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THE EFFECT OF 5E LEARNING CYCLE MODEL ON ACADEMIC ACHIEVEMENT IN ACID-BASE UNIT: A META-ANALYSIS STUDY

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Abstract

This study conducted a meta-analysis of studies examining the effect of the 5E learning cycle model on students' academic success in an acid-bases unit. For this purpose, national studies published between 2000-2022 were scanned from various databases (YÖK National Thesis Center, Google Scholar, Dergipark), and a meta-analysis of eight studies was made according to inclusion criteria. A comprehensive Meta-Analysis (CMA) statistical program was used for analysis. Hedges's g coefficient was used while calculating the effect sizes, and the confidence level was accepted as 95%. A funnel plot was drawn to determine the publication bias, and Rosenthal's N analysis was performed. Since the studies were conducted at different cities, samples, and class levels, the effect size was calculated according to the random effect model. According to the results, Hedges's g coefficient was 1.845, and the standard error was 0.393. From this point of view, it was concluded that the effect of the 5E learning cycle model on the academic success of the students in the acid-base unit was excellent, positive, and significant.

Keywords: 5E Learning Cycle Model, Acid-Base, Meta-Analysis, Effect Size.

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Introduction

In the late 1960s, cognitive theories began to take the place of behavioural approaches in education programs. In this process, researchers focused on how non-observable mental processes such as problem-solving skills, formation of concepts in the mind, and information processing take place instead of observed behaviours (Ertmer

& Newby, 1993). According to cognitive theory researchers, students process newly learned information in their minds by associating it with their old information. Accordingly, students' learning of new information is affected by their prior knowledge and methods of processing information (Açıkgöz, 2005). In addition, the researchers found new information: It also focuses on how it is imported, how it is processed, how it is stored, and how the stored information is retrieved. According to different studies, cognitive theory, in which mental activities come to the fore, and behavioural theory combine in an objectivist line (Vrasidas, 2000). Accordingly, both theories aim to provide students with objective and the same knowledge about the world. In addition, the constructivist approach argues that learning will not be in the form of knowledge transfer but in the form of interpretation and structuring of knowledge by students (Yurdakul, 2005). According to the constructivist theory, experiences and prior knowledge are essential in constructing knowledge. In addition, learning takes place based on context, and social interactions significantly affect learning and mental processes (Beothel & Dimock, 2000; Koç & Demirel, 2004). In science teaching based on constructivist theory, learning environments are created for students to understand scientific concepts and processes. In addition, instead of giving direct answers to students' questions, they are provided with the answers. In this way, while learning by rote is minimized, students' scientific process skills develop (Saygın et al., 2006).

Literature review

Many countries that want to raise students who are science literate and have advanced scientific process skills have made reforms that include the constructivist approach in their education programs (Liu, 2009). Over the years, Turkey, like many countries, revised its education program in 2005 according to the constructivist approach. Accordingly, it is aimed that students acquire achievements by doing and experiencing at their own learning pace (Dal & Köse, 2017). On the other hand, a process-oriented approach has come to the fore instead of the result-oriented approach, and how to teach has gained importance rather than what to teach (Ekici & Güven, 2020). It is aimed that the students take an active role in the planned teaching processes and that the information is structured in the student's minds (Canpolat et al., 2004). In line with this goal, new teaching models and techniques have been developed in which the student leaves the observer position and actively participates in the centre of learning. One of these models is the 5E learning cycle model. 5E learning cycle model; It is a model in which students reconstruct new information based on their own experiences and experiences in the learning process. This model; consists of steps: introduction, exploration, explanation, elaboration, and evaluation. The initial step is the step in which the level of prior knowledge of the students about the subject is determined, and the relationship between this information and the new subject is established (Şahin, 2010). Pre-knowledge in students can facilitate the acquisition of new learning outcomes and create an obstacle (Akkuş & Üner, 2015). For this reason,

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revealing students' prior knowledge is essential for efficient teaching. At this stage, the teacher poses questions that will attract students' attention and aims to reveal the students' prior knowledge. Also, according to different studies, if the students are confused by the questions asked and are willing to learn new things, the initial step has achieved its goal (Boddy et al.,2003). At the discovery stage, students are expected to form new ideas about the subject and hypotheses by doing experiments and interacting with each other (Kabapınar et al., 2003). This stage is the most comprehensive part of the learning model (Akkuş & Üner, 2015). In this process, the teacher is a guide and can ask guiding questions to the students when necessary (Değirmençay, 2010). In the explanation step, teachers ask questions to check that the students have acquired the subject-related acquisition (Akkuş & Üner, 2015). Students make statements about the results they have reached from their experiments or discussions (Wilder & Shuttleworth, 2004). In the deepening step, students use the information they have obtained in the previous steps in the face of new situations (Şahin, 2010). Teachers can make students able to use the newly learned information in their daily lives by giving them a problem situation (Koç, 2002). The evaluation step shows how much the students' knowledge levels and performances have changed at the end of the process (Akkuş & Üner, 2015). At this stage, the teacher can use alternative assessment methods such as concept maps, peer assessments, and portfolios (Ekici, 2007).

The 5E Learning cycle model is one of the models that can be explicitly used in science education (Magnusson et al., 1999; Lee et al., 2007; Aydin et al., 2013; Aydin et al., 2014; Gencer & Akkus, 2021). For this reason, a meta-analysis study on the 5E Learning cycle model was conducted in this study, as it was thought to provide a holistic view of the chemistry education studies related to this model. In addition, when the studies in the literature are examined, it is seen that the 5E learning cycle model positively affects the education process in the field of science and chemistry and is a model that can be applied in teaching many subjects. In these studies, it was determined that the 5E learning cycle positively affected students' chemistry course success, scientific thinking skills, mental modelling processes, learning chemistry concepts, STEM application processes, motivation, and attitudes toward chemistry courses (Campbell, 2006; Schlenker et al., 2007; Ceylan & Geban, 2009; Sadi & Cakiroglu, 2010; Bektas, 2011; Ajaja & Eravwoke, 2012; Qarareh, 2012; Supasorn & Promarak, 2014; Supasorn, 2015; Pabuccu & Geban, 2015).

Some of the studies on the 5E learning cycle model are related to student's academic success and misconceptions in chemistry topics. When the literature is examined, one of the topics in which chemistry misconceptions are identified is acid bases (Altınyüzük, 2008; Yalçın, 2011; Widarti., Permanasari & Mulyani, 2017; Supatmi et al., 2019; Pikoli, 2020; Şen & Nakiboğlu, 2021). Studies conducted in different countries and cities determined misconceptions about students of different sizes in the acid-base topic. In the literature, a positive effect on the teaching of the concepts in the acid-base topic (Akar, 2005; Pabuççu, 2008; Yalçın & Bayrakçeken,

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2010; Metin, 2011) of the 5E learning Cycle model has been determined. However, these studies were conducted in different cities and relatively small samples. However, combining the research results, that is, statistically combining the results of many studies on the same subject and with the same method, is essential in aiming to reach the expected results and reducing the limitations of individual studies. It is essential to demonstrate the effectiveness of the applied teaching model. In addition to determining the effectiveness of the teaching model, these results can be a source for educational planning based on the teaching model. Therefore, in this study, the results of studies examining the effect of the 5E learning cycle model, which positively affects chemistry education in many studies in the literature, on the academic success of students in acid-base were combined with meta-analysis, and the direction of this effect size was determined. In this direction, the effect of the 5E learning cycle model on the academic success of students in acid-base was revealed. Considering that the subjects included in chemistry are related to the events in daily life and that many events we encounter in daily life are acid-base reactions, it is understood that the subject of acids and bases is one of the main subjects in learning chemistry (Ayas & Özmen, 1998). In addition, misunderstandings about acids and bases form a basis for not understanding the following issues (Morgil et al., 2002; Özmen & Demircioğlu, 2003). For this reason, it can be said that learning the topic of acids and bases is essential for understanding chemistry and the following topics.

Materials and Research method

In this study, a meta-analysis of studies examining the effect of the 5E learning cycle model on students' academic achievement in acid-base was conducted. Meta-analysis is a type of statistical analysis used to examine different studies on similar subjects together and to reveal a synthesis from the findings of these studies (Fraenkel & Wallen, 2012). Meta-analysis provides a general solution to the problem that constitutes the research topic by eliminating the inconsistencies related to the results of multiple studies. In addition, meta-analysis brings studies together to obtain strong estimates of the effect sizes of these studies on large sample groups. In this way, it may be possible to interpret the effects of an intervention applied in different studies on a large scale (Balcı & Baydemir, 2015). For this purpose, studies published nationally and internationally between 2000-2022 were obtained from various databases (YÖK National Thesis) with Turkish and English keywords in the form of, "acid-base", "5E model", "5E learning model", "5E learning cycle model". National Thesis Center, Google Scholar, and Dergipark were scanned. As a result of this screening, 12 studies were reached and examining academic success: Studies using a quasi-experimental design, including sample size (n), standard deviation (sd), and arithmetic mean (X) values of the experimental and control groups, or containing data from which these values can be calculated, were determined as inclusion criteria. These criteria are the values required to calculate the effect size and studies that do not have these values

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were not included in the study. Eight studies for these criteria were included in the current study. The studies are in an experimental model examining the effects of independent variables (5E teaching cycle model) on dependent variables (student achievement). This model used a pre-test and post-test comparative group quasi-experimental design. In this design, the knowledge levels of the participants are measured before and after the research (Fraenkel et al., 2012). In addition, in this study, a detailed study form containing the studies' identity, characteristics, and statistical data was prepared, and the characteristics of the studies were presented in detail. Some of these characteristic features are; The sample numbers of the studies, the type of publication and the years they were published, the city where the study was conducted, the pre-test and post-test scores, and the deviation values of the experimental and control groups. Theses and articles included in the research; (Akar, 2005; Pabuççu, 2008; Yalcin & Akpınar, 2010; Yalçın & Bayrakçeken 2010; Metin, 2011; Dindar, 2012; Çağatay &, Demircioğlu 2014). The transaction efficiency method was used to analyze the data in the study. This method is preferred when calculating the difference between the experimental and control groups in separate studies and when different scales are used (Camnalbur & Erdoğan, 2008). Hedges "d" formula was used to calculate the effect size. The effect size is expressed as finding out how effective the application data examined in different studies are by combining them. The calculated value accordingly; Small in the range of 0.15-0.40, medium in the range of 0.40-0.75, large in the range of 0.75-1.10, extensive in the range of 1.10-1.45, excellent in the range of 1.45 and above effect is noted. In addition, if the effect size value is zero, there is no difference between the experimental and control groups; if the effect size value is negative, the situation is in favour of the control group; if the effect size value is positive, the situation is in favour of the experimental group (Cohen, 1992). Fixed effects and random effects models are used to combine effect sizes. The fixed effects model assumes that all the factors affecting the study's effect size are the same (Borenstein et al., 2013). In the random effects model, the effect size differs in each study due to the different number of participants and the combination of different studies (Borenstein et al., 2013). The random effects model was preferred in calculating effect size due to the different number of participants in the studies examined in this study and the use of different application and evaluation methods. The direction of the effect sizes is shown with the forest plot. The forest plot shows the effect size of each study included in the study and the effect size of all studies (Lewis & Clarke, 2001). A funnel plot was drawn to determine publication bias in the study. According to the funnel plot, the horizontal axis (x-axis) shows the effect size, and the vertical axis (y-axis) shows the standard error. Studies evenly distributed to the left and right of the symmetry axis show no publication bias (Rodriguez, 2001). In addition, "Rosenthal N" test was performed to determine publication bias. The Rosenthal N test indicates the number of studies that should be added to the meta-analysis for the result obtained from a meta-analysis study to become meaningless (Borenstein et al., 2013). The study data

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were analyzed with the Comprehensive Meta-Analysis (CMA) program, and the significance level was determined as .05.

Reulats

In this part of the study, information about the studies included in the meta-analysis is given in Table 1.

Table 1. *Descriptive Characteristics of Studies*

Study	Year of Study	Type	Sample		
			Sample Group	Sample Size	City of Study
Effectiveness of the 5E Learning Cycle Model on Students' Understanding of Acid-Base Concepts	2005	Master's Thesis	10th-grade students	56	Ankara
Improving 11th Grade Students' Understanding of Acid-Base Concepts by Using the 5E Learning Cycle Model	2008	Master's Thesis	11th-grade students	130	Balıkesir
The Effect of the 5E Learning Cycle Model on the Academic Achievements of Students with Different Learning Style in Teaching Acids-Bases	2010	Article	11th-grade students	94	Erzurum
The Effect of the 5E Learning Cycle Model on Pre-Service Science Teachers' Achievement of Acids-Bases Subject	2010	Article	Prospective Science Teachers	43	Bayburt
Effects of Teaching Material Based on 5E Learning Cycle Model Removed Pre-service Teachers' Misconceptions about Acids-Bases	2011	Article	Prospective Science Teachers	25	Artvin
The Effect of the 5E Learning Cycle Model on Eleventh Grade Students' Conceptual Understanding of Acids and Bases Concepts and Motivation to Learn Chemistry	2012	Master's Thesis	11th-grade students	78	Ankara
The effect of laboratory activities based on the 5E learning cycle model of the constructivist approach on 9th-	2014	Article	9th-grade students	52	Trabzon

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grade students' understanding of solution chemistry					

When Table 1 is examined, it is seen that the studies were published between 2005 and 2014, covering the 9th, 10th, and 11th grades at the high school level and science teacher candidates, with a total of 6 different cities and 538 participants. The effect sizes, p and z values, lower and upper limits, and heterogeneity values obtained by the analysis of the data obtained from these studies are shown in Table 2.

Table 2. Homogeneous Distribution Value, Average Effect Size, and Confidence Intervals of Studies Included in the Meta-Analysis

						%95 Confidence Interval					
	N	Effect Size	Z	P	Standard Error	Lower Limit	Upper Limit	df	Q	P	I^2
Fixed Effects	8	1.733	27.05	0.000	0.262	6.575	7.6	7	133.1	0.000	94.74
Random Effects	8	1.845	5.49	0.000	1.22	4.32	9.1				

When Table 2 is examined, the effect size was calculated as 1.733 according to the fixed effects model and 1.845 according to the random effects model. The random effects model was used since the studies included were conducted in different samples, cities, and levels. When the heterogeneity value was examined, the I2 value was 94.74. According to this value, it can be interpreted that there is a high level of heterogeneity. In addition, the random effect size value was calculated as 1.845. The distribution of the study's effect sizes according to the random effects model is shown in Table 3 in the forest plot.

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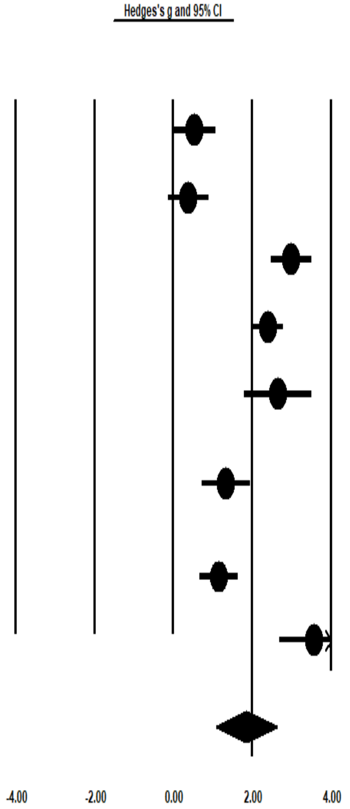
Table 3. Distribution of Studies Included in Meta-analysis by Random Effect Sizes.

Study name	Statistics for each study			Statistics for each study				Relative weight
	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	
Effectiveness of the 5E Learning Cycle Model on Students' Understanding of Acid-Base Concepts	0.531	0.268	0.072	0.005	1.057	1.979	0.048	12.73
The Effects Of the 5E Learning Cycle Model Based on Constructivist Theory on Tenth-Grade Students' Understanding Of Acid-Base Concepts	0.376	0.257	0.066	-0.128	0.881	1.464	0.143	12.79
Improving 11th Grade Students' Understanding of Acid-Base Concepts by Using the 5E Learning Cycle Model	2.986	0.256	0.066	2.483	3.488	11.649	0.000	12.80
The Effect of the 5E Learning Cycle Model on the Academic Achievements of Students with Different Learning Style in Teaching Acids-Bases	2.394	0.191	0.036	2.020	2.768	12.557	0.000	13.12
The Effect of the 5E Learning Cycle Model on Pre-Service Science Teachers' Achievement of Acids-Bases Subject	2.651	0.429	0.184	1.811	3.492	6.182	0.000	11.66
Effects of Teaching Material Based on 5E Learning Cycle Model Removed Preservice Teachers' Misconceptions about Acids-Bases	1.331	0.309	0.095	0.726	1.936	4.314	0.000	12.49
The Effect of the 5E Learning Cycle Model on Eleventh Grade Students' Conceptual Understanding of Acids and Bases Concepts and Motivation to Learn Chemistry	1.142	0.242	0.059	0.667	1.617	4.716	0.000	12.87
The effect of laboratory activities based on the 5E learning cycle model of the constructivist approach on 9th-grade students' understanding of solution chemistry	3.561	0.443	0.197	2.692	4.430	8.032	0.000	11.55
	1.845	0.393	0.155	1.075	2.616	4.693	0.000	



Distribution of Studies Included in Meta-analysis by Random Effect Sizes When Table 3 is examined, the effect sizes of the studies are positive. Accordingly, the effect of the 5E learning cycle model is in favour of the experimental group in all of the studies. To ensure the reliability of these results, the funnel plot shown in Table 4 was drawn to control the publication bias.

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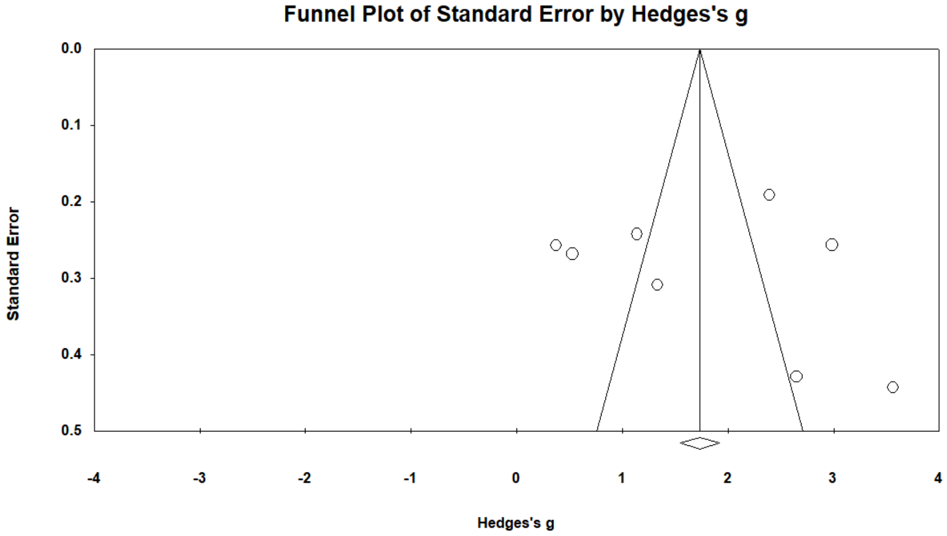
Table 4. Funnel Plot of Effect Sizes of Studies Included in the Research



When Table 4 is examined, it is seen that the effect sizes of the studies are evenly distributed to the right and left of the symmetry axis. In addition, the values of the error protection number (Rosenthal Fail-Safe N) calculated to determine the publication bias are shown in Table 5.

Table 5. Research Failure Protection Number (Rosenthal Fail-Safe- N) Values

Rosenthal fail-safe N	
Observed Z-value for the studies	17.99326
Observed P-value for the studies	0.00000
Alpha	0.05000
Direction	2.00000
Z-value for Alpha	1.95996
Number of observed studies	8.00000
Fail-Safe N	667.00000

When Table 5 is examined, it is seen that there should be 667 studies that will invalidate the results of this study examining the academic achievement of students in the 5E learning cycle model in acid-base.

Discussion

In this study, in which the effect of the 5E learning cycle model on academic achievement in the topic of acid-base was examined, the effect size values of eight studies (four master's theses and four articles) were calculated, and it was observed that

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all of the values were positive. Accordingly, the 5E learning cycle model used in the studies is more effective than the traditional model. In addition, since studies were conducted in different samples, cities, and levels, the average effect size was calculated according to the random effect model, which was found to be 1.845. This value means an excellent level of effect (Cohen, 1992). From this point of view, the 5E learning cycle model greatly affects students' academic achievement in acid-base. In addition, a funnel plot was drawn to determine the publication bias, and it was determined that the effect sizes were equally distributed to the right and left of the symmetry axis. In this case, it can be interpreted that there is no publication bias (Rodriguez; 2001). In addition, the Rosenthal N value was calculated, and it was concluded that 667 more studies should be reached for the results of the study to lose their meaning. The inability to reach a study in this number also supports the interpretation that there is no publication bias (Borenstein et al., 2009). This is consistent with the results obtained with the funnel plot. Based on these results, the 5E learning cycle model has a high and positive effect on academic achievement in the topic of acid-base. These results were included in the research (Kılavuz, 2005; Pabuçcu, 2008; Yalçın & Akpınar, 2010; Yalçın & Bayrakçeken, 2010; Metin, 2011; Dindar, 2012; Demircioğlu & Çağatay, 2014) and not (Seyhan & Morgil, 2007; Cahyarini, Rahayu & Yahmin, 2016; Singsathid, 2021) are consistent with studies. In addition, it can be said that these results are consistent with the studies in the literature that the 5E learning cycle model facilitates conceptual understanding (Akar, 2005; Ceylan, 2008; Bektaş, 2011). In addition, the research results are consistent with studies showing that the 5E learning cycle model eliminates students' misconceptions (Kör, 2006; Özsevgec et al., 2006). However, in different studies the effect of the 5E learning cycle model in teaching the topic of evolution was investigated (Garcia, 2005) It was determined that the 5E learning cycle model did not significantly affect conceptual success. Accordingly, it can be interpreted that the 5E learning cycle model may yield different results depending on the type of topic being researched. In addition, the results of the research are consistent with the results of the studies showing that the 5E learning cycle model increases the motivation of the students and the learning of the students participating in the 5E activities is positively affected (Pintrich, 2003; Güvercin et al., 2010). When the studies were examined, it was determined that in the 5E learning cycle model, students' desire and responsibilities for learning increased as they structured the knowledge themselves, thus increasing their success. (Demircioğlu et al, 2004).

Conclusion and Recommendations

In light of all these data, it can be said that the 5E learning cycle model positively affects the student's academic success on acid bases. From this point of view, it can be interpreted that educators will increase the student's success in this unit by arranging the lesson plans in the topic of acid-base according to the 5E learning cycle model. With the increase in the student's success, changes can be observed in their motivation and attitudes toward the course. In addition, considering the results of this study, different studies can be carried out in which the 5E learning cycle model will be used together with different techniques determined to be effective in the topic of acid bases.

In this study, the effect of the 5E learning cycle model on the academic achievement of students on acid bases was investigated. The meta-analysis can examine academic achievement, student attitude, and motivation of more studies conducted with the 5E learning cycle model on similar and different subjects. According to the results of the research, it can be suggested that the 5E learning cycle model, which is effective in teaching the topic of acid bases, is used by educators in chemistry lessons, as well as the preparation of supplementary course materials to be designed for the topic of acid bases by considering the steps of the 5E learning cycle model. In addition, the effect of the 7E learning cycle model, which has the same paradigm and is a more detailed and comprehensive learning cycle model, on academic achievement and student motivation can also be investigated.

References

Açıkgöz, K. Ü. (2005). Etkili Öğrenme ve Öğretme. İzmir: Eğitim Dünyası Yayınları.

Ajaja, O.P. & Eravwoke, U.O. (2012). Effects of 5E learning cycle on student’s achievement in biology and chemistry. Cypriot Journals of Educational Sciences, 7(3), 244-262.

Akar, E. (2005). Effectiveness of 5E learning cycle model on students' understanding of acid-base concepts. Master’s thesis, Middle East Technical University, Ankara, Turkey.

Akkuş, H & Üner, S. (2015). “Öğrenme Döngüsüne Dayalı Öğrenme Öğretme Yaklaşımı”, Etkinlik Örnekleriyle Güncel Öğrenme-Öğretme Yaklaşımları-II, (pp.377-416), Ankara: Pegem.

Altınyüzük, C. (2008). 8th graders’ misconceptıons in science lesson chemistry concepts. Master’s thesis, Institute of Social Sciences, Inönü University.

Ayas, A. & Özmen, H. (1998). “Level of integration of acid-base concepts with current events: a case study”. Karadeniz Technical University III. National Science Education Symposium Proceedings Books. 153-159.

Aydin, S., Demirdogen, B., Tarkin, A., Kutucu, S., Ekiz, B., Akin, F. N., & Uzuntiryaki, E. (2013). Providing a set of research-based practices to support preservice teachers’ long-term professional development as learners of science teaching. Science Education, 97(6), 903-935.

Aydin, S., Friedrichsen, P. M., Boz, Y., & Hanuscin, D. L. (2014). Examination of the topic specific nature of pedagogical content knowledge in teaching electrochemical cells and nuclear reactions. Chemistry Education: Research and Practice, 15(4), 658-674.

ISSN 2415-8178, e-ISSN 2415-8186. https://ilim.okmpu.kz

Balcı, S. & Baydemir, C. (2015). Meta-analysis in medical sciences. Journal of Health Sciences of Kocaeli University,1(1), 9-11.

Bektas, O. (2011). The effect of 5E learning cycle model on tenth grade students' understanding in the particulate nature of matter, epistemological beliefs. Doctorate Dissertation, Middle East Technical University, Ankara, Turkey.

Beothel, M., Dimock, K. V. (2000). Constructing knowledge with technology. Austin, TX: Southwest Educational Development Laboratory.

Boddy, N., Watson, K., & Aubusson, P. (2003). A trial of the es: A referent model for constructivist teaching and learning. Research in Science Education, 33, 27-42.

Borenstein, M., Hedges, L.V., Higgins, J.P.T. & Rothstein, H.R. (2013). Meta-Analize Giriş. Serkan Dinçer. Ankara: Anı

Cahyarini, A., Rahayu, S., & Yahmin. Y. (2016). The effect of 5E learning cycle instructional model using socioscientific issues (SSI) learning context on students' critical thinking. Journal Pendidikan IPA Indonesia, 5(2), 222-229.

Campbell, M. (2006). The effects of the 5E learning cycle model on students' understanding of force and motion concepts. Master's thesis. University of Central Florida, Florida, USA.

Camnalbur, M. & Erdoğan, Y. (2008). A meta-analysis study on the effectiveness of computer aided instruction: The example of Turkey. Educational Sciences in Theory and Practice, 8(2), 497-505.

Canpolat, N., Pınarbaşı, T., Bayrakçeken, S. & Geban, Ö. (2004). Some common misconceptions in chemistry. Gazi University, Journal of Gazi Education Faculty, 24(1)

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

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, 41-50.

Cohen, J. (1992). Statistical power analysis. Current Directions in Psychological Science, 1(3), 98 101.

Çağatay, G. & Demircioğlu, G. (2014). The effect of laboratory activities based on 5E model of constructivist approach on 9th grade students' understanding of solution chemistry. Procedia-Social and Behavioral Sciences 116(2014), 3120 – 3124

Dal, S., & Köse, M. (2017). Öğretim ilke ve yöntemleri, Etkinlik ve ders planı örnekleriyle zenginleştirilmiş, Ankara: Anı.

Değirmençay, Ş. A. (2010). Effects of guide materials based on diversified 5E teaching model on conceptual cahange? Heat diffusion and expansion? Doctorate dissertation, Karadeniz Technical University Institute of Science and Technology, Trabzon.

ISSN 2415-8178, e-ISSN 2415-8186. https://ilim.okmpu.kz

Demircioğlu, G., Özmen, H. & Demircioğlu, H. (2004). Investigating the effectiveness of implementing activities developed based on integrative learning theory. Journal of Turkish Science Education (1), 21- 34.

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. Master's thesis. The Graduate School of Natural and Applied Sciences of Middle East Technical 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. Master's thesis, Gazi University Graduate School of Educational Sciences, Ankara.

Ekici, G., & Güven, M. (2020). Yeni öğrenme öğretme yaklaşımları ve uygulama örnekleri. Ankara: Pegem.

Ertmer, P. A., & Newby, T. J. (1993). Behaviorism, cognitivism, constructivism: comparing critical features from an instructional design perspective, Performance Improvement Quarterly, C.6, S.4, s. 50-72.

Fraenkel, J.R., Wallen, N.E., & Hyun, H.H. (2012). How to design and evaluate research in education (Eight Edition). New York: McGraw-Hill.

Garcia, M. C. (2005). Comparing the 5E's and traditional approach. Master's thesis. Thesis Presented to The Faculty of California State University, Fullerto

Güvercin, O., Tekkaya, C., & Sungur, S. (2010). A cross age study of elementary students' motivation towards science learning. Hacettepe University Journal of Education, 39, 233-243.

Kabapınar, F.M., Sapmaz, N.A., & Bıkmaz F.H. (2003). Aktif Öğrenme ve Öğretmen Yöntemleri, Fen Bilgisi Öğretimi. Ankara Üniversitesi Eğitim Bilimleri Fakültesi Eğitim Araştırma ve Uygulama Merkezi (EAUM) Yayınları.

Kılavuz, Y. (2005). The effects of 5E learning cycle model based on constructivist theory on tenth grade students understanding of acid –base concepts. Master's thesis. The Graduate School of Natural and Applied Sciences of Middle East Technical University, Ankara.

Koç, G. (2002). Effects of constructivist learning approach on affective and cognitive learning outcomes. Doctorate Dissertation, Hacettepe University Institute of Social Sciences, Ankara.

Koç, G. & Demirel, M. (2004). From behaviorism to constructivism: a new paradigm in education, Hacettepe University Journal of Education. S.27, s. 174-180.

Kör, A.S. (2006). Effects of materials developed according to the contructivist learning approach in removal of conceptual errors seen in unit "electiricity in our life" by 5th grade students in primary school. Master's thesis, Karadeniz Technical University Institute of Science and Technology, Trabzon

ISSN 2415-8178, e-ISSN 2415-8186. https://ilim.okmpu.kz

Lee, E., Brown, M., Luft, J.A., & Roehrig, G. (2007). Assessing beginning secondary science teachers' PCK: Pilot year results. School Science and Mathematics, 107, 2, 418-426.

Lewis, S., Clarke, M. (2001). Forest plots: Trying to see the wood and the trees. British Medical Journal, (322)1479-1480.

Liu, X. (2009), Beyond science literacy: science and the public. International Journal of Environmental & Science Education. 4(3), 301-311.

Magnusson, S., Krajcik, J., & Borko, H. (1999). Nature, sources, and development of pedagogical content knowledge for science teaching. Examining pedagogical content knowledge: The construct and its implications for science education, 95-132.

Metin, M., (2011). Effects of teaching material based on 5E model removed prospective teachers' misconceptions about acid – bases, Asia-pacific forum on science learning and teaching. Bulgarian Journal of Science and Education Policy (BJSEP), 5(2), 89-103.

Morgil, İ., Yılmaz, A., Şen, O., & Yavuz, S. (2002). Students' misconceptions about acid-base and the use of different substance types to detect misconceptions. V. National Science and Mathematics Education Congress, Ankara.

Özmen, H. & Demircioğlu, G. (2003). The effect of conceptual change texts on eliminating student misconceptions about acids and bases. National Education Journal, 159, 111-119.

Özsevgeç, T., Çepni, S. & Özsevgeç, L. (2006). The effectiveness of the 5E model in eliminating misconceptions: force-motion example, 7th National Science And Mathematics Education Congress, Gazi University, Faculty of Education, 7-9 Eylül, Ankara.

Pabuççu, A. (2008). Improving 11th grade students' understanding of acid-base concepts by using 5E learning cycle model. master thesis. The Graduate School of Natural and Applied Sciences of Middle East Technical University, Ankara.

Pabuçcu, A. & Geban, Ö. (2015). The effect of applications organized according to the 5E learning cycle on misconceptions about acid-base. Bolu Abant Izzet Baysal University Journal of Faculty of Education (1), 191-206.

Pikoli, M. (2020). Using guided inquiry learning with multiple representations to reduce misconceptions of chemistry teacher candidates on acid-base concept. International Journal of Active Learning, 5(1), 1-10.

Pintrich, P. R. (2003). A motivational science perspective on the role of student motivation in learning and teaching contexts. Journal of Educational Psychology, 95(4), 667–686.

Qarareh, A. O. (2012). The effect of using the learning cycle method in teaching science on the educational achievement of the sixth graders. International Journal of Science Education, 4(2), 123-132.

ISSN 2415-8178, e-ISSN 2415-8186. https://ilim.okmpu.kz

Rodríguez, M., D., (2001). Glossary on meta-analysis. Journal Epidemiol Community Health, (55) 534-536.

Sadi, O., & Cakiroglu, J. (2010). Effects of 5E learning cycle on students' human circulatory system achievement. Journal of Applied Biological Sciences, 4(3), 63-67.

Saygın, Ö., Atılboz, G. & Salman., S. (2006). The effect of constructivist teaching approach on learning biology subjects: the basic unit of the living things-cell. Journal of Gazi Education Faculty, 26(1), 51-64.

Schlenker, R. M., Blanke, R., & Mecca, P. (2007). Using the 5E learning cycle sequence with carbon dioxide. Science Activities, 44(3), 83-93.

Singsathid, P., (2021) Development of scientific conceptual understanding by using 5E learning cycle with concept mapping on acid-base of grade 11 students. Master's thesis. Mahasarakham University, Maha Sarakham.

Seyhan, H.G. & Morgil, İ. (2007). The effect of 5E learning model on teaching of acid-base topic in chemistry education. Journal of Science Education, 8(2), 120.

Supasorn, S., & Promarak, V. (2014). Implementation of 5E inquiry incorporated with analogy learning approach to enhance conceptual understanding of chemical reaction rate for grade 11 students. Chemistry Education Research and Practice, 16, 121-132.

Supasorn, S. (2015). Grade 12 students' conceptual understanding and mental models of galvanic cells before and after learning by using small-scale experiments in conjunction with a model kit. Chemistry Education Research and Practice. 16, 393-407.

Supatmi, S., Setiawan, A. & Rahmawati, Y. (2019). Students' misconceptions of acid-base titration assessments using a two-tier multiple-choice diagnostic test. AJCE, 9(1), 18-37.

Şahin, Ç. (2010). Design, implementation and evaluation of the guided materials based on the "enriched 5E instructional model" for the elementary 8th grade "force and motion" unit. Doctorate dissertation, Karadeniz Technical University Institute of Science and Technology, Trabzon.

Şen, A. Z. & Nakiboğlu, C. (2021). Prospective chemistry teachers' transformation of their theoretical knowledge into practice regarding the misconceptions in high school chemistry subjects. Trakya Journal of Education, 11(3), 1735-1760.

Vrasidas, C. (2000). "Constructivism versus objectivism: implications for interaction, course design, and evaluation in distance education", International Journal of Educational Telecommunications. C. 6, S.4, s.39-62.

Widarti, H., Permanasari, A., & Mulyani, S. (2017). Undergraduate students' misconception on acid base and argentometric titrations: a challenge to implement multiple representation learning model with cognitive dissonance strategy. International Journal of education, 9(2), 105-112.

Wilder, M., & Shuttleworth, P. (2004). Cell inquiry: A 5E learning cycle lesson. Science Activities, 41(1), 25-31.

ISSN 2415-8178, e-ISSN 2415-8186. https://ilim.okmpu.kz

Yalçın, A., 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.

Yalçın, A., F., & Akpınar, A., İ. (2010). The effect of 5E learning model on the academic achievements of students with different learning style in teaching acids-bases. Erzincan University Journal of Science and Technology, 3(1), 1-17.

Yalçın, A., F. (2011). Examining the change in science teacher candidates' misconceptions about acid-base according to their grade levels, Journal of Turkish Science Education, 8(3), 161-172.

Yurdakul, B. (2005). Yapılandırmacılık, Eğitimde Yeni Yönelimler. (s.39-65), Ankara: Pegem.

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Қышқыл-негіз бірлігіндегі оқу жетістіктеріне оқу циклі 5е моделінің әсері: мета-анализдік зерттеу

Аңдатпа. Бұл зерттеуде 5Е оқу циклі моделінің қышқыл-негіз агрегаты бөліміндегі студенттердің академиялық жетістіктеріне әсерін қарастырған зерттеулерге мета-талдау жасалды. Осы мақсатта әртүрлі дерекқорлардан (YÖK National Thesis Center, Google Scholar, Dergipark) 2000-2022 жылдар аралығында жарияланған ұлттық зерттеулер сканерленді және қосу критерийлеріне сәйкес сегіз зерттеудің мета-талдауы жүргізілді. Талдау үшін кешенді мета-талдаудың статистикалық бағдарламасы (CMA) қолданылды. Эффект шамасын есептеу кезінде Hedges's g коэффициенті қолданылды, ал сенімділік деңгейі 95%-ға тең қабылданды. Жарияланымның қателігін анықтау үшін воронка әдісі бойынша кесте жасалды және Розенталь N-талдауы жасалды. Зерттеулер әр түрлі қалаларда, үлгілерде және сыныптарда жүргізілгендіктен, эффект мөлшері кездейсоқ эффект моделіне сәйкес есептелді. Нәтижелерге сәйкес, Hedges's g коэффициенті 1,845, ал стандартты қате 0,393 болды. Осы тұрғыдан алғанда, 5Е оқу циклінің моделінің қышқыл-негіз агрегаты бойынша оқушылардың академиялық жетістіктеріне әсері айтарлықтай оң болды деген қорытындыға келді.

Кілт сөздер. Оқу циклінің 5Е моделі, қышқыл-негіз, мета-талдау, әсер мөлшері.

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Влияние модель 5е цикла обучения на академическую успеваемость в кислотно-основном отделении: метаанализовое исследование

Аннотация. В этом исследовании был проведен мета-анализ исследований, изучающих влияние модели 5е учебного цикла на академическую успешность студентов по разделу кислотно-щелочного агрегата. С этой целью были отсканированы национальные исследования, опубликованные в период с 2000 по 2022 год, из различных баз данных (YÖK National Thesis Center, Google Scholar, Dergipark), и проведен мета-анализ восьми исследований в соответствии с критериями включения. Для анализа была использована статистическая программа комплексного мета-анализа (CMA). При расчете величины эффекта был использован коэффициент g Хеджеса, а уровень достоверности был принят равным 95%. Для определения погрешности публикации был составлен график воронки и проведен N-анализ Розенталя. Поскольку исследования проводились в разных городах, выборках и классах, величина эффекта была рассчитана в соответствии с моделью случайного эффекта. Согласно результатам, коэффициент g Хеджеса составил 1,845, а стандартная ошибка - 0,393. С этой точки зрения был сделан вывод о том, что влияние модели 5E учебного цикла на академические успехи учащихся по разделу кислотно-щелочного агрегата было значительно положительным.

Ключевые слова: модель 5е цикла обучения, кислотно-щелочной, мета-анализ, величина эффекта.