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Argumentation-Based Teaching in Science Education: Meta-Analysis

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Abstract
The aim of this study is to conduct a meta-analysis study to examine the effectiveness of the argumentation-based teaching method in terms of sample, subject, years and some variables (academic success, attitude, interest, etc.). Meta-analysis method was used in this study. In order to gather the studies included in meta-analysis, various sources were used in the study. Three type studies were brought together for the meta-analysis: journal articles, doctoral and master thesis. The Social Science Citatio Index (SSCI) journals, Turkish Academic Network and Information Center Social Science Database, national printed journals, Academic Search Complete, Education Research Complete and ERIC databases were searched for journal articles. The Council of Turkish Higher Education Thesis Center was scanned to get the dissertations/theses. While scanning these platforms, the key concepts of "argumentation", "argumentation-based science teaching", "argumentation-based science education", "discussion-oriented teaching method to science" were used. So, 47 studies were used in the meta-analysis. In the study, as a result of the meta-analysis on the argumentation-based teaching process at the national level, it was determined that there was no significant difference in terms of the level of classes in which the studies were conducted and the independent variables examined in the studies, but there was a significant difference between the subject areas in favor of the subject area of chemistry.

Keywords: Argumentation, Meta-Analysis, Science Education

1. Introduction

Science education has played a key role in the development of societies from the past to the present, and for this reason, it has been the focal point of scientific reform movements and discussions of countries. In this context, among the primary objectives of today's science education; There is training of well-equipped manpower who can research, question, think analytically, use scientific ways and methods in solving problems, and develop new knowledge and processes with the knowledge they have acquired. In order to raise these individuals, it is necessary to create learning environments where students can develop their social aspects, cooperation and communication skills, and provide them with the opportunity to choose, collect, question and use information (Hasançebi, 2014). As one of the methods that can be used in such learning environments, the argumentation method has come to the

fore in recent years. The argumentation method (Hand & Keys, 1999), which helps students form arguments in a scientific inquiry (Choi, et al., 2010) and thus construct scientific knowledge (Hand & Keys, 1999), is characterized as an important tool for the teaching process (Aktamış & Hiğde, 2015; Çaycı, 2019; Günel, Kıngır & Geban, 2012; Kıngır, 2011; Martin & Hand, 2007; Nam, Choi & Hand, 2011; Şahin-Kalyon & Taşar, 2020). With this method, it is expected that students will not only construct knowledge correctly, but also improve their communication, cooperation and social aspects (Hasançebi, 2014). In this respect, the argumentation method is also capable of contributing to the training of individuals targeted by the future age. In this sense, in recent years, many studies investigating the reflections of the argumentation process on learning in national and international dimensions have been revealed (Cavagnetto, Hand & Norton-Meier, 2010; Chin & Osborne, 2010; Çaycı, 2019; Günel, Kıngır & Geban, 2012; Martin & Hand, 2007; Hand & Norten-Meier, 2011; Kıngır , 2011; Nam, Choi & Hand, 2011; Şahin-Kalyon & Taşar, 2020). The common point of the studies is that the argumentation method affects the learning-teaching process in many ways, cognitively, culturally and socially.

Argumentation method has started to be included in the Science course curriculum within the scope of the change made in the curriculum by the Ministry of National Education in 2013. In the continuation of this situation, studies have been conducted and are being conducted in the national literature in which the effectiveness of this method is examined at many educational levels and on different subjects, and opinions are taken. Studies examining the effectiveness of the method are comparative studies. Generally, experimental and control groups were formed, while the subject determined in the experimental group was taught with the argumentation-based teaching method, no intervention was made in the control group. In the studies examined, it is seen that the effectiveness of the method based on argumentation in socioscientific issues as well as the subjects such as Matter and Change, the structure of the Atom, Electric energy, Solar system and beyond, Matter and heat, Human and environment, Acids and bases in the Science curriculum are examined. In addition, samples were studied at the 5th, 6th, 7th, and 8th grade levels. The effect of the method on many variables such as academic success, interest and attitude towards science lesson, interest in the environment, scientific process skills, and willingness to discuss were examined. In addition, there are also meta-analysis studies in which the studies on the argumentation-based teaching method are analyzed. These studies are generally aimed at examining the effects of the method on some variables (academic achievement, scientific process skills, attitude, conceptual understanding) (Çömek, Sarıçayır & Erdoğan, 2015, Karakuş & Yalçın, 2016, Özer, 2019). There are no studies examining in more detail on the basis of grade level, subject, and years. By analyzing the studies on the ABL method in detail, general results can be obtained about which grade level, on which subjects, on which variable, and between which years the argumentation method is more effective. Thus, it can contribute to the more effective use of this method in science education. In addition, such detailed meta-analysis studies on the argumentation-based teaching method, ABTM, will also facilitate the researchers in literature review. In this context, there is a need to categorize this applied educational research, evaluate its trends and research results, and synthesize it in order to provide clear recommendations on future research, practices, and policies related to the subject area. In this way, both the points where the studies on the same subject support or contradict each other can be revealed, and similar studies can be avoided and studies that take different perspectives into account can be produced.

In this sense, the aim of this study is to conduct a meta-analysis study to examine the effectiveness of the argumentation-based teaching method in terms of sample, subject, years and some variables (academic success, attitude, interest, etc.). Meta-analysis; It is a quantitative application that includes statistical operations used to combine, synthesize and interpret the experimental findings of individual studies conducted at different times and places on the same subject. The aim here is to identify or compare the changes related to the researched subject according to the effect values of the studies by determining a common criterion (Bayraktar, 2000). Thus, it is aimed to obtain more reliable, consistent, compatible and accurate results with a holistic perspective on the researched subject (Cohen & Manion, 2001).

2. Method

Meta-analysis method was used in this study. Meta-analysis can be defined as “a research method that aims to quantitatively integrate the results of a group of primary studies on a particular topic in order to be able to decide on the latest developments on that topic” (Kulik et al., 1985). In this study, Kulik et al. (1985) and Glass, McGaw,

and Smith (1981) had similar effect values. First, the literature was scanned. Criteria were determined for the studies to be included in the sampling. After the studies were coded, the effect values were calculated. Finally, statistical methods were applied on the results of the studies.

2.1 Data Sources

In order to gather the studies included in meta-analysis, various sources were used in the study. Three type studies were brought together for the meta-analysis: journal articles, doctoral and master thesis. The Social Science Citatio Index (SSCI) journals, Turkish Academic Network and Information Center Social Science Database, national printed journals, Academic Search Complete, Education Research Complete and ERIC databases were searched for journal articles. The Council of Turkish Higher Education Thesis Center was scanned to get the dissertations/theses. While scanning these platforms, the key concepts of "argumentation", "argumentation-based science teaching", "argumentation-based science education", "discussion-oriented teaching method to science" were used. So, 47 studies were used in the meta-analysis.

2.2 Inclusion Criteria

The following criteria were taken into account in determining the studies included in the research;

- Studies about the subject or concepts in the science course curriculum in which the argumentation-based teaching method is used.
- Studies had to include an experimental method with a experimental and a control group. Studies with no comparison group were not used in the analysis.
- Studies had to report means, standard deviations and number of subjects of experimental and control groups separately (If these were not reported, F or tvalues had to exist).
- Studies had to include Turkish students as subjects.
- Studies had to have been published between 2010-2021 years.
- The sample consists of the 5th, 6th, 7th and 8th grades of primary schools in Turkey.

2.3 Coding

Studies were chosen to use in the meta-analysis. Then, a coding paper was prepared for the coding process. Two researchers' coded variables and quantitative data needed to calculate effect sizes to the paper for each study separately. The researchers compared the coding papers for coding reliability. Agreement was obtained 0.87 between the coding papers. The different codings were discussed by the researchers.

2.3. *Variables*

Five variables were coded for each study:

1. Type of publication (journal article, dissertation/thesis)
2. Grade level (5th, 6th, 7th and 8th grades of secondary schools)
3. Subject area (physics, chemistry, biology)
4. The variables affected by argumentation (Willingness to participate in the discussion, success, the nature of science, critical thinking, problem solving skills, attitude, environmental awareness)

2.3. *Calculation of Effect Sizes*

Many approaches are used to calculate the impact value. In this study, the method used by Hunter and Schmidt (1990) was used. The formulas used in the calculation of the effect value in the study are given below.
Meanings of abbreviations used in formulas:
d = effect value
t = result from t test
F = result from the F test
What = number of students in the experimental group

Nc = number of students in the control group
Xe = experimental group success average
Xc = control group success mean
Sp= total standard deviation
Se = experimental group standard deviation
Sc = control group standard deviation

If the value of t is given $d = t \times \sqrt{\frac{1}{Ne} + \frac{1}{Nc}}$

If the value of F is given $d = \sqrt{F} \times \sqrt{\frac{1}{Ne} + \frac{1}{Nc}}$

In cases where F and t values are not given $d = \frac{\overline{Xe} - \overline{Xc}}{Sp}$ $Sp = \sqrt{\frac{(Ne-1)Se^2 + (Nc-1)Sc^2}{Ne+Nc-2}}$

2.3 *Analysis of Data*

The SPSS package program was used to compute the ESs and variability measurement. Each variable was evaluated as a factor in an analysis of variance (ANOVA) to investigate whether there were significant differences within each variable on the ESs.

3. Results

When the literature is examined, there are many studies examining the effectiveness of ABTM. However, the studies selected in accordance with the above criteria were classified according to the type of publication and the classification made is presented in Table 1.

Table 1: Type of studies reviewed

PhD Thesis	Master Thesis		Article
Cömert, 2019 (a)	Akman, 2019	Kardaş, 2013(a)	Akkaş ve Memiş, 2020
Cömert, 2019(b)	Altun, 2010 (a)	Kardaş, 2013(b)	Aktaş ve Doğan, 2018(a)
Çınar, 2013(c)	Altun, 2010 (b)	Kaya,2018(a)	Aktaş ve Doğan, 2018(b)
Çınar, 2013 (a)	Altun,2010 (c)	Kaya,2018(b)	Çinici vd., 2014
Çınar, 2013(b)	Aydoğdu, 2017(a)	Köse,2019(a)	Demirel ve Özcan, 2021
Demirel, 2017	Aydoğdu, 2017(b)	Köse,2019(b)	Demirel, 2016
Memiş, 2011(a)	Aydoğdu, 2017(c)	Kutluer, 2020	Er ve Kırındı, 2020(a)
Memiş, 2011(b)	Aydoğdu, 2017(d)	Kuyucu, 2019(a)	Er ve Kırındı, 2020(b)
Şentürk, 2020(a)	Balcı, 2015 (a)	Kuyucu, 2019(b)	Eroğlu ve Yıldırım, 2020(a)
Şentürk, 2020(b)	Balcı, 2015(b)	Okumuş, 2012	Eroğlu ve Yıldırım, 2020(b)
Şentürk, 2020(c)	Baydar, 2018(a)	Öksüz,2019(a)	Gülseven, Tüysüz ve Tozlu, 2021(a)
	Baydar, 2018	Öksüz,2019(b)	Gülseven, Tüysüz ve Tozlu, 2021(b)
	Baydar, 2018	Öksüz,2019(c)	Oral ve Bozkurt, 2021(a)
	Ceylan, 2012(a)	Özcan, 2019(a)	Oral ve Bozkurt, 2021(b)
	Ceylan, 2012(b)	Özcan, 2019(b)	Oral ve Bozkurt, 2021(c)
	Ceylan,2012©	Özelme, 2019	Oral ve Bozkurt, 2021(d)
	Doğru, 2016(a)	Özkara,2011(a)	Türkoğuz ve Cin,2013
	Doğru, 2016(b)	Özkara, 2011 (b)	Ulu, 2019
	Doğru, 2016(c)	Özkara,2011©	Uluay ve Aydın,2018
	Eryılmaz, 2019(a)	Öztürk, 2013 (a)	
	Eryılmaz, 2019(b)	Öztürk,2013 (b)	
	Güler, 2020	Öztürk, 2013 ©	
	Gür, 2019(a)	Polat, 2014	
	Gür, 2019(b)	Şengül, 2017(a)	
	Gür, 2019(c)	Şengül, 2017(b)	
	İlk, 2019(a)	Tola, 2016(a)	

	İlk, 2019(b)	Tola, 2016(b)	
	Karacalı ve Özkan,2021	Tola, 2016(c)	
		Tüccaroğlu,2018(a)	
	Karaman, 2019(a)	Tüccaroğlu,2018(b)	
	Karaman, 2019(b)	Uçar, 2019(a)	
		Uçar, 2019(b)	
		Uçar, 2019(c)	
Total: 5		**30**	**12**

As seen in Table 1, the data obtained from 47 scientific publications within the scope of the study were evaluated. However, since more than one variable was examined in some of the publications, these studies were coded as a, b, c, and d. Therefore, the total number is high. Of the 47 publications included in the study, 12 are articles, 5 are doctoral dissertations, and 30 are master's thesis.

The subjects on which the effectiveness of ABTM was examined in studies are presented in Table 2.

Table 2: Topics and frequencies where the effectiveness of ABTM was examined

Topics	**Frequency**
Acids and bases	1
Structure of the atom	1
Let's get to know the living world	2
Reproduction, growth and development in living things	
Human and environment	4
Environmental education	
Matter cycles and environmental problems	
Earth and universe	5
Solar system and beyond	
Conduction of electricity	5
Electricity in our life	
Electrical energy	
Cell division and heredity	2
Interaction of light with matter, light	3
Force and energy, force and motion	5
Matter and heat, states of matter and their distinctive features, change and recognition of matter, particulate nature of matter	14
Socioscientific issue	3
Pressure	2

When Table 2 is examined, it is seen that most of the studies have been done on the subject of the matter.

When the samples of the studies are examined, it is seen that there are studies at different grade levels. The table showing the distribution of studies according to grade levels is presented below.

Table 3: Class levels, frequencies and percentages of the samples of the studies

Class levels	**Frequencies**	**Percentages**
5.	9	19
6.	10	21
7.	18	39
8.	10	21

Table 3 shows that there are studies in which the argumentation-based teaching method is used at all grade levels in secondary school.

When the effectiveness of the ABTM method is examined on which variables in the literature, it is seen that there are variables such as academic achievement, attitude, attitude towards the environment. These variables and their frequencies are given in Table 4.

Table 4: Variables examined in studies and their frequencies

Variables	Frequencies
Success, conceptual understanding, conceptual change	41
Scientific thinking, nature of science, Scientific process skills, Epistemological belief	9
Environmental awareness, interest in the environment, attitude towards the environment, Climate change awareness	4
Problem solving skills, Decision making skills	6
Willingness to join the discussion	7
Attitude, Interest, Motivation	13
Critical thinking, Inquiry thinking, Reflective thinking, Logical thinking skills, Metacognitive thinking, Creative thinking, Reflective thinking	11

When Table 4 is examined, it is seen that the studies mostly focus on Achievement, conceptual understanding, and conceptual change.

The distribution of studies conducted in the literature by years is given in Table 5.

Table 5: Distribution of studies by years

Year range	Frequency
2010-2015	13
2016-2021	34

In Table 5, it is seen that the studies on the argumentation-based teaching method intensified after 2016.

As can be seen from Table 6, the study reported the results of 92 effect sizes included in 42 studies, since some studies performed multiple comparisons within the same study.

Table 6: Publishing year, number of comparisons and effect sizes of each primary study

Authors and years of the studies	Number of ES	ES
Akkaş ve Memiş, 2020	1	0,779409
Akman, 2019	1	0,536352
Aktaş ve Doğan, 2018	2	1,066667
		0,365388
Aydoğdu, 2017	4	6,913011
		1,332026
		2,85296
		-0,18111
Balcı, 2015	2	0,609448
		-0,00038
Çınar, 2013	3	0,297502
		0,7951
		-0,3848
Çinici vd., 2014	1	0,203977
Demirel ve Özcan, 2021	1	1,377558
Demirel, 2016	1	-1,11702
Er ve Kırındı, 2020	2	0,472347
		0,514774
Eroğlu ve Yıldırım, 2020	2	0,176034
		0,595993
Gülseven, Tüysüz ve Tozlu, 2021	2	0,002023

		0,08275
İlk, 2019	2	-14,9449
		-5,93625
Karacalı ve Özkan,2021	1	0,770655
Kardaş, 2013	2	0,719983
		0,28414
Kaya,2018	2	1,072561
		0,162579
Köse,2019	2	-9,93705
		0,480122
Memiş, 2011	2	0,232379
		0,076911
Oral ve Bozkurt, 2021	4	0,871087
		0,608816
		0,789752
		-1,40986
Özcan, 2019	2	-0,90645
		0,549074
Tüccaroğlu,2018	1	-0,33505
Türkoğuz ve Cin,2013	1	-4,39853
Ulu,2019	1	-16,0894
Uluay ve Aydın,2018	1	2,40858
Kutluer, 2020	1	1,174337
Demirel, 2017	1	1,420018
Şentürk, 2020	3	1,014601
		0,929321
		0,784535
Güler, 2020	1	1,535793
Özelme, 2019	1	0,995741
Cömert, 2019	2	0,019463
		0,196022
Gür, 2019	3	0,500375
		0,585113
		-0,73388
Öksüz,2019	3	1,011656
		0,023364
		-0,27036
Eryılmaz, 2019	2	6,229587
		-0,60633
Karaman, 2019	2	0,10692
		-0,04899
Uçar, 2019	3	0,859489
		0,184067
		-0,07705
Kuyucu, 2019	2	0,948411
		-0,1042
Baydar, 2018	3	0,57878

		-0,1629
		0,476612
Şengül, 2017	2	-0,29872
		0,323411
Doğru, 2016	3	1,005597
		2,14329
		0,621547
Tola, 2016	3	-0,00948
		1,796537
		1,27558
Polat, 2014	1	0,871669
Ceylan, 2012	3	0,000266
		0,718218
		0,36728
Öztürk, 2013	3	0,769844
		0,730032
		0,37108
Okumuş, 2012	1	1,233288
Özkara, 2011	3	1,099852
		0,311769
		0,334863
Altun, 2010	3	0,546857
		0,534257
		0,05393
Grand Mean Of ESs		0,047265

When Table 6 is examined, it is seen that the majority of the effect values are positive values and the arithmetic averages are 0.047265.

Table 7 shows the F values and descriptive statistics for the four variables. One variable (Subject area) indicated statistically significant effects

Table 7: Descriptive statistics and the results of ANOVA for the variables

Variables	**N**	**Mean of ESs**	**SD**	**F**	**p**
Subject area					
Biology	34	0,361	0,484	0,348	0,001
Physic	39	-0,361	3,68		
Chemistry	15	0,693	1,17		
Variables affected by argumentation					
Willingness to participate in the discussion	7	-1,54	3,79	0,872	0,519
Success	41	0,466	2,95		
The nature of science	10	0,629	0,543		
Critical thinking	10	-1,24	5,28		
Problem solving skills	6	0,0523	0,704		
Attitude	13	0,0260	1,97		

Environmental awareness	6	0,248	0,596		
Grade level					
5	24	0,606	0,558	0,257	0,856
6	21	-0,0140	4,27		
7	35	0,0897	2,02		
8	15	-o,0884	4,43		

When table 7 is examined, it is seen that there is a significant difference in favor of chemistry only among the subject areas among the studies on the argumentation-based teaching process.

4. Discussion

Due to the differences in education and training approaches since the 2000s, the science course curriculum has been changed three times in 2005, 2013 and 2017, and updates have been made on the 2017 curriculum in 2018. Argumentation method, on the other hand, started to take place in the Science course curriculum within the scope of the change made in the curriculum in 2013. In the continuation of this situation, studies have been conducted and are being conducted in the national literature in which the effectiveness of this method is examined at many educational levels and on different subjects, and opinions are taken. When Table 1 is examined, it is seen that 5 of the studies examined within the scope of this research are doctoral, 30 of them are master's and 12 of them are articles. One of the doctoral theses was published right after the program change in 2013, another in 2011, and the others in 2017, 2019 and 2020. While master's theses were published between 2010-2020, it is seen that the articles are concentrated between 2020 and 2021. When the distribution of the studies conducted is also examined by years (Table 5), it is seen that the number of studies has increased after 2016.

The aim of this study is to conduct a meta-analysis study to examine the studies on the effectiveness of the argumentation-based teaching method in terms of sample, subject, and some variables (academic success, attitude, interest, etc.). In this sense, 47 studies on the subject from the literature were examined. In the examined studies, when the subject areas (Physics, Chemistry, Biology) in the science course were examined, it was observed that 16 of the studies were in the subject area of chemistry (Acids and bases, structure of the atom, pressure, matter, etc.), and 20 of them were in the subject area of physics (electricity, the interaction of light with matter, light, force and energy, force and motion etc.). interaction of light with matter, light, force and energy, force and motion, etc.) and 11 of them in biology (Let's get to know the world of living things, reproduction, growth and development in living things, cell division, heredity, etc.) (Table 2). When examining whether there is a significant difference between these subject areas, it is seen in Table 7 that there is a significant difference and this difference is in favor of chemistry subjects. When the chemistry subjects in the science curriculum are examined, it is seen that the subjects mostly consist of events that students can encounter at any time in their daily lives, such as matter, states of matter, material changes, and concepts that they can easily embody (MEB 2013, 2018). Due to this structure of topics and concepts, students can form their own claims about the problem situations given to them during the argumentation process, present evidence, and participate actively in the discussion process. In this case, it may have enabled the students to be successful in the argumentation process, especially in chemistry subjects. In the literature, there are many studies in which the argumentation process on chemistry concepts is operated and this process is examined in terms of many variables, and the results are positive (Burke & Greenbowe, 2006; Deveci, 2009; Gümrah, 2013; Ulu, 2019).

When the studies on ABMT at the level of grades are examined, it is seen in Table 3 that 10 studies were conducted with 6th and 8th grades, and 18 studies were conducted with 5th grades and 9th and 7th grades. It was determined that there was no significant difference between grade levels (Table 7). Based on this finding, it can be said that argumentation-based teaching is a method that can be used at every grade level in secondary school. Middle school students are between the ages of 11-15. For children in this period, it is very important for the next grade levels to be able to construct abstract science concepts in a meaningful way. Because the concepts they learn in this period will form the basis for the concepts they will learn in high school years. Argumentation-oriented learning environments provide students with; generating questions about concepts, participating in classroom activities

curiously and actively to answer these questions, questioning preformed models in their minds, defending one's own model or using support, justification, and evidence to refute their friends' models, thus further reflecting on concepts and It provides the opportunity to examine the issues in depth (Aslan, 2010; Okumuş, 2012). In this process, students contribute to each other's learning, question and evaluate their own and other friends' ideas (Arlı, 2014; Burke & Greenbowe, 2006; Driver et al., 2000; Günel et al., 2010; Hand, Wallace & Yang, 2004). The fact that students are in constant interaction with their peers, create their claims in interaction, strengthen or abandon their claims, refute them, and realize their limitations allows many new ideas to emerge (Cevher, 2015), enabling students to construct their knowledge structures at the conceptual level in a meaningful way (Çelik & Kılıç, 2007; Özkara, 2011). In this sense, it can be said that the argumentation method, which was included in the science curriculum in 2013, has positive effects on all secondary school students' conceptual understanding, academic achievement, attitudes towards the course, their willingness to participate in the discussion, etc., regardless of grade level.

When examining which variables (academic success, attitude, nature of science, critical thinking, problem solving skills, etc.) the ABTM has effects on, it is seen that the studies mostly focus on academic achievement (Table 4). Then there are attitudes, interests and motivation, critical thinking and reflective thinking etc. It is also seen that studies have been done on it. When examining whether there is a significant difference between these variables, it is seen in Table 7 that there is no significant difference. When the results of the studies on these variables were examined, it was determined that the results were generally positive. Argumentation includes thinking exercises and allows students to make judgments by reflecting on events, situations or facts (Erduran et al., 2004). More importantly, science education often proceeds by arguing, disagreeing, and proving or disproving claims rather than consensus. In this way, students can better understand scientific knowledge (Clark & Sampson, 2007; Niaz et al., 2002). Deep thinking and practice are important for learning. Such an argumentation process will have significant effects on students' critical thinking, reflective thinking, problem solving skills, and scientific thinking skills, and then academic success will increase. Therefore, it can be said that the reason why there is no significant difference between the variables examined is due to this dynamic interaction in the argumentation process.

5. Suggestions

In the study, as a result of the meta-analysis on the argumentation-based teaching process at the national level, it was determined that there was no significant difference in terms of the level of classes in which the studies were conducted and the independent variables examined in the studies, but there was a significant difference between the subject areas in favor of the subject area of chemistry. Considering the suggestions that can be made in line with the results obtained from the study, it is thought that the comparison of the results of the studies on the argumentation process in the international literature and the results of the national studies will be meaningful and contribute. The learning process can be enriched by comparing the data obtained from a study conducted in this direction with the studies conducted at national and international level, by determining the similarities and differences in the process.

References

Aktamış, H., & Hiğde, E. (2015). Assessment of argumentation models used in science education. *Mehmet Akif Ersoy University Jounal of Faculty of Education,* 35, 136-172.

Arlı, E. E. (2014). *The impacts of argumentation based science inquiry approach on seasonal agricultural worker students' academic achievement and thinking skills* [Master Thesis]. University of Atatürk.

Aslan, S. (2010). *The effect of argumentation-oriented teaching approach on the improvement of their top scientific process and critical thinking among high school 10. class students* [Doctoral Thesis]. University of Gazi.

Bayraktar, S. (2000). *A meta analysis study on the effectiveness of computer assisted ınstruction in science education* [Doctoral Thesis]. Ohio University.

Burke, K. A., & Greenbowe, T. J. (2006). Implementing the science writing heuristic in the chemistry laboratuary. *Journal of Chemical Education*, 83(7), 1033-1038.

Cavagnetto, A. R., Hand, B., & Norten-Meier, L.(2010). Negotiating the inquiry question: A comparison of whole class and small group strategies in grade five science classrooms. *Research in Science Education*, 41(2), 193-209.

Cevher, A. H. (2015). *The effect of eight grade gifted students' argumentation processes about anomalic cases on scientific creativity levels* [Master Thesis]. University of Inönü.

Chin, C., & Osborne, J. (2010). Supporting Argumentation Through Students' Questions: Case Studies in Science Classrooms. *The Journal of the Learning Sciences*, 19(2), 230-284. https://doi.org/10.1080/10508400903530036

Clark, D. B., & Sampson, V. (2007). Personally-seeded discussions to scaffold online argumentation. *International Journal of Science Education*, 29(3), 253-277.

Cohen, L., Manion, L., & Morrison, K. R. B. (2000) *Research methods in education* (5th edition). London: Routledge Falmer.

Çaycı, B. (2019, September 6-8). *Öğrenme stillerine göre sınıf öğretmeni adaylarının argümantasyon becerilerinin analizi.* International Symposium on Active Learning, Adana, Turkey.

Çelik, K., & Kılıç, Z. (2007, June 20-22). *The effect of scientific discussion technique on students' social interaction and communication skills.* 1. National Chemistry Education Congress, İstanbul, Turkey..

Çömek, A., Sarıçayır, H., & Erdoğan, Y. (2015). Effectiveness of the argumentation method: A meta-analysis. *Journal of Human Sciences*, 12(2), 1881–1898.

Deveci, A. (2009). *Developing seventh grade middle school students? socioscientific argumentation, level of knowledge and cognitive thinking skills in the structure of matter subject* [Master Thesis]. University of Marmara.

Driver, R., Newton, P.,& Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education*, 84, 287-312.

Erduran, S., Simon, S., & Osborne, J. (2004). TAP ping into argumentation: developments in the use of Toulmin‟s argument pattern for studying science discourse. *Science Education,* 88(6), 915–933. http://dx.doi.org/10.1002/sce.20012

Glass, G. V., McGaw, B., & Smith, M. L. (1981). *Meta-analysis in social research.* Beverly Hills, CA: Sage Publications.

Gümrah, A. (2013). *The effects of scientific argumentation on secondary students' conceptual understanding of chemical changes, nature of science views, science process, communication and argument skills* [Doctora Thesis]. University of Marmara.

Günel, M., Kabataş Memiş, E., Yeşildağ, F., Biber, B, Okçu, B., & Şahin, A. (2010, September, 23-25). *The effect of using the argumentation-based science learning (ATBO) approach in university level physics laboratories on academic success.* IX. National Science and Mathematics Education Congress, İzmir, Turkey.

Günel, M., Kıngır, S., & Geban, Ö. (2012). Analysis of argumentation and questioning patterns in argumentbased ınquiry classrooms. *Science and Education*, 37(164), 316-330.

Hand, B., & Keys, C. (1999). Inquiry investigation: A new approach to laboratory reports. *The Science Teacher*, 66, 27-29.

Hand, B., & Norton-Meier, L. (Eds.). (2011). *Voices from the classroom*. Springer Science & Business Media.

Hand, B., Wallace, C., & Yang, E. (2004). Using the science writing heuristic to enhance learning outcomes from laboratory activities in seventh grade science: Quantitative and qualitative aspects. *International Journal of Science Education*, 26(2), 131-149. https://doi.org/10.1080/0950069032000070252

Hasançebi, F. (2014). *The impacts of argument-based inquiry (ABI) approach on students' science achievements, argument skill and personal development* [Doctoral Thesis]. University of Atatürk.

Hunter, J. E., & Schmidt, F. L. (1990). *Statistical methods for meta-analysis*. San Diego, CA: Academic Press Inc.

Karakuş, M., & Yalçın, O. (2016). The effect of the argümantation-based learning in science education to the academic achievement and scientific process skills: a meta analysis study. *Anadolu University Journal of Social Sciences*, 16 (4), 1-20. https://doi.org/10.18037/ausbd.415534

Kıngır, S. (2011). *Using the science writing heuristic approach to promote student understanding in chemical changes and mixtures* [Doctoral Thesis]. Middle East Technical University.

Kulik, J., Kulik, C.-L., & Bangert-Drowns, R. L. (1985). Effectiveness of computer-based education in elementary pupils. *Computers in Human Behavior*, 1, 59–74.

Martin, A. M., & Hand, B. (2007). Factors affecting the implementation of argument in the elementary science classroom. A longitudinal case study. *Research in Science Education*, 39, 17-38. http://dx.doi.org/10.1007/s11165-007-9072-7

Ministry of National Education (2013). *Science Curriculum (Primary and Secondary School 3, 4, 5, 6, 7 and 8th grades).* Ministry of National Education Publications, Ankara.

Ministry of National Education (2018). *Science Curriculum (Primary and Secondary School 3, 4, 5, 6, 7 and 8th grades).* Ministry of National Education Publications, Ankara.

Nam, J., Choi, A., & Hand B. (2011). Implementation of the science writing heuristic (SWH) approach in 8th grade science classrooms. *International Journal of Science and Mathematics Education*, 9, 1111-1133. http://dx.doi.org/10.1007/s10763-010-9250-3

Niaz, M., Aguilera, D., Maza, A., & Liendo, G. (2002). Arguments, contradictions, resistances and conceptual change in students‟ understanding of atomic structure. *Science Education*, 86, 505-525.

Okumuş, S. (2012). *The effects of argumentation model on students achievement and understanding level on the unit of states of matter and heat* [Master Thesis]. Karadeniz Technical University.

Özer, G. (2009). *Investigating the effect of scientific argumentation based instruction approach on students' conceptual change and success concerning the concept of mole* [Master Thesis]. University of Gazi.

Özkara, D. (2011). *Teaching pressure subject to eighth class students with activities based on scientific argumentation* [Master Thesis]. University of Adıyaman.

Şahin-Kalyon, D., & Taşar, M. F. (2020). Fourth and fıfth grade students' argument structure. International Journal of Euroasian Research, 8(22), 39-71. https://dx.doi.org/10.33692/avrasyad.643598

Ulu, C. (2019). The ımpact of argumentation based ınquiry approach on metacognitive knowledge and skills. *International Journal of Science and Education*, 2(1), 11-23.