (b) to address potential moderators of the effect of LC models. This meta-analysis was conducted by calculating the effect size of 75 studies, including theses and journal papers associated with the implementation of LC models published in Turkey. The studies were selected according to the following criteria: experimental studies on LC models in science courses at different educational levels. The studies, which were included within this scope, were carried out between the years of 2004-2016. As possible moderators of LC models; effects, type of publication, educational level, period, sample size and the year of construction were investigated. This moderator analysis indicates that there are significant differences among the effect sizes of the research. Nevertheless, the values of the general effect size of the researches provide a positive outlook to increase the students' science success of the LC models. Considering the effects of LC model on the students' science success, this research could be helpful to both researchers and practitioners in the field of science education.*

Keywords: *meta-analysis, learning cycle models, science success, effect size.*

Süleyman Yaman, Şadiye Karaşah
Ondokuz Mayıs University, Turkey

Introduction

Many studies on education focus on determining how students learn and on setting out more effective educational approaches, models, methods, and techniques. This may be due to the lack of certain knowledge about how the learning is formed, the excessiveness of the variables involved, and the fact that research findings have different results. Researches on learning might give different results because of people being influenced by many characteristics of themselves and because all kinds of external factors influence those (Riding & Rayner, 2013). A student can have different levels of learning for different subjects or even for different subjects within a course (Felder & Brent, 2005). In addition, due to the increase in knowledge by time and the fact that the technology has a great deal of influence on daily life, there may occur differences between research results. Additionally, the effect of teaching on learning is one of the least debated topics. This is because researchers are almost certain that learning would be very limited and incomplete without teaching (Schunk, 2013).

Today, a variety of educational models have been developed and implemented at different levels of teaching in order to transfer the increasing fund of knowledge to the students in the most effective way (Bayram, Patlı, and Savcı, 1998). The influence of the theories of cognitive development theorists on the educational sciences increased and they were adopted all over the world in the 1950s. Thus, the focus was on studies aimed at increasing the effect of teaching and learning. The competition for space research was influential in this process, interest in science increased and research-based learning and teaching approaches were adopted. One of the most important of these approaches is the learning cycle (LC) (Ayas, 1994). LC was developed by Robert Karplus. In 1977, on the basis of the theory of mental development introduced by the famous educator and psychologist Piaget (Karamustafaoglu & Yaman, 2006). LC models were particularly important in the program which was developed by Karplus and his colleagues within the scope of the Science Improvement Study. This program is a research-based approach that centers on student-centered learning (Abraham, 2005). One of the most applied models of LC is the research-based learning, also known as 5E. This model, which is quite popular in the constructivist approach, consists of five steps (Carin & Bass, 2005; Özsevgeç, Çepni, & Bayri, 2007). Based on the 5E model, alternative models such as 3E, 4E and 7E have been developed and used at every stage of science education (Eisenkraft, 2003). The steps for these models are displayed in the table below:

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Table 1. Steps of learning cycle models.

3E	4E	5E	7E
Explore	Engage	Engage	Elicit
		Explore	Engage
Explain	Explore	Explain	Explore
	Explain	Elaborate	Explain Elaborate Evaluate
Evaluate	Evaluate	Evaluate	Extend

All of those models emphasize that the learning should be done according to constructivist understanding. The constructivist learning is a student-centered theory that examines the nature of knowledge and how information is acquired. In this theory, individuals form their own concepts and adapt them to new situations by utilizing their previous experience and prior knowledge (Açışlı, 2010). The LC models can be addressed in the constructivist theory. Constructivism is based on the fact that the learner constructs his own knowledge rather than reproducing the knowledge of another (Moussiaux & Norman, 2003). The 5E model is an important part of the constructor tradition because it involves rational learning (Tinker, 1997). The 5E model allows students to be more curious and get more familiar with the real world, and helps them to develop problem-solving skills. It also allows them to reflect upon basic information and to develop the skills necessary to learn, analyze and synthesize this knowledge (Yoon & Onchwari 2006). This model allows students to learn in real life, by letting them take their own learning responsibilities, learn by experience and transfer information (Bıyıklı & Yağcı, 2015).

In the very step of 5E learning model, in "elicit" step, it is attempted to get the students' attention and reveal the preliminary information and the teachers get the opportunity to understand the current concepts of the students. What is important in this step is not to let students find the right answer, but to encourage them to put forward different ideas and to improve their ability to ask questions. Asking interesting questions to students, reading an attention-grabbing story, showing a video or experiment can be done in this step (Ekici, 2007; Newby, 2004). Unanswered questions in the previous step are resolved in the explore step. In this step, the student activity is at its highest. Students reach out to some information on their own by researching, using various sources, experimenting or discussing (Kabapınar, Sapmaz, & Bıkmaz, 2003; Özmen, 2002). "Explain" is the step where the teacher helps students combine the results of their experiences, explain the results that they've found and created new concepts by making explanations at the basic knowledge level. Students describe the concepts they understand, use their own abilities and explain the events by expressing their own approach (Ekici, 2007). The deepening step allows students to apply their new definitions, explanations and skills to new but similar situations and encompasses the experimental inquiry, investigation projects, problem solving and decision-making activities. "Evaluate" is the step that students are expected to demonstrate their understanding, the change in their behavior, how much of the new concepts and skills have been learned, and that they evaluate their own self-development (Linn & Miller, 2005; Özmen, 2002).

The 3E model was developed on the 5E model based on Piaget's theory of mental development. This model is based on explore, explain and evaluate. Explore corresponds to the step of entering and discovering, explain corresponds to the explaining and expanding, evaluate corresponds to the evaluating step on the 5E model. The 4E model consists of four consecutive stages of engage, explore, explain and evaluate. This model helps teachers who use the constructivist learning approach in their lessons (Bybee, 1997). The first step of the 4E LC model which is the engage step is the step where the mental assimilation and explain in the 3E LC model occur. In this step, students collect data on the concept or subject they will learn using scientific process skills such as observation, interpretation, and prediction. Explore step is where the connection happens. In this step, the students organize the information obtained with the help of the advisor, present it to the class and discuss it together. Explain step is the step that the structure in Piaget's model is performed. In this step, the counselor helps the students to extend the meaning of the concept and to apply this concept to their daily life by allowing the concept to be implemented in various places (Marek & Cavallo, 1997). In the final step which is evaluate, students are subjected to performance evaluation rather than traditional evaluation.

The 4E model is a very effective way to implement the constructivist theory easily within the classroom (Bybee, 1997). Students find this model fun and interesting. This model enhances the motivation of students and encourages high-level thinking skills, encourages them to think about the subject, and enables them to learn by experimenting

(Yılmaz & Huyugüzel Çavaş, 2006). The 7E model is the reinterpreted version of the 5E model developed separately by Bybee (2003) and Eisenkraft (2003). Studies on the 7E learning model show that it contributes to the development of critical thinking in students (Mecit, 2006) and shows that students develop scientific process skills. At the same time, it gives more successful results in the lessons carried out in the laboratory (Kanlı, 2007) compared to the teacher-centered (TC) models.

When the national and international literature is examined, it is stated that LC models can be used to improve many skills of students. According to the traditional teaching methods (no constructivist approach), these models improve academic success (Ceylan & Geban, 2009; Chen, 2008; Kunduz & Seçken, 2013), metacognition (Feyzioğlu & Ergin, 2012), attitude (Aktaş, 2013; Mecit, 2006) and high-level cognitive skills (Aydın & Yılmaz, 2010). The purpose of this research is to determine the effect size of LC models by comparing students' science success with LC models (3E, 4E, 5E, and 7E) and TC models.

Two sets of research questions guided this meta-analysis. Firstly, the main effects of LC models on outcomes including success in science were addressed. Secondly, potential moderators of the effect of LC models were indicated. A first category of moderators include the LC model used in the research. In the second category of moderators, whether the effect of LC models differs across the study types (journal paper, master' theses, dissertations) was examined. Thirdly, the effect of the level of school, where the research was conducted (primary school/middle school/ high school/ undergraduate), was examined. In the fourth category of moderators, the effect of LC models according to sample sizes (0-50/51-75/76-100/101 and above) was investigated. Lastly, the effect of LC models based on the time of the research (2005 and before/2006-2010/2011 and later) was examined.

Methodology of Research

General Background

The research is a meta-analysis study. Meta-analysis is a quantitative technique that integrates the results of a number of different primary studies to analyze and synthesize them into a coherent product (Schroeder, Scott, Tolson, Huang, & Lee, 2007). Although meta-analysis is not a primary research study, it shares common traits in terms of formulating a problem, collecting data, coding the data, analysis, and interpretation (Cooper & Hedges, 1994). Meta-analysis is a method of screening literature in scientific research. This method is described as the synthesis of existing research on a particular research hypothesis (Jupp, 2006). Meta-analysis is a method that quantifies the generalizations obtained from different researches and suggests new emphasis for future researches by exploring the deficiencies in existing researches. It is also accepted as an analysis of the analysis of other studies (Cohen, Manion, & Morrison, 2007). The studies in this research included theses and dissertations about the LC models applied in 2004-2016 years and the articles of the refereed journals in Turkey available during research. In the analysis, the random effects model was used, and the effect sizes were recalculated using the free-effects model.

Collection of the Data

The studies examined in the research include the published theses and dissertations about the LC models between 2004-2016 years and the articles published in the refereed journals in Turkey. The reason for choosing 2004 as a starting year is that very few studies have been done before and the data of these studies are not available. The reason for ending with 2016 year is that it is the time when data analysis has begun. In order to reach the theses, keywords were used to make research on the website of the Council of Higher Education's (YÖK) National Thesis Screening Center. 39 master theses and 37 dissertations were found in this way. The full text of the three works with restriction is not accessible; the authors were contacted and requested for research data for analysis. One study was reached in this way. Two of the theses were not reached despite all attempt. It was examined the suitability of data obtained from 75 theses accessed for meta-analysis and it was found out that the data of 18 do not have a data format that can be analyzed. Thus, 57 studies were included in the scope of the studies to conduct a meta-analysis.

Between October 2016 and January 2017, Ondokuz Mayıs University Library Database, Google Academic and Turkish Academic Network and Information Center (ULAKBİM) Social Sciences Database were used to access the journal papers published in national and international journals. 24 papers were reached at the end of this review; but since 2 publications were included in the study as theses, 4 papers were excluded from the analysis because they do not have the data format that can be analyzed. At the end of this examination, a total of 18 papers published in the journals were included in the meta-analysis study. One of these papers examines the animation technique, while

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

another examines the effect of peer learning on science success. However, these applications were based on the 5E learning model and since this situation is stated in the research, they are included in the study. As a result, analysis was made with 75 studies from theses, dissertations, and journal papers that included the learning-cycle approach and appropriate data for meta-analysis.

Analysis Inclusion Criteria

The criteria used for inclusion into meta-analysis study are given below in detail:

a) The research must be conducted in Turkey between 2004 and 2016
b) It must be an article published in master' these/dissertations or scientific refereed journal which is written in Turkish or English language.
c) It must consider science success as one of the dependent variables in studies,
d) The studies must be designed according to true or quasi-experimental design,
e) One of the LC models to the experimental group and the TC models to the control group or the applications stated in the current curriculum must be applied. Applications (model, technique, method, strategy, or approach) used for the control groups were generally not well-defined in most studies, but TC models meant more teacher-dominated instruction with passive student participation.
f) Mean and standard deviations of the science success scores of experimental and control groups must be given in the findings
g) The simple size in the experimental and control groups must be given.
h) Assessment tools used in studies must have adequate levels of validity and reliability.

Coding of Data

Rater reliability is an important criterion in coding data analyzed in meta-analysis studies. For this purpose, it is expected that the coding of at least two different raters in the studies and the percentage of correspondence between these coding is expected to be high (Açıkel, 2009; Akçil & Karaağaoğlu, 2001). For this purpose, a coding form (Appendix2) has been developed. This form consists of three parts. First part; the name of the work, the name of the author(s), the publication year, and the type of work (thesis or article). In the second part entitled "study content", the subject area (physics, chemistry, biology) in which the LC models are applied, as well as the level of learning and experimental work are included. The third part is the "study data" which refers to the mean, standard deviation obtained from experimental and control groups and the size of the study group.

The data were entered simultaneously onto the coding form by two different researchers. One of these researchers is continuing his graduate education in science education and the other researcher is a lecturer in the related field. The Miles and Huberman (2002) formula was used to determine the percentage of consensus on data that researchers independently code. The consistency level of the researchers' codes was found to be 96%. For incompatible encodings, the data were analyzed together, and coding of the data was maintained until a consensus was reached. Three data that could not be agreed on, were removed from the coding form. It was decided that the reliability level of the coded data was sufficient since it was taken into consideration that 70% or more of the correspondences were sufficient in such coding (Yıldırım & Şimşek, 2011).

Variables

Dependent Variable: The dependent variable examined in the research is the science success score from which the effect of the LC models is researched.

Independent Variables: The basic independent variable of the research is the different model of the LC models. The 3E, 4E, 5E and 7E LC models applied within this approach were addressed separately. Since only 1 study is available for 3E, this research is not included in the study. In addition, TC models that are influenced by the control group are another independent variable. The moderator variables discussed in this research are; the number of students in the study groups, the duration of the experimental work, and the field of the applied courses (physics, chemistry, biology or science). In these areas, studies conducted in primary and middle schools within the scope of science lessons are coded as physics, chemistry or biology according to the subjects of the research. Since there is more than one field related to three different studies, random assignment of each field is performed in the coding. The mesh-terms or key words used in the search were LC models, constructivist approach, Karplus' learning model, science success, science

course, science teaching, science learning.

Validity

The validity level of the data obtained from the sources studied in the meta-analysis studies is related to the ability of the data collection tools used in these studies to measure what they are trying to measure (Petitti, 2000). For this reason, it has appeared that assessment tools used in studies have high levels of validity which is a common criterion for acceptance of publications and thesis in Turkey.

Data Analysis

The researches that satisfied the criteria stipulated were then uploaded into the Comprehensive Meta-Analysis (CMA) software program, and analysis was performed with this program (Hunter & Schmidt, 2004). The standard unit of measurement in the meta-analysis is the effect size. The effect size increases as the difference between the mean scores of the variables examined in the experimental and control groups increases and as the standard deviation decreases (Aron & Aron, 1997). Developed by Glass, this method is especially preferred in psychology, social sciences and educational studies. Standardized magnitude of impacts, defined as Hedges' g or Cohen's, can be used to determine the effect size of the independent variables discussed in the research. In this research, Cohen's values, which are calculated by dividing the difference between the science success scores of the experimental and control groups by the combined standard deviation, are taken into account (Schulze, 2004). This formula makes it possible to translate the data obtained from independent studies into a standard system and to compare the effect sizes obtained in a meaningful way. The significance level of the statistics used in the research was chosen as .05. Cohen's effect size classification is as follows: ".00 ≤ d ≤ .20 weak; .21 ≤ d ≤ .50 small; .51 ≤ d ≤ 1.00 moderate; 1.01 ≤ d strong" (Cohen, 1988). For graphics, Hedges' g value given by CMA program was preferred.

Chi-square homogeneity test (Q statistic) was used to test for accurate heterogeneity among the studies included in the research. This test tests the null hypothesis that is assert that it has same effect on any study that includes the independent variable effect (Higgins, Tompson, Deeks, & Altman, 2003). The combination of meta-analysis and studies with different effect sizes has a significant effect on the selected model. There are two types of models in meta-analysis: Fixed and random effects model. "n" the constant-effect model (SEM), the parameters of the universe are taken into account. In this model, the standard deviation value for universe magnitude is assumed to be zero. In addition, the fixed effect model is based on the assumption that each study has only one actual effect size (Borenstein, Hedges, Higgins, & Rothstein, 2009 as cited in Üstün & Eryılmaz, 2014). In the random effects model (REM), it is accepted that the effect sizes of the universe get different values in different studies.

While deciding which model was going to be preferred in the analysis of the studies, it was checked whether the effect size values were homogeneous or heterogeneous. When the data shows heterogeneous distribution, it is suggested to be used a random effects model and when it has a homogeneous distribution, it is suggested that the fixed effect model should be preferred (Ellis, 2010). It is found out that the factors affecting the study differ in each of the studies examined in this research. It is also claimed that the basic assumption of the fixed effect model, which predicts only one true effect size for all studies in the meta-analysis, is not realistic for many situations (Borenstein *et al*., 2009 as cited in Üstün and Eryılmaz, 2014). Finally, intra-group, inter-group and total heterogeneity values -which were obtained when the fixed effect model was applied in the meta-analysis method- were higher than the critical value. Because of these differences, it was decided to use the random effects model in this research. The effect sizes were recalculated using the free-effects model.

Results of Research

Findings of General Effect Size

In order to be able to calculate the magnitude of the effects of the studies on which the LC models are applied, the meta-analysis model to be used first has to be determined. For this purpose, the homogeneity of the LC models with the fixed and random effects models and the homogeneity of the studies and the overall effect size are given in Table 2.

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Table 2. Findings about the effect size of the meta-analysis in accordance with the fixed effect model and the random effect model.

Model	Effect Size (ES)	SD	Homogeneity Level (Q)	Z	Standard Error (Se)	I^2	Effect Size (ES)	
							Lowest	Highest
FEM	1.12	74	784.25	37.48	.03	90.56	1.06	1.18
REM	1.22			12.39	.10		1.03	1.42

According to the fixed effects model, the average effect size is calculated to be 1.12. The homogeneity test resultant Q statistical value for examining the homogeneity of the effect sizes of the studies included in the research was found to be 784.25. According to this result, the effect sizes of the studies within the scope of the research are heterogeneous. This effect size has been regarded as "the effect at a strong level" according to the Cohen's (1988) classification.

As a result of analysis made according to the random effects model; the upper limit at 95% confidence interval is 1.42, the lower limit is 1.03 and the average effect size is 1.22. According to this result, the effect sizes of the studies included in the research are homogeneous according to the random effects model. This effect size that was calculated, has been regarded as "the effect at a strong level" according to Cohen's classification. The graph below shows the distribution of the effect sizes of the studies studied in the research.

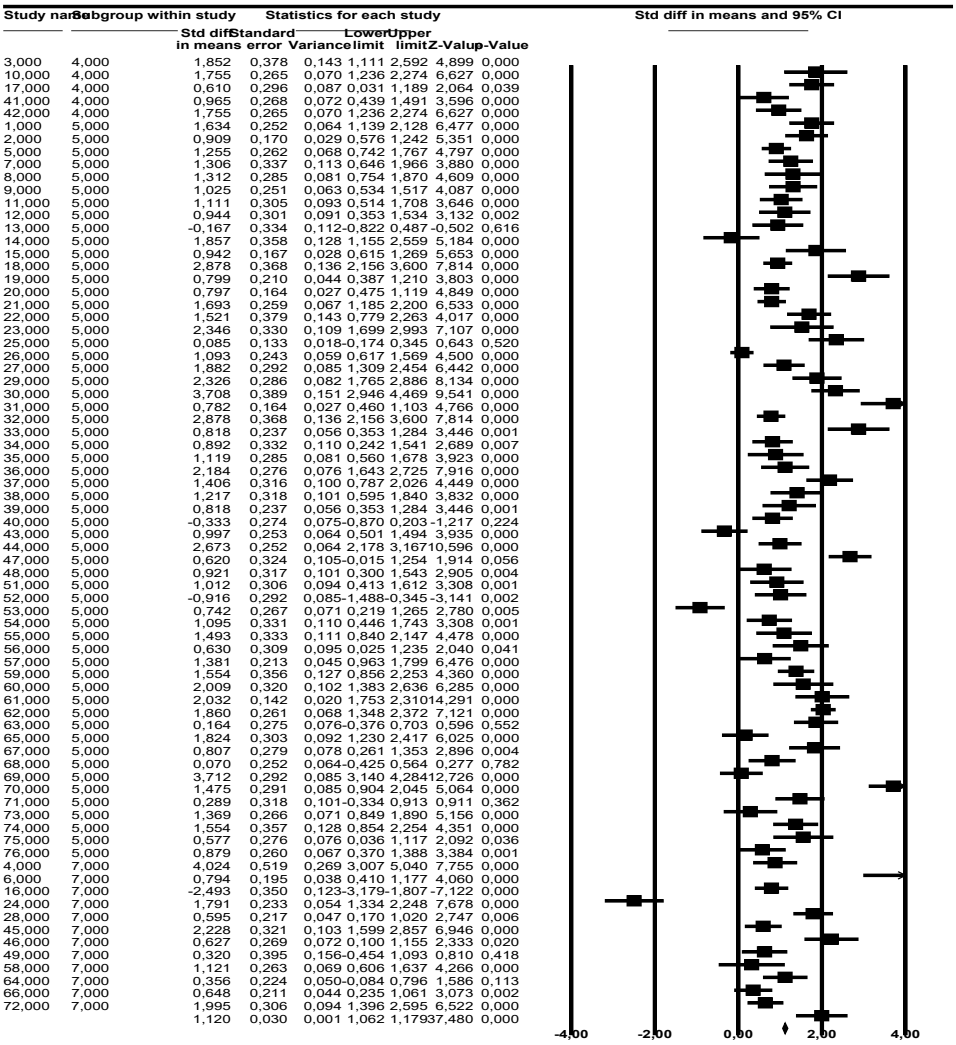

Figure1: A Forest Plot showing science success with the use of the learning cycle models.

The graph below shows the distribution showing the slope of the effect levels of the studies covered by the research.

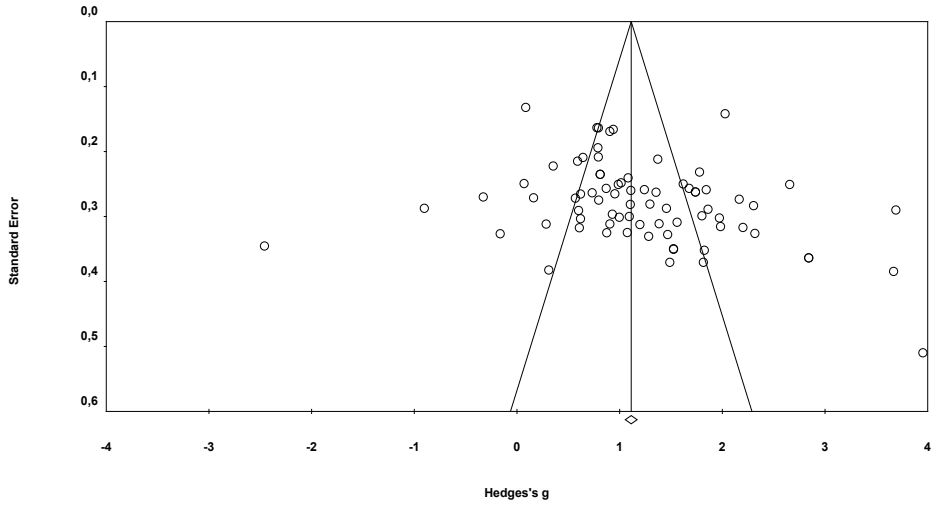

Figure 2: Funnel Plot showing publication bias.

Funnel graphic of the researches that have been included in the analysis can be seen in Figure 3. According to the graphic, the researches are seen on a symmetrical basis, in other words, they concentrate on one single side. It can be said that there is not any publication bias in the research because when publication bias exists, a skew and asymmetric range is observed in the graphic.

Findings about Effect Size of Independent Variables

Table 4 shows the findings regarding whether effect sizes differ depending on different fields of science.

Table 4. Findings about effect levels of learning models.

LC models	Q	p	ES	n	Se	ES	
						Lowest	Highest
	1.02	**.599**					
4E			1.38	5	.25	.89	1.87
5E			1.26	58	.11	1.05	1.47
7E			.97	12	.32	.35	1.60

The results of the analysis have shown that 4E learning model has the highest impact value with 1.38, and the 7E learning model has the lowest impact value with .97. According to the chi-square distribution, the critical value at the 95% significance level has been found to be 5.99. The homogeneity value (Q) between the groups formed in the LC models used is 1.02. The homogeneity value between groups is smaller than the critical value. For this reason, there was no statistically significant difference in terms of science success between groups formed according to the LC models applied in the experimental study. In terms of impact sizes, the greatest difference was found in the 7E model applications (range 1.25) while the lowest difference was found in the 5E model applications (range .42).

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Table 5. Findings about the effect size in different types of publications.

Type of publication	Q	p	ES	n	Se	ES	
						Lowest	Highest
	2.39	**.302**					
Journal paper			1.11	18	.20	.72	1.50
Master theses			1.09	29	.14	.83	1.36
Dissertations			1.44	28	.19	1.07	1.80

As seen in Table 5, when the percentage values are examined according to the LC models and the publication type of the study, the highest rate belongs to the master's theses with 39.47% followed by dissertations with 36.84%. The journal papers have the lowest rate with 23.68%. When the effect value is considered, the dissertations have the highest effect value with 1.44%. In the chi-square distribution, the critical value was found to be 5.99. The homogeneity value (Q) between the groups formed according to the publication types of the studies was found to be 2.39. Because the homogeneity value between the groups is smaller than the critical value, it has been determined that there is no significant difference in science success according to the publication types. When lower and upper effect size values are examined, it is determined that dissertations varied less than other studies.

Table 6. Findings about the effect size in different subjects.

The subject of the course	Q	p	ES	n	Se	ES	
						Lowest	Highest
	.50	**.781**					
Physics			1.28	38	.17	.96	1.60
Biology			1.23	16	.14	.95	1.50
Chemistry			1.11	21	.18	.77	1.46

When the distributions of subject areas of the studies were examined, it was determined that the most studied subject was physics (51%), then. chemistry (28%); and biology (21%). According to the results of the research, it was determined that the highest effect value is 1.28 and the lowest effect value is 1.13. The critical value according to chi-square distribution is 5.99. The homogeneity value (Q) between the groups is 0.50. There was found no statistically significant difference between the groups in terms of the homogeneity value of the group and the science success scores of the group. Moreover, it was determined that the most homogeneous effect sizes are in subject of Biology and the most heterogeneous effect sizes are in subject of Chemistry according to the range values.

Table 7. Findings about the effect size at different educational levels.

Educational level	Q	p	ES	n	Se	ES	
						Lowest	Highest
	0.92	**0.821**					
Primary School			1.49	7	0.09	0.89	2.08
Middle School			1.18	29	0.03	0.86	1.50
High School			1.21	29	0.03	0.86	1.56
Undergraduate			1.17	10	0.04	0.80	1.54

According to the data in Table 7, the LC models were applied at the middle and high school levels at most. It was also determined that it was applied at the primary school level at least. The findings reveal that the highest impact value was at primary school level with 1.49 and the lowest impact value at middle school level with 1.18. The critical value for chi-square distribution was determined to be 7.814. The homogeneity value (Q) between the groups formed according to the learning model used is 0.92. Since the homogeneity value between the groups was smaller than the critical value, there was found no statistically significant difference between the groups formed according to the topic studied in terms of science success.

Table 8. Findings about the effect size depending on the study implementation period.

Period	Q	p	ES	n	Se	ES	
						Lowest	Highest
	3.77	**.287**					
3-5 week			1.15	25	.14	.87	1.43
6-8 week			1.42	27	.20	1.02	1.82
9 vet + week			1.26	10	.29	.69	1.83
Unspecified			.91	13	.17	.58	1.25

As a result of analysis, it was determined that studies which took more than 9 weeks to apply have the least proportion. It was also determined that researches which took more than 9 weeks to apply have the least proportion. It was found out that the highest impact level (1.42) among these studies belongs to those that cover a period of 6-8 weeks while the lowest impact level (.91) belongs to those whose periods of applications were not specified. The critical value according to the chi-square distribution is 7.81. It was determined that the homogeneity value (Q) between the groups formed according to the length of the experimental work done was 3.77. It was determined that there was found no statistically significant difference between the groups because the homogeneity value between the groups was smaller than the critical value. In addition, it was determined that according to the range values, the studies with the most variable impact size were those that lasted 9 weeks or longer while those that showed the least difference in terms of impact size are those which took 3 to 5 weeks to apply.

Table 9. Findings about effect size of the sample size of studies.

Sample size	Q	p	ES	n	Se	ES	
						Lowest	Highest
	1.13	**.769**					
0- 50			1.15	21	.15	.86	1.44
51-75			1.15	29	.20	.77	1.53
76-100			1.29	14	.17	.96	1.62
101- +			1.43	11	.27	.89	1.96

According to the table, the maximum number of students who applied the LC models is 50-75. This is followed by 21 studies involving between 0 and 50 students. The studies in which 101 or more students participated have the least proportion. The results of the analysis show that the studies in which 101 and more students participated have the highest impact value with 1.43 while the studies in which between 0 and 50 students participated have the lowest impact value with 1.15. The critical value in the chi-square distribution is 7.81 and the homogeneity value (Q) between the groups is 1.13. Since this value was smaller than the critical value, it was determined that the sample size did not make any significant difference in terms of science success. When the range values of the studies are examined, it was determined that, in terms of impact sizes, the studies which involved 101 and more students had the highest variability while the lowest variability belonged to those which involved 0- 50 students.

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Table 10. Findings about effect size of the years in which the research.

Year	Q	p	ES	n	Se	ES	
						Lowest	Highest
	.99	**.607**					
……-2005			.86	3	.47	-.07	1.78
2006-2010			1.30	34	.14	1.03	1.57
2011-……			1.18	38	.15	.90	1.47

As a result of analysis, it is determined that LC models have been mostly applied since 2011. It was also found that the studies carried out before 2005 have the lowest rates. According to the meta-analysis results, the highest impact value (1.30) was found in the studies carried out between 2006 and 2010 while the lowest impact value (.86) was found in the studies carried out in and before 2005. The critical value according to chi-square distribution was found to be 5.99. The homogeneity value (Q) between the groups is .99. The homogeneity value between the groups is less than the critical value. This means that there was no statistically significant difference between the groups according to the years when the study was carried out. Besides, the ranges of the impact size values in the studies reveal that the studies carried out before 2005 had the highest variability while those carried out between 2006 and 2010 had the lowest variability.

Discussion

In the research, an analysis was made by using the experimental study results in order to determine the effect of LC models (4E, 5E and 7E) used in different subject areas of science education in Turkey on science success of students. Since the data obtained by reviewing the databases and libraries were heterogeneously distributed, the random effects model was used. 3E model with an insufficient number of data and the studies with missing data were not included in the survey. In these studies, which were analyzed according to the statistical data of 75 researchers, LC models were used in the experimental group and TC models were used in the control group. The reason that there is a large number of studies on LC models can be the effect of the student-centered curriculum in the science class started in 2000 (Bozdoğan & Altunçekic, 2007). The aim of this research is to analyze the effect level of these models which have a specific sub-structure and application culture in Turkey according to different variables and determine the general effect level. Similarly, Ural, & Bumen (2016) analyzed the studies regarding the constructivist approach to science education. The researchers analyzed three studies of the LC model and found that they were effective in increasing science success. Apart from this work, Balta & Saraç (2016) analyzed the 7E LC model; Saraç (2017) analyzed the 5E model and they stated that the effect on science success is significant. Unlike these studies, the effect of all LC models on science success was examined in this research.

In the majority of the studies included in the research, the effect size of the LC models (ES=1.23) was found to be significantly higher than the TC models. A total of 75 studies were carried out. In 71 (the LC models) of the studies showed higher science success compared to the other 4 studies (TC models). TC models were proved to be more effective than 3 studies of 5E and 1 study of 7E. According to this finding, it can be asserted that the LC models have a higher effect on the science success of the students than the TC models in the field of science. This result was interpreted as 5E models give less variable results than other models (4E and 7E). It can be argued that this was due to the fact that the vast majority of examinations were made regarding the 5E model. The increase in the number of samples of the past few days provides a certain amount of contribution to the level of homogeneity (Privitera, 2012). As this model is widely-known and experienced by the researchers compared to the 7E and 4E models, the change ratio in the results may be lower. This result shows that LC models have a strong effect on the science success levels of students according to the Cohen (1988) effect size classification.

It was found that the highest effect size from the three learning models belongs to 4E with 1.38, and the lowest impact value belongs to 7E with 0.97. In the study of the effect, it was determined that the overall effect size of the science success level of 7E model was found to be 1.2 in national and international studies by Balta and Saraç (2016). When the Q values of this research were examined, it was determined that the difference between the effect sizes of these three models did not make a significant difference in science success levels of the students. In other

words, it was found that in the case of giving a content related to the sciences, it is not a matter whether which of these three models are used and it is also found that all three models have similar effect levels. When the range values of effect sizes are compared, it can be said that the most heterogeneous studies belong to 7E and the most homogeneous studies belong to 5E model.

It was found that dissertations have a higher effect size than both the journal papers and master' theses, depending on the effect sizes of the works. In addition, it was found that the effect sizes of papers and theses are close to each other. Besides, it was found that the effect size of dissertations gave more heterogeneous results compared to the theses and papers. This can be due to the fact that the number of dependent variables handled in dissertations is higher than in other types of studies. In addition, the high effect of studies on doctoral level LC models may be due to the fact that researchers have better control over the process. In the study conducted by Saraç (2017) on the meta-analysis of the 5E model, it was seen that the effect size of dissertations was slightly greater than that of master' theses.

The results obtained for the other moderator variables addressed in the research are as follows: The subject with the highest effect level of the LC models is physics, and the subject with the lowest is chemistry. Unlike the results of this research, Saraç (2017) suggested that the highest effect size in the subject fields of the 5E model is biology and the lowest effect size is in the field of chemistry.

According to education levels, the effect sizes of studies done at primary school level were higher than the other education levels. It was found that the lowest effect value emerged at the university level. Similarly, Saraç (2017) also proved that 5E model is more effective at the primary school level; while it is less effective at the university level as the decrease in the number of studies may alter the data (Privitera, 2012).

It was determined that the lowest effect value according to the effect sizes of the working periods belongs to the studies carried out for three to five weeks, and the highest effect value belongs to the studies for 6-8 weeks. From these results, it can be said that the change between the length of the experimental period and the effect size values is not directly proportional. However, according to Hsieh, Acee, Chung, Hsieh, Kim *et al.* (2005), an increase in the duration of the application in an experimental study contributes to an increase in the effect level of the study. It can be said that the opinions of the authors are partly confirmed as the works of which the duration is not specified are not taken into account.

It was pointed out that the increase in the sample size in the studies examined and the effect size values of the LC models tend to increase. Particularly, the effect size of the participants with 101 or more participants was found to be significantly higher than in the smaller number of participants. Hedges (1994) noted that the increase in sample size is an important variable on effect size. In experimental studies, if the number of students does not increase as much as in the screening studies, it may stabilize the effect value and possibly decrease it after a certain point. It is thought that the effect of the number of students can be more clearly demonstrated by carrying out a larger experimental study.

When the effect sizes are examined according to years of the studies, it is seen that the studies between 2006 and 2010 have higher effect sizes. Another point that is noteworthy in the findings is the level of change in the effect size related to the studies in 2005 and before. In applications during these years, it is seen that the value of the effect size is larger than the others. Toraman and Demir (2016) stated that the constructivist approach's effect on attitude is higher than the value of the effect size in the studies after 2010. It can be said that this situation is caused by the fact that student-centered models entered our curricula after 2005 and that researchers did not have enough experience in this area.

Conclusions

The major contribution of this analysis is to combine 75 outcomes of the fields of science education about LC models. Also, this research aids in identifying different variables that need further attention in the literature on LC models in science education. The results demonstrate clear distinction between LC models and TC models on science success in science education. The results of the research show that LC models have a strong effect on the science success levels of students. The average effect, although slightly favoring LC models, was heterogeneous and should be interpreted cautiously. The results obtained from this study consist of significant information that can be used to increase the homogeneity levels of the effect sizes of LC models in the field of science education.

Although the findings of the study suggest that the 4E model has a greater impact on increasing success level in science education, they also indicate that the 5E model, which has a great deal of accumulation of knowledge

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

which is more experienced in Turkey, has clearer standards. Based on the standard error values, the error difference between the effect sizes which occur in the 5E model is smaller than that in other models. This situation makes the 5E model more preferable in the field of science education to a significant extent.

Another result of the study is that journal papers and master's theses display a smaller effect size than the dissertations do. In Turkey, the process of dissertations is examined by thesis monitoring committees, which consist of three scholars, for at least three times and evaluated by juries that consist of five scholars (YÖK, 2016). Journal papers are published according to blind reviewing process, whereas; master's theses are carried out under the control of an advisor and are only evaluated by a thesis defense jury for once. This allows for dissertations to be more controlled and for researchers to make changes throughout the process. Thereby, it becomes possible for the studies conducted to have a greater impact on the success level in the field of science.

According to the moderator of the study field, the reason why the greatest effect size is in the field of physics is because there are more studies carried out in this field. The researchers have planned their experimental studies in a better manner and controlled the process in a stricter way by examining the previous examples. This result also supports the finding that the decrease in the number of standard errors in a certain field of study is due to the increase in the number of studies in that certain field.

According to the education level, which is another moderator, it is observed that the LC model implementations in the elementary schools, where seven - the least number of studies were conducted, have a greater impact than the studies conducted at other education levels. Considering the fact that the range value of the effect size of the studies carried out in the elementary schools is the highest one, this situation needs to be examined individually. According to the duration moderator, it is observed that the studies, which take about 6-8 weeks, have a greater impact than the studies carried out for a longer or shorter period of time. It is believed that this situation results from usually planning the studies in the duration of a unit. The reason why short-duration studies have a smaller effect size may be because the students need a certain amount of time in order to adapt to a new implementation.

According to the moderator of number of students, the studies with the greatest effect size are those whose student number is higher than 101. This result suggests that the increase in the number of samples in experimental studies positively affects the effect size. Even though effect size analyses are used to eliminate the problems resulting from the number of samples, the results of this meta-analysis indicate the significance of these variables.

Also, the results of this research demonstrate that the LC models are more effective than widely used in science education in Turkey. The most important conclusion resulting from the analysis of this research seems to be the positive effect of LC models on science success, if the quality of the research is categorized as simple size, period of research, subject etc. Educators use LC models throughout many other parts of the world. This combination of theory and practice makes LC models one of the most distinguished of all educational practices. This meta-analysis study first supplied similar results about the general effect of LC models on science success. Then this meta-analysis went further by analyzing potential moderators of the main effects.

Recommendations

Meta-analyses studies are useful tools for characterizing the evidence base for educational practices objectively, but they have some limitations. Also, the fact that meta-analysis cannot be conducted due to some experimental risks such as controlling sample sizes, missing value, and outlier data. Small samples lead to the sensitivity of data analysis. Additionally, it is impossible for any meta-analysis to evaluate (and code) the quality of experimental design (intervention of LC models in this research) used in studies.

When the results of the research are examined, it can be claimed that the effect of the experimental studies carried out with the LC models, over the 6-8-week time period, will contribute to the increase in the effectiveness of the results. For this reason, it is suggested that researchers should not keep the experimental period of study very short. Considering that the most effective models for increasing science success are 4E, 5E, and 7E respectively, it can be argued that the application of models with fewer steps would be beneficial for researchers compared to the less effective multi-grade models. It can be stated that these models give more effective results in large student groups than small groups. It can be said that this situation is due to the increase in interaction and sharing between the students. LC models give more effective results in physics subjects than biology and chemistry. It also helps give explanations to why the studies at high school level are higher than other levels.

There are a lot of studies that examine the effects of LC models on the science success aimed at the science teaching. These studies need to consider the variable not mentioned in the research and in terms of variables that

are not discussed in the research and the effect sizes should be examined with new criteria. Dependent variables of LC models outside of science success in this research such as motivation, self-efficacy, scientific process skills, problem solving can also be examined in the research. The studies analyzed in this research include the research carried out in Turkey. It may be possible to increase the global validity level of the research by including in international studies.

It has been pointed out that some of the studies examined during the data collection process for this research have missing or inadequate information. Considering the positivist nature of the sciences, the variables and the process must be well monitored in such studies and also the data must be presented completely. Such incomplete and incorrect data lead to the loss of the validity of the studies. For this reason, researchers must fulfill the requirements of experimental studies and they must be careful with their design and presentation of their findings. More studies that take into account the specific characteristics of LC models are needed. Because, the results of this meta-analysis clearly show that there is a need for research on this topic in science education settings.

Acknowledgements

A limited part of this research was presented at the X. European Conference on Social and Behavioral Science, 19-22 May 2016, Sarajevo.

References

Abraham, M. R. (2005). Inquiry and the learning cycle approach. N. J. Pienta, M. M. Cooper, & T. J. Greenbowe (Eds.), *Chemists' guide to effective teaching* (pp. 41-52), New Jersey. Upper Saddle River Pearson Prentice Hall, 2005.

Açıkel, C. (2009). Meta-analysis and evidence-based place. *Bulletin of Psychiatry and Clinical Psychopharmacology, 19* (2), 164-172.

Akçil, M., & Karaağaoğlu, E. (2001). Meta-analysis of the envy. *Hacettepe Medical Journal, 32* (2), 184-190.

Ayas, A. (1994). Assessing two new approaches used in the development and implementation of science curriculum programs. *I. Educational Sciences Congress*, April 28-29, Cukurova University, Adana.

Aydın, N., & Yılmaz, A. (2010). The effect of constructivist approach in chemistry education on students' higher order cognitive skills. *Hacettepe University Journal of Education Faculty*, *39*, 57-68.

Balta, N., & Saraç, H. (2016). The effect of 7E learning cycle on learning in science teaching: A meta-analysis study. *European Journal of Educational Research, 5* (2), 61-72. http://dx.doi.org/10.12973/eu-jer.5.2.61

Bayram, H., Patlı, H., & Savcı, H. (1998). Learning ring model in science teaching. *Atatürk Education Journal of Educational Sciences, 10,* 31-40.

Bethel, E. C., & Bernard, R. M. (2010). Developments and trends in synthesizing diverse forms of evidence: Beyond comparisons between distance education and classroom instruction. *Distance Education, 31* (3), 231-256.

Borenstein, M., Hedges, L.V., Higgins, J.P.T., & Rothstein, H.R. (2009). *Introduction to meta-analysis.* United Kingdom: John Wiley and Sons, Ltd. Publication.

Bozdoğan, A. E., & Altunçekiç, A. (2007). Opinions of prospective science teachers about the availability of the 5E teaching model. *Kastamonu Education Journal, 15* (2), 579-590.

Bulut, H. (2012). Sexual reproduction and meiosis 7E model for the investigation of the effect of success. *Master's Thesis*, Atatürk University, Erzurum

Bybee, R. W. (2003). *Why the seven E's*. Retrieved 20 February 2010, from http://www.miamisci.org/ph/lpintro7e.html.

Carin, A., & Bass, J. (2005). *Teaching science as inquiry.* New Jersey: Pearson Prentice Hall.

Ceylan, E., & Geban, Ö. (2009). Facilitating conceptual change in understanding state of matter and solubility concepts by using 5E learning cycle model. *Hacettepe University Journal of Education Faculty*, *36*, 41-50.

Chen, J. H. (2008). Research of elementary school student's learning achievements with the implementation of 5E learning cycle based on nanotechnology curriculum. *Master's Thesis*, National Pingtung University of Education, Taiwan.

Cohen, J. (1988). *Statistical power analysis for the behavioural sciences*. New York: Academic Press.

Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education* (6th Ed.). *New York: Routledge.*

Cooper, H., & Hedges, L. (1994). Research synthesis as a scientific enterprise. In H. Cooper & L. V. Hedges (Eds.), *the handbook of research synthesis* (pp. 3-14). New York: Russell Sage.

Eisenkraft, A. (2003). Expanding the 5E model: A proposed 7E model emphasizes "transfer of learning and the importance of eliciting prior understanding. *The Science Teacher, 70* (6), 56–59.

Ellis, P. (2010). *The essentials of effect sizes*. New York: Cambridge University Press.

Felder, R. M., & Brent, R. (2005). Understanding student differences. *Journal of Engineering Education, 94* (1), 57-72.

Feyzioğlu, E. Y., & Ergin, Ö. (2012). The effect of 5E learning model instruction on seventh grade students' metacognitive process. *Turkish Journal of Science Education, 9* (3), 78-86.

Gök, G. (2014). The effect of 7E learning cycle instruction on 6th grade students' conceptual understanding of human body systems, self-regulation, scientific epistemological beliefs, and science process skills. *Dissertation*, Middle East Technical University, Ankara, Turkey.

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Hedges, L. V. (1994). Statistical considerations. In H. Cooper & L. V. Hedges (Eds.), *the handbook of research synthesis* (pp. 29-39). New York: Russell Sage Foundation.

Higgins, J. P., Tompson, S. G., Deeks, J. J., & Altman, D. G. (2003). Measuring inconsistency in meta-analyses. *British Medical Journal, 2*, 557-560.

Hsieh, P., Acee, T., Chung, W. H., Hsieh, Y. P., Kim, H., Thomas, G. D., ... & Robinson, D. H. (2005). Is educational intervention research on the decline? *Journal of Educational Psychology, 97* (4), 523-529.

Hunter, J. E., & Schmidt, F. L. (2004). *Methods of meta-analysis: Correcting error and bias in research findings* (2nd Ed.). California: Sage Publication.

Jupp, V. (2006*). The Sage dictionary of social research methods*. London: Sage Publication.

Kabapınar, F. M., Sapmaz, N. A., & Bıkmaz, F. H. (2003). *Active learning and teacher methods, teaching science.* Ankara University Educational Sciences Faculty Education Research and Application Center (EAUM) Publications.

Kunduz, N., & Seçken, N. (2013). Development and application of 7E learning model based computer-assisted teaching materials on precipitation titrations. *Journal of Baltic Science Education, 12* (6), 784-792.

Linn, R. L., & Miller, D. M. (2005). *Measurement and assessment in teaching* (9th Ed.). Saddle River, NJ: Prentice Hall.

Marek, E. A., & Cavallo, A. M. L. (1997). *The learning cycle: Elementary school science and beyond.* Portsmouth, NH: Heinemann.

Mecit, Ö. (2006). The effect of 7E learning cycle model on the improvement of fifth grade students' critical thinking skills. *Dissertation,* Middle East Technical University, Ankara.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. Thousand Oaks, California: Sage Publication.

Moussiaux, S. J., & Norman, J. T. (2003). *Constructivist teaching practices: Perceptions of teachers and students.* Retrieved from www. ed.psu.edu, 11.07.2017.

Newby, D. E. (2004). *Using inquiry to connect young learners to science, national charter schools institute.* Retrieved 20 April 2008, from http://www.nationalcharterschools.org/uploads/p df/resource_20040617125804_ Using%20Inquiry.pdf.

Özmen, H., (2002). Developing and implementing guide materials for chemistry teachers for the chemical reaction unit. *Dissertation*, Karadeniz Teknik University, Trabzon.

Özsevgeç, T., Çepni, S., & Bayri, N. (2007). The effectiveness of the 5E model on retentive conceptual learning. *Edu7, 2* (4), 1-17.

Petitti, D. B. (2000). *Meta-analysis, decision analysis, and cost-effectiveness analysis* (2nd Ed.). New York: Oxford University Press.

Privitera, G. J. (2012). *Statistics for the behavioral sciences*. California: Sage Publications, Inc.

Riding, R., & Rayner, S. (2012). *Cognitive styles and learning strategies: Understanding style differences in learning and behavior.* New York: Routledge.

Sağlam, M. (2006). An investigation of guide material development and its effectiveness according to 5E model for the sound and light unit. *Dissertation*, KTÜ, Trabzon.

Saraç, H. (2017). The effect of 5E learning model usage on students' learning outcomes: Meta-analysis study. *The Journal of Limitless Education and Research, 2* (2), 16-49.

Schroeder, C. M., Scott, T. P., Tolson, H., Huang, T. Y., & Lee, Y. H. (2007). A meta-analysis of national research: Effects of teaching strategies on student achievement in science in the United States. *Journal of Research in Science Teaching, 44* (10), 1436-1460.

Smith, M. L., & Glass, G. V. (1977). Meta-analysis of psychotherapy outcome studies. *American Psychologist, 32*(9), 752-760.

Schunk, D. H. (2013). *Learning theories: An educational perspective* (6th Ed). Boston: Pearson Education.

Schulze, R. (2004). *Meta-analysis a comparison of approaches*. Göttingen: Hogrefe and Huber Publishers

Tinker, I. (1997). *Street foods: Urban food and employment in developing countries.* Oxford University Press.

Toraman, C., & Demir, E. (2016). The effect of constructivism on attitudes towards lessons: A meta-analysis study. *Eurasian Journal of Educational Research, 62,* 115-142. http://dx.doi.org/10.14689/ejer.2016.62.8

Ural, G., & Bümen, N. (2016). A meta-analysis on instructional applications of constructivism in science and technology teaching: A sample of Turkey. *Education and Science, 41* (185), 51-82. http://dx.doi.org/10.15390/EB.2016.4289

Üstün, U., & Eryılmaz, A. (2014). A research methodology to conduct effective research syntheses: Meta-analysis. *Education and Science, 39* (174), 1-32. http://dx.doi.org/100.15390/EB.2014.3379.

Yaman, S., & Karamustafaoğlu, S. (2006). Investigation of logical thinking skills and attitudes scale towards chemistry of prospective teachers. *Journal of Education Faculty*, *8* (1), 91-106.

Yıldırım, A., & Şimşek, H. (2011). *Qualitative research methods in the social sciences*. Ankara: Seçkin Publishing.

YÖK (Yüksek Öğretim Kurulu-Council of Higher Education). (2016). *Post-graduate education and training regulations.* Retrieved 05 January 2017, from http://www.yok.gov.tr/documents/18755141/21995093/10_lisansustu_egitim_ve_ogretim_y%C3%B6netmeligi.pdf.

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Appendix1: Studies Investigated in Meta-analysis

Açışlı, S. (2010). The examination of the influence of the materials generated in compliance with 5E learning model on physics laboratory applications. *Dissertations*, Atatürk University, Erzurum.

Açışlı, S. (2014). General physics laboratory applications in the materials developed by the 5E learning model to examine the effects on students' academic achievement and the science process skills. *Ondokuz Mayıs University Journal of Education Faculty, 33* (2), 628-641.

Ağgül Yalçın, F., & Bayrakçeken, S. (2010). The effect of 5E learning model on pre-service science teachers' achievement of acids-bases subject. *International Online Journal of Educational Sciences, 2* (2), 508-531.

Aksoy, G., & Gürbüz, F. (2013). An Example for the effect of 5E model on the academic achievement of students: In the unit of "force and motion. *İnonu University Journal of Education Faculty, 14* (2), 1-16.

Aktaş, M. (2013). The effect of the 5E learning model and cooperative learning method on attitude toward biology lesson. *Gazi University Journal of Education Faculty, 33*(1), 109-128.

Altınay, Ö. (2009). The effects of the teaching method based on the 5e model on eighth grade students' understanding of the concepts of related to genetics, DNA, gene, and chromosome. *Master' Thesis,* Balıkesir University, Balıkesir.

Andaç, K. (2007). The effect of 5E model of constructivist learning approach supported by reviewing strategy on student's achievement, the permanence of knowledge and attitude in pressure issue. *Master' Thesis,* Dicle University, Diyarbakır.

Arslan, H.Ö. (2014). The effect of 5E learning cycle instruction on 10th grade students' understanding of cell division and reproduction concepts, *Dissertation*, Gazi University, Ankara.

Avcıoğlu, O. (2008). Investigation of the effects of 7E model on success, in the subject of Newton laws of second grade high school students' physics classes. *Master' Thesis,* Gazi University, Ankara.

Aydemir, N. (2012). Effectiveness of 5E learning cycle model on high school students understanding of solubility equilibrium concept. *Dissertation*, Middle East Technical University, Ankara.

Aydin, N. (2009). The effect of constructivist approach on students' higher order cognitive skills. *Master' Thesis*, Hacettepe University, Ankara.

Aydoğmuş, E. (2008). The effects of 5E model on success of the students during the instruction of work-energy chapter at physics course of tenth grade. *Master' Thesis,* Selçuk University, Konya.

Ayvacı, H. Ş., & Yıldız, M. (2013). The evaluation of the effectiveness of the teaching process conducted through a laboratory material designed in accordance with 5E model: The refraction of light. *Journal of Bayburt Education Faculty, 8* (1), 1-20.

Bal, E. (2012). The effect of 5E Model based laboratory approach on the attitudes and successes of prospective science teachers in physics laboratory course. *Master' Thesis*, Kastamonu University, Kastamonu.

Balcı, A. S. (2007). Effect of applying constructivism in science teaching. *Dissertation*, Selçuk University, Konya.

Bilgin, İ., Yusuf, A. Y., & Coşkun, H. (2013). The effects of 5E model on the 4th grade Students' success about substance and their opinions on the model. *Kastamonu Education Journal, 21* (4), 1449-1470.

Bıyıklı, C. (2013). The effect of 5E learning model designed according to learning experiences on the science process skills, level of learning and attitude. *Dissertation*, Hacettepe University, Ankara.

Bıyıklı, C., & Yağcı, E. (2015). The effect of learning experiences designed according to 5E learning model on level of learning and attitude. *Abant Izzet Baysal University Journal of Faculty of Education, 15*(1), 302-325.

Ceylan, E. (2008). Effects of 5E learning cycle model on understanding of state of matter and solubility concepts. *Dissertation*, Middle East Technical University, Ankara, Turkey.

Coşkun, H. (2011). The effect of 5E learning model on achievement, attitude, critical thinking and intellectual structure of 4th grade students in the "let's learn about substance" unit. *Master' Thesis*, Mustafa Kemal University, Hatay.

Çekiç Toroslu, S. (2011). Effect of 7E learning model integrated with real-life context based instruction on students' conceptual achievement, misconceptions and science process skills about 'energy'. *Dissertation*, Gazi University Ankara.

Çekilmez, S. (2014). The effect of 7E model on success and attitude of the students during the instruction of electric chapter at physics course of second level of high school. *Master' Thesis,* Necmettin Erbakan University, Konya.

Çepni, S., & Çoruhlu, T. Ş. (2014). Investigation the effects of learning environment enriched with 5E model on students' achievement. *Uludağ University Journal of the Education Faculty, 27*(2), 349-369. http://dx.doi.org/10.19171/uuefd.45874

Demirci, N. (2015). The effect of metacognitive inquiry based learning on 4th grade students' academic achievement, scientific process skills, and metacognitive processes in science course. *Master' Thesis*, Adnan Menderes University, Aydın.

Demirezen, S. (2010). The effect of 7E model to student's achievement, development of scientific process skills, conceptual achievement and retention levels in electrical circuit's subject. *Dissertation*, Gazi University, Ankara.

Demirezen, S., & Yağbasan, R. (2013). The effect of 7E model on misconceptions about simple electrical circuits. *Hacettepe University Journal of Education Faculty*, *28*(2), 132-151.

Dindar, A. Ç. (2012). The effect of 5E learning cycle model on eleventh grade students' conceptual understanding of acids and bases concepts and motivation to learn chemistry. *Dissertation*, Gazi University, Ankara.

Ekici, F. (2007). The effect of instructional material designed according to 5E learning cycle which is based on constructivist approach on 11th grade students' understanding of redox reactions and electrochemistry. *Dissertation*, Gazi University, Ankara.

Ercan, S. (2009). The effect of constructivist approach 5E learning model on teaching material cycle. *Master' Thesis*, Gazi University, Ankara.

Erdoğdu, S. (2011). The effect of teaching electricity subjects according to 5E model on students' success and attitudes. *Dissertation*, Selçuk University, Konya.

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Ergin, İ. (2009). The effect of the 5E model on the academic achievement and recall of students: An example of a slanting motion. *Mehmet Akif Ersoy University Journal of Education, 18,* 11-26.

Ergin, İ., Ünsal, Y., & Tan, M. (2006). The effect of 5E model on students' academic achievement and attitude levels: Horizontal shot motion example. *Ahi Evran University Education of Journal, 7*(2), 1-15.

Ersoy, İ. (2011). Handling of the topic of electrical and magnetism, 5E deepening stage model for evaluation of effects on student achievement of the materials developed. *Dissertation*, Selçuk University, Konya.

Ersoy, İ., Sarikoç, A., & Cerit Berber, N. (2013). Effectiveness of materials prepared on electric magnetism subject considering elaboration stage of 5E model. *Buca Education Faculty Journal, 35*, 144-154.

Ezberci, E. (2014). The effect of 5E learning cycle model supported with teaching activities that activate metaconceptual processes on 7th grade students' conceptual understanding of moon phases. *Master's Thesis,* Gazi University, Ankara.

Gönen, S., & Andaç, K. (2009). The influence of the constructivist learning approach supported by the review strategy on the students' access to the pressure and the permanence of their knowledge. *Dicle University Ziya Gökalp Education journal, 12*, 28-40.

Gül, S. (2011). The effect of course software based on 5E model on students' achievements, attitudes and remedy of misconceptions. *Dissertation*. Atatürk University, Erzurum.

Gürbüz, F. (2012). The effect 7E model on academic achievement and retention of knowledge in the unit of "electricity in our life" in 6th grade science and technology. *Master' Thesis,* Atatürk University, Erzurum.

Hırça, N. (2008). An investigation of effects on conceptual change of developed materials based on 5E model in unit "work, power and energy". *Dissertation*, Atatürk University, Erzurum.

Huyugüzel Çavaş, P. (2004). Teaching the unit 'electricity which directs our life' in the science lessons of primary school within the approach of learning cycle. *Dissertation*, Ege University, İzmir.

İstanbuloğlu, B. (2014). The effects of students' success of computer based 5E learning cycle model. *Master's Thesis,* Kırıkkale University, Kırıkkale.

Kanlı, U. (2007). The effects of a laboratory based on the 7E model with verification laboratory approach on students' development of science process skills and conceptual achievement. *Dissertation*, Gazi University, Ankara.

Kaynar, D. (2005). The effect of 5E learning cycle approach on sixth grade students understanding of cell concept, attitude toward science and scientific epistemological beliefs. *Master's Thesis*, Middle East Technical University, Ankara.

Kaynar, D., Tekkaya, C., & Çakiroğlu, J. (2009). Effectiveness of 5E learning cycle instruction on students' achievement in cell concept and scientific epistemological beliefs. *Hacettepe University Journal of Education Faculty*, *37,* 96-105.

Keskin, V. (2008). Effectiveness of constructivist 5E learning cycle model on high school students' learning of simple pendulum concepts and attitudes. *Master' Thesis*, Marmara University, Istanbul.

Kolomuç, A. (2009). Animation aidet instruction on "rate of chemical reactions" unit in grade 11 in regard to 5E model. *Dissertation*, Atatürk University, Erzurum.

Köseoğlu, F., & Tümay, H. (2010). The effects of learning cycle method in general chemistry laboratory on students' conceptual change, attitude and perception. *Ahi Evran University Journal of Kırşehir Education Faculty, 11* (1), 279-295.

Kunduz, N. (2013). The effect of teaching with animations and educational games on academic achievement in subject of precipitation titration. *Master's Thesis,* Hacettepe University, Ankara.

Küçük, Z. (2011). Effect of enriched 5E model on grade 7 students' conceptual change: A case for electric current. *Master's Thesis*, Karadeniz Teknik University, Trabzon.

Meşeci, B., & Karamustafaoğlu, S. (2015). The effect of the activities supported by 4E model which is aimed at granular nature of matter on academic success. *Karaelmas Journal of Educational Sciences, 3* (1) 1-12.

Meydan, A. M. (2015). The effect of the 7E learning method implemented in the subject of the structure of atom on the academic achievement and attitude of students. *Master' Thesis,* İbrahim Çeçen University, Ağrı.

Nas, S. E., Çepni, S., Yıldırım, N., & Şenel, T. (2007). Effect of worksheets on student achievement: Acid base sample. *Yeditepe University Journal of Education Faculty, 2,* 1-17.

Önder, E. (2011). The effect of constructivist 5E learning strategy used in the unit 'reproduction, growth and development in living beings' in science and technology course on the success of 6th grade students. *Dissertation*, Selçuk University, Konya.

Özbayrak, Ö. (2013). Misconceptions in chemistry education: Compounds. *Dissertation*, Dokuz Eylül University, İzmir.

Özsevgeç, T. (2007). Determining effectiveness of guided materials about force and motion unit based on the 5E model for elementary students. *Dissertation*, Karadeniz Teknik University, Trabzon.

Öztürk, N. (2013). The effect of activities based on 5E learning model in the unit titled light and sound at the sixth-grade science and technology lesson on learning outcomes. *Dissertation*, Gazi University, Ankara.

Pabuçcu, A. (2008). Improving 11th grade students' understanding of acid-base concepts by using 5E learning cycle model. *Dissertation*, Gazi University, Ankara.

Saka, A. (2006*).* The effect of 5E model on removing science student teachers' misconceptions about genetics. *Dissertation*, Karadeniz Teknik University, Trabzon.

Saygın, Ö., Atılboz, N. G., & Salman, S. (2006). Effects of constructivist approach on the success of the teaching the biology: The basic unit of viability cell. *Journal of Gazi Education Faculty, 26*(1), 51-64.

Saraç, H. (2015). The Effect of multimedia supported applications designed according to 7E model on students' learning products at fi fth grade sci ence course 'changi ng states of matter' uni t. *Dissertation*, Dumlupınar University, Kütahya.

Temiz, B. (2010). The effect of 5E model supported with case study on 6th grade students' academic success in the unit 'the systems of body structures' and attitude towards science. *Master' Thesis*, Gazi University, Ankara.

Toprak, F. (2011). The effects of 3E and 5E teaching models practiced in general chemistry laboratory of science education on students' academic success scientific process skills and their attitude to the course. *Master' Thesis,* Ondokuz Mayıs University, Samsun.

Ural Keleş, P. (2009). Determining effectiveness of guided materials based on the 5E model enriched with conceptual change texts, games and drama students: A sample of classification of living things. *Dissertation*, Karadeniz Teknik University, Trabzon.

Ültay, N. (2012). Designing, implementing and comparing 'acids and bases' instructional tasks based on REACT strategy and 5E model. *Dissertation*, Karadeniz Teknik University, Trabzon.

Yalçın, E. (2010). The effect of 'the teaching method of 5E on the life of 8th class students on understanding the electric subject and attitudes to science. *Master' Thesis*, Sakarya University, Sakarya.

Yazman, İ. (2013). The effect of Jigsaw technique which is a cooperative learning method and 5E model to the academic achievements and permanency on the let's get to know coils with working and energy subject of grade seventh students who educate science and technology course. *Master' Thesis*, Kafkas University, Kars.

Yerdelen-Damar, S. (2013). The effect of the instruction based on the epistemologically and metacognitively improved 7E learning cycle on tenth grade students' achievement and epistemological understandings in physics. *Dissertation*, Kastamonu University, Kastamonu.

Yıldız, E. (2008). The effects of metacognition during the instruction based on conceptual change used with 5E model: An application regarding the force and motion subject in the 7th grade. *Dissertation*, Dokuz Eylül University, Izmir.

Yenice, E. (2014). Researching the effect of 7E learning model of constructivist approach on students' academic success on the topic of 'mitosis and meiosis division" at 8th grade science and technology class. *Master' Thesis*, Kafkas University, Kars.

Yılmaz, H., & Huyugüzel, Çavaş, P. (2006). Method of 4E learning cycle student's electricity understanding the effect of the subject. *Journal of Turkish Science Education, 3* (1), 2-18.

Yörük, Z. N. (2008). Effects of science, technology, society and environment (STSE) approach teaching chemistry with using the 5E learning model. *Master's Thesis,* Hacettepe University, Ankara.

Yurt, Y. (2012). Effect of model 5E on 6th grade elementary students' achievement and attitude in science and technology course. *Master's Thesis*, Mehmet Akif University, Burdur.

Ziyafet, E. (2008). The effect of 5e methods on student achievement and attitude for teaching periodic table in science lesson. *Master's Thesis*, Gazi University, Ankara.

Appendix2: List of included studies, codes applied, and effect sizes

Study	Model		Level	Subject field	Period	N		Effect size
	Treatment	Control				Treatment	Control	
Açışlı (2010)	5E	TC	U	P	6-8 week	41	41	2.30
Açışlı (2014)	5E	TC	U	P	6-8 week	30	30	1.29
Ağgül Yalçın et al. (2010)	5E	TC	U	C	3-5 week	20	23	1.28
Aksoy & Gürbüz (2013)	5E	TC	M	P	3-5 week	27	30	1.10
Aktaş (2013)	5E	TC	U	B	6-8 week	32	30	2.31
Altınay (2009)	5E	TC	M	B	3-5 week	42	42	1.84
Andaç (2007)	5E	TC	M	P	6-8 week	37	40	0.80
Arslan (2014)	5E	TC	H	B	3-5 Week	114	114	0.08
Avcıoğlu (2008)	5E	TC	H	P	3-5 week	18	18	-0.16
Aydemir (2012)	5E	TC	H	C	6-8 week	53	56	1.37
Aydin (2009)	5E	TC	M	C	9 + week	150	150	2.02
Aydoğmuş (2008)	5E	TC	H	P	3-5 week	35	35	1.35
Ayvacı et al. (2013)	5E	TC	U	P	Unspecified	48	50	0.79
Bal (2012)	5E	TC	U	P	6-8 week	30	30	1.45
Balcı (2007)	4E	TC	M	B	6-8 week	31	31	0.95
Bilgin, et al. (2013)	5E	TC	P	C	Unspecified	79	81	0.79
Bıyıklı (2013)	5E	TC	P	S	9+ week	30	30	2.84
Bıyıklı et al. (2015)	5E	TC	P	S	9+ week	30	30	2.84

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Study	Model		Level	Subject field	Period	N		Effect size
	Treatment	Control				Treatment	Control	
Bulut (2012)	7E	TC	H	B	3-5 Week	58	55	0.78
Coşkun (2011)	5E	TC	P	C	9+ week	79	81	0.77
Ceylan (2008)	5E	TC	H	C	6-8 week	59	60	2.65
Çekiç Toroslu (2011)	7E	TC	H	P	9+ week	50	45	0.64
Çekilmez (2014)	7E	TC	H	P	6-8 week	34	33	1.10
Çepni et al. (2014)	5E	TC	M	P	Unspecified	35	37	1.01
Demirci (2015)	5E	TC	P	S	3-5 Week	35	35	0.98
Demirezen (2010)	7E	TC	H	P	6-8 week	29	29	0.61
Demirezen et al. (2013)	7E	TC	H	P	6-8 week	29	29	-2.45
Dindar (2012)	5E	TC	H	C	6-8 week	40	38	1.08
Ekici (2007)	5E	TC	H	C	6-8 week	24	25	0.92
Ercan (2009)	5E	TC	H	B	3-5 Week	27	23	1.09
Erdoğdu (2011)	5E	TC	H	P	3-5 Week	29	33	1.80
Ergin (2009)	5E	TC	H	P	3-5 Week	44	40	2.16
Ergin et al. (2006)	5E	TC	H	P	Unspecified	44	40	1.61
Ersoy (2011)	5E	TC	M	P	9+ week	20	20	0.60
Ersoy et al. (2013)	5E	TC	M	P	Unspecified	20	20	0.87
Ezberci (2014)	5E	TC	M	P	3-5 Week	27	26	0.16
Gönen et al. (2009)	5E	TC	M	P	Unspecified	37	40	0.80
Gül (2011)	5E	TC	H	B	6-8 Week	20	21	1.52
Gürbüz (2012)	7E	TC	M	P	3-5 week	24	21	3.95
Hırça (2008)	5E	TC	H	P	6-8 week	21	21	1.07
Huyugüzel Çavaş (2004)	4E	TC	M	P	3-5 week	40	39	1.73
İstanbuloğlu (2014)	5E	TC	M	P	3-5 week	30	26	0.79
Kanlı (2007)	7E	TC	U	P	6-8 week	43	38	0.35
Kaynar (2007)	5E	TC	M	B	3-5 week	80	80	0.93
Kaynar et al. (2009)	5E	TC	M	B	3-5 week	77	76	0.90
Keskin (2008)	7E	TC	H	P	6-8 week	31	32	2.20
Kolomuç (2009)	5E	TC	H	C	6-8 week	36	36	3.66
Köseoğlu et al. (2010)	4E	TC	U	C	Unspecified	20	20	1.81
Kunduz (2013)	7E	TC	H	C	Unspecified	44	45	0.58
Küçük (2011)	5E	TC	M	P	3-5 week	23	23	1.46
Meşeci et al. (2015)	4E	TC	M	C	Unspecified	25	23	0.59
Meydan (2015)	7E	TC	M	C	6-8 week	13	13	0.30
Nas et al. (2007)	5E	TC	M	C	Unspecified	26	24	1.38
Önder (2011)	5E	TC	M	B	9+ week	22	22	0.90
Özbayrak (2013)	5E	TC	H	C	Unspecified	30	30	0.73
Özsevgeç (2007)	5E	TC	P	P	3-5 week	37	31	1.86
Öztürk (2013)	5E	TC	M	P	6-8 week	25	17	1.52
Pabuçcu (2008)	5E	TC	H	C	6-8 week	42	39	1.67
Saka (2006)	5E	TC	U	B	3-5 week	22	22	0.61

Study	Model		Level	Subject field	Period	N		Effect size
	Treatment	Control				Treatment	Control	
Saygın et al. (2006)	5E	TC	U	B	6-8 week	24	23	1.19
Saraç (2015)	7E	TC	P	C	9+ week	48	50	0.79
Temiz (2010)	5E	TC	M	B	6-8 week	20	20	0.28
Toprak (2011)	5E	TC	U	C	9+ week	20	30	1.55
Ural Keleş (2009)	5E	TC	P	B	6-8 week	26	29	0.56
Ültay (2012)	5E	TC	U	C	3-5 week	32	33	0.86
Yalçın (2010)	5E	TC	M	P	3-5 week	35	35	1.24
Yazman (2013)	5E	TC	M	P	3-5 week	24	31	-0.32
Yerdelen-Damar (2013)	7E	TC	H	C	3-5 week	52	51	1.77
Yıldız (2008)	5E	TC	M	P	Unspecified	25	27	-0.90
Yenice (2014)	7E	TC	M	B	3-5 week	32	32	1.97
Yılmaz et al. (2006)	4E	TC	M	P	Unspecified	40	39	1.73
Yörük (2008)	5E	TC	H	C	3-5 week	33	30	0.06
Yurt (2012)	5E	TC	M	P	6-8 week	64	64	3.68
Ziyafet (2008)	5E	TC	M	C	3-5 week	25	20	1.82

Model: TC-Teacher-centered models
Level: P-Primary; M-Middle; H-High; U- Undergraduate School
Subject field: B- Biology; C- Chemistry; P- Physics; S- Science

Received: *November 15, 2017* Accepted: *January 25, 2018*

Süleyman Yaman *(Corresponding author)*	PhD., Associate Professor, Ondokuz Mayıs University, Faculty of Education, Department of SSME, Science Education, Atakum, Samsun, Turkey. E-mail: syaman@omu.edu.tr Website: https://personel.omu.edu.tr/en/syaman
Şadiye Karaşah	Master' Student, Ondokuz Mayıs University, Faculty of Education, Department of SSME, Science Education, Atakum, Samsun, Turkey. E-mail: karasah08sados@gmail.com