Education and Science tedmem

Vol 42 (2017) No 190 281-303

A Thematic Review of Argumentation Studies at The K-8 Level

Hasan Bağ [1], Muammer Çalık [2]

Abstract

This research aimed to thematically review the argumentation studies at the K-8 level from 2006 to 2016. Given the criteria 'the K-8 level and a period of 2006-2016' for the argumentation studies, relevant databases yielded a total of 73 articles and 9 theses. These studies were exposed to thematically content analysis via such parameters as *aim, method/design, sample, data collection, data analysis, subject employed for argumentation, type of used argumentation, argumentation model, general knowledge claim and recommendation.* The results indicated that most of the argumentation studies examined the effect of argumentation on student achievement and attitudes towards science. Also, these studies under investigation mostly used experimental research design while generally preferring scales and audio-video records for data collection tools. Moreover, the argumentation activities were mostly developed in 'physics' topics and middle school level. The results of the current study suggest to deploy different methods (e.g. argumentation accompanied with gamification) to improve argumentation skills from primary school level.

Keywords

Argumentation
K-8 level
Scientific discourse
Science education
Thematic review

Article Info

Received: 08.04.2016
Accepted: 02.20.2017
Online Published: 03.29.2017

DOI:10.15390/EB.2017.6845

Introduction

Scientific knowledge construction extensively handling a subject as a whole requires strong argumentation and reasoning skills (Topdemir & Unat, 2014, pp. 7). In this process, scientists use scientific arguments to explain their experiments and observations (Bakırcı, Çalık, & Çepni, 2017; Köseoğlu, Tümay, & Budak, 2008). In other words, producing scientific knowledge frequently undergoes argumentation procedure that involves in asking questions, creating claims, and supporting these claims with evidences (Erduran & Jimenez-Alexandre, 2007; Erduran, Simon, & Osborne, 2004; Günel, Kıngır, & Geban, 2012). Because "*data-claim-justification*" process in the nature of argumentation overlaps with the ways of scientific knowledge (Toulmin, 1958), a clear interaction between argumentation skills and the nature of science appears (Uluçınar Sağır & Kılıç, 2013). A demand on equipping students with these scientific skills suggests that curriculum should include argumentation activities, (Özkara, 2011). Since argumentation is seen as an important option for teaching scientific concepts in curriculum and socio-scientific issues (Herrenkohl & Cornelius, 2013; Khishfe, 2014), the objectives of any curriculum have been revised or updated. For example; science curricula of developed (USA, New Zealand, Australia) and developing (Turkey) (Hiğde & Aktamış, 2017; Ministry of National

[1] Recep Tayyip Erdoğan University, Faculty of Education, Department of Primary Education, Turkey, hsnbag@gmail.com
[2] Karadeniz Technical University, Faculty of Education, Department of Primary Education, Turkey, muammer38@hotmail.com

Education [MEB], 2013) countries emphasize to train individuals with the argumentation skills through inquiry-based learning approach.

This emphasis in science curricula has accelerated the studies integrating argumentation into science education (Berland & Reiser, 2011; Evagorou ve Osborne, 2013; Munford, 2002; Pedretti & Nazır, 2011; Ravenscroft, 2000; Sadler, 2006; Simon, 2008; Uskola, Maguregi, & Jimenez-Aleixandre, 2010; Varelas, 1996) and proposed various argumentation models (Belland, 2008; Clark & Sampson, 2008; Osborne, Erduran, & Simon, 2004; Park & Kim, 2012; Toulmin, 1958). These models are generally underpinned by Toulmin's Argumentation Model firstly illuminating argumentation process and its components. Therefore, the number of the argumentation studies with the Toulmin Argumentation Model is considerably many (Berland & McNeill, 2012; Maloney & Simon, 2006; Song, Karimi, & Kim, 2015).

Toulmin (1958) defined the argumentation process with three main components (data, claim, and justification) and three sub-components (warrant, limitation and refutation). Toulmin (1958) viewed argumentation as the whole of the warranted claims. Therefore, any claim is to base on the data. To strengthen the connection between the claim and data, justification is referenced. 'Warrant' word in 'Warranted claims' statement means 'justification' term. For this reason, any claim should contain a strong justification. On the other hand, each justification has its own warrant and limiting that reveal the quality of the justification. If there is no valid justification for the claim or the justification rejects the claim, the claim is rejected by refutation (Erduran et al., 2004). Given the entire process, the use of proper justification is more important than scientific claim(s) (Aldağ, 2006; Yakmacı Güzel, Erduran, & Ardaç, 2009). For this reason, strong justification results in a better argumentation process. Thus, the argumentation process gives an opportunity for students to gain such skills as argumentation and reasoning whilst constructing scientific knowledge (Erduran & Jimenez-Aleixandre, 2007).

Because the aforementioned processes/skills are consistent with the objectives of science curriculum, an adaptation of argumentation into science education studies have often been preferred. Given the characteristics of argumentation and science education, presenting the historical development of argumentation in science education is crucial to see its overall effect(s). As a matter of fact, Erduran, Özdem, and Park (2015) went over the argumentation studies (between 1998 and 2014) published in three important journals (Science Education, International Journal of Science Education and Journal of Research in Science Education) in order to identify the effectiveness of the argumentation studies and their trends. The articles were categorized according to year of publication, cognitive (find evidence, explain, make reasoning) and linguistic (negotiation, conversation, discussion) aspects of argumentation keywords and the distribution of these keywords over years. However, to determine trends in the argumentation studies necessitates investigating their different aspects (i.e. purpose, methodology, sample, conclusion, recommendation). In this regard, the current study handles different parameters from Erduran et al. (2015)'s study. On the other hand, the fact that Erduran et al. (2015) did not include all argumentation studies (published in other journals and theses) has appeared an unexplored important area in identifying the trends in the argumentation studies, which is of interest in the present study. In other words, a need for an extensively synthesis of the argumentation studies (not only three journals) has resulted in the current study. Therefore, reviewing these studies in regard to *aims, methods, sampling, data collection, data analysis, argumentation topics, argumentation models, results and recommendations* might provide a holistic view of the argumentation. Similarly, this thematic review would provide insights of the results of the argumentation studies over years as well as their effectiveness. Furthermore, a thematic review at the K-8 level would also inform future studies on unexplored areas.

This research aimed to thematically review the argumentation studies at the K-8 level from 2006 to 2016. For this purpose, the following questions guided the current study:

1. What were the aims of the argumentation studies?
2. What methods did these studies use?
3. Which sample levels did these studies prefer?
4. What data collection tools did these studies exploit?
5. What data analysis methods did these studies use?
6. What topics did these studies focus on?
7. Which type(s) of argumentation did these studies involve?
8. Which argumentation model(s) did these studies exploit?
9. What were the results of these studies?
10. Which recommendations did these studies depict?

The Significance of the Study

Considering the impact(s) of argumentation on learning outcomes, identifying its possible effects and results on science education is quite important for the relevant literature. In particular, because the majority of the argumentation studies were conducted with such samples as high school and university, the researchers critically asked whether argumentation might be effective at the K-8 level. Phrased differently, they inquired whether the K-8 level possessed some problems in creating an appropriate argumentation environment. Furthermore, the idea 'argumentation involving in such processes as argument and reasoning should be acquired from an early age' called the current study for thematically reviewing the argumentation studies at the K-8 level. In other words, this thematic review could shed more light on how to effectively implement the argumentation studies at the K-8 level as well as eliciting their deficiencies. Given the foregoing issues, the current study is unique to fill in an important gap in the related literature. Hence, this study would offer an opportunity for researchers, teachers and curriculum developers to follow the trends in the argumentation studies by lessening their workloads.

Limitations of the Study

This research aimed to examine the argumentation studies in science education in that the number of studies in science education is higher than other disciplines (social studies, Turkish, mathematics). Thereby, it was intended to accumulate adequately the argumentation studies to emerge reasonable results. On the other hand, reviewing several disciplines via a thematic review may act as a barrier for an in depth analysis. Overall, the current study is limited to the argumentation studies in science education.

To find a realistic trend with contemporary studies, the current study has paid more attention to the studies published in recent years. For this reason, the researchers decided to take into account the argumentation studies in a period of 2006-2016, which may be seen as another limitation of the current study.

Finally, the idea 'argumentation process should be acquired from early ages' has led to only consider the argumentation studies at the K-8 level. For this reason, this may be viewed as another limitation of the current study.

Method

This study employed the thematic review, which critically synthesizes trends in studies of a field (e.g. science education) by creating themes and templates (Çalık & Sözbilir, 2014; Çalık, Ünal, Coştu, & Karataş, 2008). Hence, the thematic review provides a rich source for researchers, who work in the relevant field and have limited access to all studies (Çalık, Ayas, & Ebenezer, 2005; Ültay & Çalık, 2012). Because this study aimed to examine the argumentation studies at the K-8 level, the thematic review was preferred.

Data Collection

This study searched international and national well-known databases to go over the argumentation studies in the K-8 level. Firstly, to gather related studies in international literature published in a period of 2006--2016, the following well-known databases were looked for respectively; Academic Search Complete, Education Research Complete, ERIC (EBSCO), Springer LINK, Taylor & Francis, Wiley Online Library Full Collection, Science Direct, ProQuest Dissertations and Theses Global, Sage Premier 2013, Google Scholar and Scopus (A&I). Then, the subsequent national databases were searched; ULAKBIM National Databases and YOK National Thesis Centre. The keywords were as follows: *argumentation, scientific argumentation, science education, K-8 level, elementary school.* Hence, a total of 88 studies were found. 7 out of the argumentation studies, which were not open-access, were requested from correspondence authors by e-mails. However, only 2 of them returned and sent full-texts of their theses. Moreover, in case any duplication, theses and articles belonging to the same author were matched with each other; and theses were preferred to the articles. As a result, this study thematically handled with a total of 82 studies (9 theses and 73 articles).

Data Analysis

All articles and theses from the related literature were initially transferred to Nvivo 9.2 software. These studies were examined in detail by means of content analysis using the program (Patton, 2002). Afterwards, parameters were determined for the thematic review. These parameters were: *aim, method/design, sample, data collection, data analysis, subject employed for argumentation, type of used argumentation, argumentation model, general knowledge claim and recommendation.* A sample data analysis of these parameters is presented in Table 1.

Table 1. A Sample Data Analysis of These Parameters

Aim	**Methodology-Design**[a]	**Sample**[b]	**Data collection**[c]	**Data analysis**[d]	**Subject employed for argumentation**	**Type of used argumentation**	**Argumentation model**	**General knowledge claim**	**Recommendation**
To analyze 6th grade students' argumentation process of "heating and isolation" topic	Qualitative Case Study	Middle school	Video records	Descriptive analysis	Heating and isolation	Argumentation activities developing argumentation skills of	Toulmin's model	Students used basic arguments of the 'heating and isolation' topic.	In-class activities improving argumentation skills should be planned

[a,b,c,d] Some of the studies may contain more than a research method, data collection and data analysis. If any study contains several characteristics of one parameter, it can be coded more than once in the same parameter. In this case, frequency of the parameter under investigation may exceed the total number of the study.

Each study was categorized and coded separately in accordance with the parameters (see Table 1). Thus, a total of 50 codes were determined. The aforementioned parameters also constituted the themes determined by the codes in the content analysis. Discussion and results were presented in regard to these themes and codes.

Validity and Reliability of the Study

The studies under investigation were carefully examined to avoid any missing data. Coding procedure was meticulously carried out given the parameters. To minimize any error, all codes for each study were utterly performed. This process took about a month. Also, after the codes and themes, re-confirmations from the findings to the themes, the codes, the aim of the study and raw data were made. A group of experts (researchers and two post-graduate students, who enrolled to 'Meta-synthesis applications in primary teacher education') independently coded two studies randomly selected for the credibility of the codings. Hence, inter-rater co-efficient formulated by Miles and Huberman (1994) was found to be 0.96. A high value of the inter-rater co-efficient drove the researchers to conduct coding procedure themselves (Çil, 2010). In addition, an expert, who was quite familiar with content analysis and thematic review, looked over this analysis procedure and ensured its suitability and applicability.

Findings

Frequencies of the argumentation studies via the codes and themes are presented in this section. Frequencies of the *aim* theme and related codes are displayed in Table 2.

Table 2. Frequencies of the Aims of the Argumentation Studies

Theme	Codes	f
Aim	The effect of argumentation on related variable (achievement and attitude)	29
	The development of argumentation with intervention (using different methods and techniques)	19
	Diagnosing the existing case(s) of argumentation (level of skill, competence)	13
	The effect of different teaching tools (i.e. laboratory, online software(s), computer games) on argumentation	8
	Design based argumentation (material, evaluation tool, etc.)	6
	The relationship between argumentation and different variable(s) (individual-group discussions, science learning)	4
	Factors affecting argumentation (subject matter of knowledge)	3
Total		82

As seen in Table 2, the 'aim' theme consisted of seven different codes. Of these codes, while the effect of argumentation on related variable denotes such factors as achievement and attitude; intervention means the effect(s) of different methods and techniques on the development of argumentation. Also, different teaching tools comprises of science laboratory, online software(s), computer games etc. Diagnosing the existing case(s) contains to determine levels of argumentation skills and/or competences. The 'Design-based argumentation' code contains devising any teaching material and assessment tool of the argumentation processes as well as testing its effectiveness. Further, the relationship between argumentation and different variables embraces the link(s) between individual/group discussion and students' argumentation skills. The 'Factors affecting argumentation' code addresses the studies on what factors influence the argumentation process and students' skills (i.e. subject matter of knowledge).

As can be seen in Table 2, 29 of the argumentation studies fell into the code 'the effect of argumentation on related variable' whereas the frequency of the studies classified under the code 'The development of argumentation with intervention' was 19. Frequencies of the codes 'Diagnosing the existing case(s) of argumentation', 'The effect of different teaching tools on argumentation', 'Design based argumentation', and 'The relationship between argumentation and different variable(s)' were 13, 8, 6 and 4 respectively.

Frequencies of the *methodology/design* theme in the argumentation studies are presented in Table 3.

Table 3. Frequencies of the Methodology/Design Theme in the Argumentation Studies

Theme	Codes		f
Methodology/Design	Quantitative	Experimental	26
		Other (Quantitative but design is not specified)	2
	Qualitative	Case study	11
		Grounded theory	2
		Action research	2
		Other (Qualitative but design is not specified)	18
	Mixed (Quantitative + Qualitative)		16
	Design based research		4
	A systematically review study		1
Total			82

As seen in Table 3, 26 of the argumentation studies were carried out with experimental research methodology, whereas 16 of them were conducted with mixed (quantitative + qualitative) methodology. 18 of the argumentation studies were labelled under 'other' code (qualitative but the design is not specified), while 11 of them were implemented with case study methodology. Frequencies of the argumentation studies, which employed action research, systematically review study, grounded theory and design based research were 2, 1, 2 and 4 respectively. Further, two argumentation studies were classified under 'Other' code, which was quantitative with unspecified design.

Frequencies of the '*sample*' theme in the argumentation studies are shown in Table 4.

Table 4. Frequencies of the sample theme in the argumentation studies

Theme	Codes	f
Sample	8th grade	30
	7th grade	21
	6th grade	22
	5th grade	18
	4th grade	10
	3rd grade	7
	2nd grade	2
Total		110

As can be seen in Table 4, frequencies of the *sample* theme in the argumentation studies were 30 for 8th grade, 21 for 7th grade, 22 for 6th grade, 18 for 5th grade, 10 for 4th grade, 7 for 3rd grade and 2 for 2nd grade.

Frequencies of the *data collection tool* theme in the argumentation studies are presented in Table 5.

Table 5. Frequencies of the Data Collection Tool Theme in the Argumentation Studies

Theme	Codes	f
Data Collection Tool	Open-ended questions	40
	Audio-video record	30
	Interview	26
	Alternative tools	16
	Written text	16
	Rubric	14
	Observation	13
	Learning Science Based on Argumentation (LSBA) report form	2
Total		147

As seen in Table 5, 40 of the argumentation studies used open-ended questions, whilst 30 of them exploited audio-video records. 26 of them deployed interviews while 16 of them preferred alternative tools. Frequencies of the argumentation studies, which recruited written texts and observations, were 14 and 13 respectively. Also, two of the argumentation studies collected data with the Learning Science Based on Argument (LSBA) report form involving templates for teachers and students in the argumentation process.

Frequencies of the *data analysis* theme in the argumentation studies are displayed in Table 6.

Table 6. Frequencies of the Data Analysis Theme in the Argumentation Studies

Theme	Codes		f
Data Analysis	Quantitative	T-test	18
		ANOVA	14
		ANCOVA	12
		Mann Whitney U	3
		MANCOVA	2
		Regression	2
		MANOVA	1
	Qualitative	Descriptive analysis	27
		Content analysis	22
	Alternative scoring keys		13
Total			114

As seen in Table 6, 27 of the argumentation studies used descriptive analysis, whereas 22 of them exploited content analysis. Frequencies of the argumentation studies, which employed t-test, ANOVA and ANCOVA were 18, 14 and 12 respectively. Also, 13 of these studies deployed alternative scoring keys. Further, frequencies of the argumentation studies, which recruited Mann Whitney U test, MANCOVA, Regression analysis and MANOVA, were 3, 2, 2 and 1 respectively.

Frequencies of the *subject employed for argumentation* theme in the argumentation studies are presented in Table 7.

Table 7. Frequencies of the Subject Employed for Argumentation Theme in the Argumentation Studies

Theme	Codes	f
Subject Employed for Argumentation	Physics (pressure, force and motion, matter)	22
	Biology (plants, biodiversity, living, photosynthesis)	14
	Socio-scientific issues (Genetically modified products, use of the water)	9
	Environment (ecosystems, climate change)	8
	Science (history of science, nature of science)	6
	Chemistry (solutions, diffusion, reaction)	5
	Others	18
Total		82

As seen in Table 7, 22 of the argumentation studies focused on physics topics whilst 14 of them concentrated on biology topics. Further, 9 of them used 'environment' topics while frequencies of the argumentation studies, which exploited socio-scientific issues and 'science' topics, were 8 and 6 respectively. Also, 6 of them employed chemistry topics for argumentation. Moreover 18 of them (investigating the existing cases and argumentation skills) did not explicitly state the subject employed for argumentation.

Frequencies of the *type of used argumentation* theme in the argumentation studies are shown in Table 8.

Table 8. Frequencies of the Type of Used Argumentation Theme in the Argumentation Studies

Theme	Codes		f
Type of Used Argumentation	Activities developing argumentation skills		29
	The development of argumentation with different teaching tools	Argumentation with online computer software	8
		Argumentation with alternative methods	8
		Argumentation with computer game	2
		Argumentation with laboratory activities	2
	Argumentation-oriented curriculum		17
Not applicable			16
Total			82

As seen in Table 8, frequency of the argumentation studies categorized under the 'Activities developing argumentation skills' code was 29, while that for the 'Argumentation-oriented curriculum' code was 17. Also, frequencies of the argumentation studies, which used argumentation along with online computer software, alternative methods, computer game and laboratory activities, were 8, 8, 2 and 2 respectively.

Frequencies of the *argumentation model* theme in the argumentation studies are shown in Table 9.

Table 9. Frequencies of the Argumentation Model Theme in the Argumentation Studies

Theme	Codes	f
Argumentation Model	Toulmin (1958)	21
	Osborne et al. (2004)	14
	Clark and Sampson (2008)	1
	Belland (2008)	1
	Furtak et al. (2008)	1
	Chen (2011)	1
	Park and Kim (2012)	1
	Venville and Dawson (2010)	1
Not applicable		41
Total		82

As can be seen in Table 9, the *argumentation model* theme consisted of eight different codes. These models were called with authors' names. 21 of the argumentation studies focused on Toulmin Model (1958), whereas 14 of them concentrated on that of Osborne et al. (2004). The rest of the argumentation studies only employed their authors' models. That is, one study was available for the argumentation models of Clark and Sampson (2008), Belland (2008), Furtak et al. (2008), Chen (2011), Park and Kim (2012) and Venville and Dawson (2010).

Frequencies of the *general knowledge claim* theme in the argumentation studies are presented in Table 10.

Tablo 10. Frequencies of the General Knowledge Claim Theme in the Argumentation Studies

Theme	Codes		f
General Knowledge Claim	Effectiveness of the teaching intervention	Positive effect	45
		Neutral effect	3
		Negative effect	2
	Levels of Argumentation		16
	Factors influencing argumentation (prior knowledge, learning motivation, classroom atmosphere)		7
	Effectiveness of technology integrated argumentation		7
	Unclear		2
Total			82

As seen in Table 10, five different codes appeared in this theme. 50 of the argumentation studies referred to the effectiveness of the teaching intervention with argumentation. Moreover, 45 out of 50 argumentation studies had positive effect, while 3 out of them depicted neutral effect. Also, two studies classified under the code 'Effectiveness of the teaching intervention' reported a negative effect. In addition, 16 of the argumentation studies provided general knowledge claims for levels of argumentation; frequencies of the codes 'Factors influencing argumentation' and 'Effectiveness of technology integrated argumentation' were the same (7 by 7).

Frequencies of the *recommendation* theme in the argumentation studies are presented in Table 11.

Table 11. Frequencies of the Recommendation Theme in the Argumentation Studies

Theme	Codes	f
Recommendation	Implications for classroom practices	25
	Implications for future studies	23
	Implications for practitioners or specialists	14
	Implications for design based studies	6
	Not applicable	14
Total		82

As seen in Table 11, 25 of the argumentation studies recommended implications for classroom practices, whilst 23 of them illuminated implications for future studies. Also, while 14 of them made implications for practitioners or specialists, 6 of them suggested design based studies.

Discussion and Conclusion

Given the results of the argumentation studies, a high number of the code 'The effect of argumentation on related variable' (see Table 2) may come from the idea viewing attitude and achievement as the most important dependent variables (Aymen Peker, Apaydın, & Taş, 2012; Çalık, Ültay, Kolomuç, & Aytar, 2015). Also, the fact that attitude and achievement tests may easily be administered to collect many data may have led researchers to frequently prefer these variables within the aims of the argumentation studies. A high number of the argumentation studies under the codes 'The development of argumentation with intervention' may result from the experimental research design that most of researchers often prefer. In other words, the question 'How does various teaching interventions impact the argumentation process?' may have triggered such a trend in the argumentation studies. A great number of the argumentation studies under the code 'Diagnosing the existing case(s) of argumentation' may stem from a learning demand on students' levels and competences of argumentation process. Furthermore, the number of the argumentation studies under the code 'The effect of different teaching tools on argumentation' was very limited for integrating technologies into argumentation (Squire & Jan, 2007). This may result from complex structure of technology-integrated argumentation. On the other hand, this may come from financial burden in creating such a learning environment. A low number of the argumentation studies accompanied with technological tools seems to have disregarded the use of technology in the teaching process that provides several significant benefits (perception, competency, academic achievement, self-efficacy etc.) (Çalık, 2013). This may stem from inability to exploit technological tools (Kaleli Yılmaz, 2015). In addition, low frequencies of the argumentation studies under the codes 'The relationship between argumentation and different variable(s)' and 'Factors affecting argumentation' reveal a missing point that needs to be elaborated. This may come from complicated frameworks of relationships/factors as compared to the argumentation studies of attitude, achievement, intervention and diagnosis.

The fact that the argumentation studies often used qualitative research methods (see Table 3) may come from the nature of the argumentation process. That is, qualitative research methodologies may be viewed as more appropriate to analyze the argumentation process and/or arguments. Furthermore, a close numerical relationship between quantitative and qualitative research designs may result from their research aims examining the development of argumentation with different interventions. Namely, such a process may have increased the number of experimental research design. Also, a low number of the argumentation studies with mixed method (quantitative + qualitative) may neglect advantages of mixed method. Otherwise, these studies may have not preferred it due to its possible requirements and workload(s). The fact that some of the argumentation studies with the experimental research methodology deployed both quantitative and qualitative methods may stem from a need for an in-depth analysis and data triangulation. Further, this may come from their concerns of validity and reliability of the study. Moreover, the fact that few studies methodologically recruited action research, systematically review and grounded theory, may result from their varied requirements and workloads (common dominant view(s) of quantitative methodologies, a lack of knowledge of these methodologies, time, sampling etc.). On the other hand, a lack of meta-analysis and meta-synthesis on the argumentation studies at the K-8 level shows an unexplored area that needs to be filled. However, these studies require researchers to systematically handle and synthesize the related studies via higher-order skill(s). In other words, especially limited number of the argumentation studies in the K-8 level seems to have resulted in a deficiency of meta-analysis and meta-synthesis.

The fact that majority of the argumentation studies were conducted with 5th, 6th, 7th and 8th grade students (see Table 4) may come from the idea 'an increase in age result in better argumentation

skills'. On the contrary, given the idea 'individuals develop scientific images from early ages' (Güler & Akman, 2006), students at early ages (i.e. primary school) are able to claim original ideas and defend their arguments. Unfortunately, given pivotal role of early ages, minority of the argumentation studies was carried out with 2nd, 3rd and 4th grade students. Hence, how students evolve argumentation skills/competences should be explored. But, limited number of the argumentation studies in the lower grades may stem from difficulties in determining proper science topics.

As seen in Table 5, the argumentation studies mostly exploited open-ended questions and audio-video records. A higher frequency of open-ended questions in the quantitative research methodologies may come from selecting the experimental research methodology. However, these tests were mostly used to go over the effect(s) of argumentation on other independent variables (e.g. academic achievement, attitude) rather than directly examining the argumentation skills. A demand easily describing the level of argumentation in a short time seems to have encouraged researchers to prefer these tests (especially, open-ended questions) (Günay & Aydın, 2015). In addition, the majority of the argumentation studies employing qualitative records seem to have preferred measuring the argumentation skills through long-term observations. This may result from the idea 'levels of argumentation skills should be measured through observations instead of tests'. However, as compared with the foregoing data collection tools, frequencies of the argumentation studies employing interviews and observations were very low. This may stem from concerns of missing data. In fact, audio-video records are germane to observation. However, advantages of audio-video records (i.e. repeated watching if necessary) seem to be more suitable for the qualitative studies. Therefore, the argumentation studies may have preferred using audio-video records to direct/participant observations. The fact that few argumentation studies used the argumentation reports may result from avoiding a single template. Instead, the argumentation studies could have preferred different appropriate templates, surveys or alternative assessments in regard to the frameworks of their research interests.

The fact that frequencies of the argumentation studies using quantitative and qualitative data analysis were almost the same (see Table 6) may stem from their research aims. That is, the argumentation studies seem to have generalized their results with quantitative data analysis as well as deeply making sense of the argumentation processes through qualitative data analysis. The fact that the frequency of qualitative descriptive analysis was slightly higher than that of content analysis may stem from the idea 'descriptive analysis is more appropriate and time-efficient to respond research questions in analyzing audio-video record, interviews, observations and student reports'. A high frequency of t-test in quantitative data analysis may come from the experimental research methodology with pre- and post-test design. Similarly, variance analysis in quantitative analysis may result from the studies examining the effects of argumentation on students' attitudes and achievement levels. In other words, this may come from the studies investigating the effect(s) of data collection tools on descriptively eliciting argumentation levels. Furthermore, the limited frequency of regression analysis may be attributed to few studies focusing on the relationships between argumentation and different variables.

A higher frequency of the argumentation studies dealing with physics topics (see Table 7) may stem from an individual perception 'people frequently encounter physics topics in daily life and maximally link science with life' (Ayaz & Söylemez, 2015). The fact that some of the argumentation studies concentrated on biology, environment topics and socio-scientific issues may come from their scientific properties (e.g. nature, living things, human life, society and ill-structured scientific issues). Moreover, few studies of science and chemistry may arise from their limited ratios of the objectives in the K-8 science curriculum. Thus, researchers seem to have possessed difficulties in preparing argumentation activities for these scientific disciplines.

A high frequency of the argumentation studies classified under 'Activities developing argumentation skills' (see Table 8) may stem from a high frequency of the experimental research methodology. Additionally, the argumentation studies seem to have paid more attention to the development of the argumentation skills. The frequency of the argumentation studies developing the argumentation skills through computer software and computer game pointed out some problems in integrating technological tools into science learning. Furthermore, because there were only two studies employing laboratory activities in the argumentation process, the argumentation studies seem to have neglected to actively stimulate student's curiosity of learning. This may be viewed as an important gap in the argumentation studies. Phrased differently, limited number of the argumentation studies accompanied with technology and laboratory can be interpreted as a crucial deficiency in argumentation-oriented teaching tools into science education.

The argumentation studies under investigation mostly underpinned by the Toulmin Model (1958) and its adapted version by Osborne et al. (2004) (see Table 9). Structures and quality of students' arguments were evaluated given elements of these argumentation models. Although Toulmin (1958) launched his own argumentation model, Osborne et al. (2004) indicated how to practically use argumentation in science classes. For this reason, Osborne et al.'s (2004) argumentation model, which has been popular since early of 2000s, has often been preferred by science educators. The fact that the remaining of argumentation models was seldom used may result from an unclear argumentation process or a lack of explicitly illuminating argumentation process. Further, the fact that the foregoing argumentation models (Osborne et al., 2004; Toulmin, 1958) were dominantly employed in the argumentation process may have overshadowed the others.

Most of the argumentation studies reported positive effects of the interventions on the argumentation process and/arguments (see Table 10). This effect may come from contemporary teaching strategies (i.e. student-centred learning, inquiry based learning) and experimental practices in science classes (that engage students in experimental scientific practices) rather than conventional ways (Aydeniz, Pabuccu, Çetin, & Kaya, 2012; Herrenkohl & Cornelius, 2013; Kabataş Memiş, 2014; McNeill, 2011). Further, neutral effect in the argumentation studies may stem from the preferred intervention, which has already been suggested by science curriculum. Similarly, negative effect may result from improper use of the argumentation. Minority of the argumentation studies referred to general knowledge claims of the developmental levels of students' arguments. The fact that these studies went over the number and quality of the arguments in depth seems to have possessed less attraction as compared with the experimental studies. Also, limited alternative argumentation models, apart from the Toulmin model (1958), seem to have resulted in few studies in determining the level of argument. Nevertheless, the fact that few studies investigated the effectiveness of technology-oriented argumentation and the factors influencing the argumentation may stem from a priority perception. That is, the argumentation studies may have preceded the effectiveness of any intervention and/or the developmental level of argument. Phrased differently, the studies eliciting students' competence levels of the argumentation may have been preferred. Besides, a low frequency of the argumentation studies integrating technological tools into argumentation process seems to have yielded limited general knowledge claims of technology-integrated argumentation.

The argumentation studies recommended several implications for the questions 'How to get students to have a good argumentation?' 'How to create a classroom culture?' and 'How to assess the arguments/argumentation process?' (Belland, Glazevski, & Richardson, 2011; Chin & Osborne, 2010; Yun & Kim, 2015). These recommendations may come from few studies handling these issues that need to be inquired. Besides, the argumentation studies suggested several future researches that examine the relationships between argumentation and different variables (Çinici et al., 2014; Skoumios, 2009). Such an implication for future research may result from a need to identify how different factors (e.g. environment, family) affect students' argumentation skills. Similarly, examining the effects of technology-integrated argumentation was also recommended for future research (Ault, Craig-Hare, Frey, Ellis, & Bulgren, 2015). A rapid integration of technology into science education may have

appeared this implication for future research in the argumentation studies. Finally, an implication for repeating similar research with different samples (Kaya & Kılıç, 2008) may come from a need for generalizing the effectiveness of the preferred intervention(s) or testing its applicability for other samples. However, low frequencies of the argumentation studies studying on practitioners, specialists, and design-based studies seem to have appeared limited implications for them.

Recommendations

Given general knowledge claims of the argumentation studies, the current study addresses the following recommendations:

1. Because few studies determined the factors affecting students' argumentation skills, further studies ought to be undertaken about such factors as topics of argumentation, student readiness, discussion habits, scientific habits of mind. In addition, at which level these factors are related to argumentation skills should be inquired.
2. Few studies under investigation employed mixed methods to examine the argumentation process and the development of argument skills. For this reason, argumentation studies should be methodologically enriched with ethnographic research, action research, etc.
3. Taking into account proverb 'You cannot teach an old dog new tricks', few argumentation studies were available at primary school. Future studies are supposed to deeply examine the argumentation process at the primary school. Further, how to improve these argumentation skills should be inquired throughout intervention/design-based researches.
4. Argumentation studies should focus on chemistry, biology, environment and science rather than physics. Hence, developing appropriate argumentation activities for various disciplines may improve students' attitudes towards these disciplines and shape conceptual framework(s).
5. Given the widespread use of technology and significant investments in technological facilities, technology-integrated argumentation should be increased and tested its possible effect(s) on students' argumentation skills.
6. Considering the importance of the laboratory into science education, different laboratory activities should be designed to improve their argumentation skills. Thus, laboratories may not only engage students in learning scientific discussion process but also support long-term learning via experimental continuum.
7. Given the idea 'different cultures have different perception(s) of the argumentation process', cross-cultural studies should be implemented to probe various conceptual frameworks and assessment criteria.

References

Aldağ, H. (2006). Toulmin's debate model. *Çukurova Universities Journal of Social Science Institute*, *15*(1), 13-34.

Au, W. (2007). High-stakes testing and curricular control: A qualitative metasynthesis. *Educational Researcher*, *36*(5), 258-267. doi:10.3102/0013189X07306523

Ault, M., Craig-Hare, J., Frey, B., Ellis, J. D., & Bulgren, J. (2015). The effectiveness of Reason Racer, a game designed to engage middle school students in scientific argumentation. *Journal of Research on Technology in Education*, *47*(1), 21-40. doi:10.1080/15391523.2015.967542

Ayaz, M. F., & Söylemez, M. (2015). The effect of the project-based learning approach on the academic achievements of the students in science classes in Turkey: A meta-analysis study. *Education and Science, 40*(178), 255-283.

Aydeniz, M., Pabuccu, A., Çetin, P. S., & Kaya, E. (2012). Argumentation and students' conceptual understanding of properties and behaviours of gases. *International Journal of Science and Mathematics Education, 10*, 1303-1324. doi:10.1007/s10763-012-9336-1

Aymen Peker, E., Apaydın, Z., & Taş, E. (2012). Understanding the thermal insulation with argumentation: The case studies with 6th grade students. *Dicle University Journal of Social Science Institute*, *4*(8), 79-100.

Bakırcı, H., Çalık, M., & Çepni, S. (2017). The effect of the common knowledge construction model-oriented education on sixth grade students' views on the nature of science. *Journal of Baltic Science Education, 16*(1) 43-55.

Belland, B. R. (2008). *Supporting middle school students' construction of evidence-based arguments: Impact of and student interactions with computer-based argumentation scaffolds* (Doctoral dissertation). Purdue University, West Lafayette.

Belland, B. R., Glazevski, K. D., & Richardson J. C. (2011). Problem-based learning and argumentation: testing a scaffolding framework to support middle school students' creation of evidence-based arguments. *Instructional Science, 39*, 667-694. doi:10.1007/s11251-010-9148-z

Berland, L. K., & Reiser, B. J. (2011). Classroom communities' adaptations of the practice of scientific argumentation. *Science Education*, *95*(2), 191-216. doi:10.1002/sce.20420

Berland, N. K., & McNeill, K. L. (2012). For whom is argument and explanation a necessary distinction? A response to Osborne and Patterson. *Science Education, 96*(5), 808-813. doi:10.1002/sce.21000

Çalık, M. (2013). Effect of technology-embedded scientific inquiry on senior science student teachers' self-efficacy. *Eurasia Journal of Mathematics, Science & Technology Education*, *9*(3), 223-232. doi:10.12973/eurasia.2013.931a

Çalık, M., & Sözbilir, M. (2014). The parameters of the content analysis. *Education and Science*, *39*(174), 33-38.

Çalık, M., Ayas, A., & Ebenezer, J. V. (2005). A review of solution chemistry studies: insights into students' conceptions. *Journal of Science Education and Technology, 14*(1), 29-50. doi:10.1007/s10956-005-2732-3

Çalık, M., Ültay, N., Kolomuç, A., & Aytar, A. (2015). A cross-age study of science student teachers' chemistry attitudes. *Chemistry Education: Research and Practice, 16*(2), 228-236 doi:10.1039/c4rp00133h

Çalık, M., Ünal, S., Coştu, B., & Karataş, F. Ö. (2008). Trends in Turkish science education. *Essays in Education*, Special Edition, 23-45.

Chen, Y. C. (2011). *Examining the integration of talk and writing for student knowledge construction through argumentation* (Doctoral dissertation). University of Iova, Iova.

Chin, C., & Osborne, J. (2010). Students' questions and discursive interaction: their impact on argumentation during collaborative group discussions in science. *Journal of Research in Science Teaching*, *47*(7), 883-908. doi:10.1002/tea.20385

Çil, E. (2010). *Teaching the nature of science with conceptual change pedagogy and direct reflective approach* (Doctoral dissertation). Karadeniz Technical University, Institute of Nature and Applied Science, Trabzon.

Çinici, A., Özden, M., Akgün, A., Herdem, K., Deniz, Ş. M., & Karabiber, H. L. (2014). To assess the effectiveness of argumentation-based applications supported by Concept cartoon. *Adıyaman University Journal of Social Science Institute*, *18*, 571-596.

Clark, D. B., & Sampson, V. (2008). Assessing dialogic argumentation in online environments to relate structure, grounds, and conceptual quality. *Journal of Research in Science Teaching, 45*(3), 293-321. doi:10.1002/tea.20216

Erduran, S., & Jimenez-Aleixandre, M. P. (2007). *Argumentation in science education: Recent developments and future directions*. New York, NY: Springer.

Erduran, S., Özdem, Y., & Park, J. Y. (2015). Research trends on argumentation in science education: a journal content analysis from 1998-2014. *International Journal of STEM Education*, *2*(5), 1-12. doi:10.1186/s40594-015-0020-1

Erduran, S., Simon, S., & Osborne, J. (2004). TAPping into argumentation: Developments in the application of Toulmin's argument pattern for studying science discourse. *Science Education*, *88*, 915-933. doi:10.1002/sce.20012

Evagorou, M., & Osborne, J. (2013). Exploring young students' collaborative argumentation within a socioscientific issue. *Journal of Research in Science Teaching, 50*(2), 209-237. doi:10.1002/tea.21076

Furtak, E. M., Ruiz-Primo, M. A., Shemwell, J. T., Ayala, C. C., Brandon, P. R., Shavelson, R. J., & Yin, Y. (2008). On the fidelity of implementing embedded formative assessments and its relation to student learning. *Applied Measurement in Education*, *21*(4), 360-389. doi:10.1080/08957340802347852

Güler, T., & Akman, B. (2006). 6 year old children's views of science and scientist. *Hacettepe University Journal of Education Faculty*, *31*, 55-66.

Günay, R., & Aydın, H. (2015). Inclinations in studies into multicultural education in Turkey: A content analysis study. *Education and Science*, *40*(178), 1-22.

Günel, M., Kıngır, S., ve Geban, Ö. (2012). Analysis of argumentation and questioning patterns in argument-based inquiry classrooms. *Education and Science*, *37*(164), 316-330.

Herrenkohl, L. R., & Cornelius, L. (2013). investigating elementary students' scientific and historical argumentation. *The Journal of the Learning Sciences, 22*, 413-461. doi:10.1080/10508406.2013.799475

Hiğde, E., & Aktamış, H. (2017). Fen bilgisi öğretmen adaylarının argümantasyon temelli fen derslerinin incelenmesi: Eylem araştırması. *İlköğretim Online*, *16*(1), 89-113.

Kabataş Memiş, E. (2014). The views of primary school students about the argumentation-based approach to learning science applications. *Kastamonu Education Journal, 22*(2), 401-418.

Kaleli Yılmaz, G. (2015). The views of mathematics teachers on the factors affecting the integration of technology in mathematics courses. *Australian Journal of Teacher Education*, *40*(8), 8. doi:10.14221/ajte.2015v40n8.8

Kaya, O. N., & Kılıç, Z. (2008). Argumentative discourse for effective science teaching. *Kırşehir Journal of Education Faculty, 9*(3), 89-100.

Khishfe, R. (2014). Explicit Nature of science and argumentation instruction in the context of socioscientific issues: An effect on student learning and transfer. *International Journal of Science Education, 36*(6), 974-1016. doi:10.1080/09500693.2013.832004

Köseoğlu, F., Tümay, H., & Budak, E. (2008). New insights about the paradigm shift and teaching about the nature of science. *Gazi Journal of Education Faculty, 28*(2), 221-237.

Maloney, J., & Simon, S. (2006). Mapping children's discussions of evidence in science to assess collaboration and argumentation. *International Journal of Science Education*, *28*(15), 1817-1841. doi:10.1080/09500690600855419

McNeill, K. L. (2011). Elementary students' views of explanation argumentation, and evidence, and their abilities to construct arguments over the school year. *Journal of Research in Science Teaching, 48*(7), 793-823. doi:10.1002/tea.20430

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

Ministry of National Education. (2013). Primary school science and technology curriculum. Retrieved from http://ttkb.meb.gov.tr/www/ogretim-programlari/icerik/72.

Munford, D. (2002). *Situated argumentation, learning and science education: A case study of prospective teachers' experiences in an innovative science course* (Doctoral dissertation). The Pennsylvania State University, Pennsylvania.

Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argumentation in school science. *Journal of Research in Science Teaching*, *41*(10), 994-1020. doi:10.1002/tea.20035

Özkara, D. (2011). *Pressure subject to be taught to eighth grade students with activities based on scientific argumentation* (Unpublished master's thesis). Adıyaman University, Institute of Nature and Applied Science, Adıyaman.

Park, J., & Kim, H. (2012). Theoretical considerations on analytical framework design for the interactions between participants in group argumentation on socio-scientific issues. *Journal of the Korean Association for Research in Science Education*, *32*(4), 604-624. doi:10.14697/jkase.2012.32.4.604

Patton, M. Q. (2002). *Qualitative Research & Evaluation Methods* (3rd ed.). London: Sage Publications.

Pedretti, E., & Nazir, J. (2011). Currents in STSE Education: Mapping a Complex Field, 40 Years on. *Science Education*, *95*, 601-626. doi:10.1002/sce.20435

Ravenscroft, A. (2000). Designing argumentation for conceptual development. *Compute Education*, *34*, 241-255.

Sadler, T. D. (2006). Promoting discourse and argumentation in science teacher education. *Journal of Science Teacher Education*, *17*, 323-346. doi:10.1007/s10972-006-9025-4

Simon, S. (2008). Using Toulmin's argument pattern in the evaluation of argumentation in school science. *International Journal of Research & Method in Education, 31*(3), 277-289. doi:10.1080/17437270802417176

Skoumios, M. (2009). The effect of sociocognitive conflict on students' dialogic argumentation about floating and sinking. *International Journal of Environmental & Science Education, 4*(4), 381-399.

Song, D., Karimi, A., & Kim, P. (2015). A remotely operated science experiment framework for under-resourced schools. *Interactive Learning Environments*, *24*(7), 1706-1724. doi:10.1080/10494820.2015.1041407

Squire, K. D., & Jan, M. (2007). Mad city mystery: Developing scientific argumentation skills with a place-based augmented reality game on handheld computers. *Journal of Science Education and Technology, 16*(1), 5-29. doi:10.1007/s10956-006-9037-z

Topdemir, H. G., & Unat, Y. (2014). *History of Science* (7th ed.). Ankara: Pegem A Publications.

Toulmin, S. (1958). *The Uses of Argument*. Cambridge: Cambridge University Press.

Ültay, N., & Çalık, M. (2012). A thematic review of studies into the effectiveness of context-based chemistry curricula. *Journal of Science Education and Technology*, *21*(6), 686-701. doi:10.1007/s10956-011-9357-5

Uluçınar Sağır, Ş., & Kılıç, Z. (2013). The effect of teaching of scientific debate into primary students' understand of level of nature of science. *Hacettepe University Journal of Faculty of Education*, *44*, 308-318.

Uskola, A., Maguregi, G., & Jimenez-Aleixandre. (2010). The use of criteria in argumentation and the construction of environmental concepts: A university case study. *International Journal of Science Education, 32*(17), 2311-2333.

Varelas, M. (1996). Between theory and data in a seventh-grade science class. *Journal of Research in Science Teaching*, *33*(3), 229-263.

Venville, G. J., & Dawson, V. M. (2010). The impact of a classroom ıntervention on grade 10 students' argumentation skills, ınformal reasoning, and conceptual understanding of science. *Journal of Research in Science Teaching*, *47*(8), 952-977. doi:10.1002/tea.20358

Yakmacı Güzel, B., Erduran, S., & Ardaç, D. (2009). Student chemistry teachers' use of scientific discourse (argumentation) technic in chemistry course. *Boğaziçi University Journal of Education, 26*(2), 33-49.

Yun, S. M., & Kim, H. B. (2015). Changes in students' participation and small group norms in scientific argumentation. *Research in Science Education*, *45*(3), 465-484. doi:10.1007/s11165-014-9432-z

Appendix 1. A List of Studies Reviewed

Acar, Ö., Tola, Z., Karaçam, S., & Bilgin, A. (2016). Argümantasyon destekli fen öğretiminin 6. sınıf öğrencilerinin kavramsal anlamalarına, bilimsel düşünme becerilerine ve bilimin doğası anlayışlarına olan etkisi. *Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi, 16*(3), 730-749.

Ault, M., Craig-Hare, J., Frey, B., Ellis, J. D., & Bulgren, J. (2015). The effectiveness of Reason Racer, a game designed to engage middle school students in scientific argumentation. *Journal of Research on Technology in Education*, *47*(1), 21-40. doi:10.1080/15391523.2015.967542

Aymen Peker, E., Apaydın, Z., & Taş, E. (2012). Understanding the thermal insulation with argumentation: Case studies primary with grade 6 students. *Dicle University, Journal of Social Science Institute*, *4*(8), 79-100.

Balcı, C. (2015). *The effect of argumentation based learning the teaching of "cell division and inheritance" unit to grade 8 students* (Unpublished master's thesis). Adnan Menderes University, Institute of Nature and Applied Science, Aydın.

Balcı, C., & Yenice, N. (2016). Effects of the scientific argumentation based learning process on teaching the unit of cell division and inheritance to eighth grade students. *Journal of Education in Science, Environment and Health*, *2*(1), 67-84.

Bathgate, M., Crowell, A., Schunn, C., Cannady, M., & Dorph, R. (2015). The learning benefits of being willing and able to engage in scientific argumentation. *International Journal of Science Education*, *37*(10), 1590-1612. doi:10.1080/09500693.2015.1045958

Belland, B. R. (2010). Portraits of middle school students constructing evidence-based arguments during problem-based learning: The impact of computer-based scaffolds. *Educational Technology Research and Development*, *58*(3), 285-309. doi:10.1007/s11423-009-9139-4

Belland, B. R., Glazewski, K. D., & Richardson, J. C. (2011). Problem-based learning and argumentation: Testing a scaffolding framework to support middle school students' creation of evidence-based arguments. *Instructional Science*, *39*(5), 667-694. doi:10.1007/s11251-010-9148-z

Berland, L. K. (2011). Explaining variation in how classroom communities adapt the practice of scientific argumentation. *Journal of the Learning Sciences*, *20*(4), 625-664.

Berland, L. K., & Hammer, D. (2012). Framing for scientific argumentation. *Journal of Research in Science Teaching*, *49*(1), 68-94. doi:10.1002/tea.20446

Berland, L. K., & Lee, V. R. (2012). In pursuit of consensus: Disagreement and legitimization during small-group argumentation. *International Journal of Science Education*, *34*(12), 1857-1882. doi:10.1080/09500693.2011.645086

Berland, L. K., & McNeill, K. L. (2010). A learning progression for scientific argumentation: Understanding student work and designing supportive instructional contexts. *Science Education*, *94*(5), 765-793. doi:10.1002/sce.20402

Berland, L. K., & Reiser, B. J. (2011). Classroom communities' adaptations of the practice of scientific argumentation. *Science Education*, *95*(2), 191-216. doi:10.1002/sce.20420

Boyraz, D. S., Hacıoğlu, Y., & Aygün, M. (2016). Argumentation and concept complexity: Melting and dissolution. *Journal of Gazi University Faculty of Gazi Education*, *36*(2), 233-267.

Cavagnetto, A., Hand, B. M., & Norton-Meier, L. (2010). The nature of elementary student science discourse in the context of the science writing heuristic approach. *International Journal of Science Education*, *32*(4), 427-449. doi:10.1080/09500690802627277

Chen, H. T., Wang, H. H., Lu, Y. Y., Lin, H. S., & Hong, Z. R. (2016). Using a modified argument-driven inquiry to promote elementary school students' engagement in learning science and argumentation. *International Journal of Science Education*, *38*(2), 170-191. doi:10.1080/09500693.2015.1134849

Chen, J. J., Lin, H. S., Hsu, Y. S., & Lee, H. (2011). Data and claim: The refinement of science fair work through argumentation. *International Journal of Science Education, Part B*, *1*(2), 147-164. doi:10.1080/21548455.2011.582707

Chen, Y. C., Hand, B., & Park, S. (2016). Examining elementary students' development of oral and written argumentation practices through argument-based inquiry. *Science & Education*, *25*(3-4), 277-320. doi:10.1007/s11191-016-9811-0

Chin, C. C., Yang, W. C., and Tuan, H. L. (2016). Argumentation in a Socioscientific Context and its Influence on Fundamental and Derived Science Literacies. *International Journal of Science and Mathematics Education*, *14*(4), 603-617. doi:10.1007/s10763-014-9606-1

Chin, C., & Osborne, J. (2010). Students' questions and discursive interaction: Their impact on argumentation during collaborative group discussions in science. *Journal of Research in Science Teaching*, *47*(7), 883-908. doi:10.1002/tea.20385

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. doi:10.1080/10508400903530036

Chin, C., & Teou, L. Y. (2009). Using concept cartoons in formative assessment: Scaffolding students' argumentation. *International Journal of Science Education*, *31*(10), 1307-1332. doi:10.1080/09500690801953179

Choi, A., Notebaert, A., Diaz, J., & Hand, B. (2010). Examining arguments generated by year 5, 7, and 10 students in science classrooms. *Research in Science Education*, *40*(2), 149-169. doi:10.1007/s11165-008-9105-x

Cin, M. (2013). *The effects of concept cartoon based on argumentation activities on levels of students' conceptual understanding and scientific process skills* (Unpublished master's thesis). Dokuz Eylül University, Institute of Educational Science, İzmir.

Clark, D. B., & Sampson, V. (2008). Assessing dialogic argumentation in online environments to relate structure, grounds, and conceptual quality. *Journal of Research in Science Teaching*, *45*(3), 293-321. doi:10.1002/tea.20216

Çal, M., & Akarsu, B. (2016). Examination of argumentation-based interrogation skills of primary school 8th grade students on PISA question. *Journal of Education and Society Educational Sciences and Social Research in the 21st Century*, *5*(14), 35-53.

Çetin, P. S., Metin, D., & Kaya, E. (2016). A new approach to laboratory practice: Argument-based interrogation research. Journal of *Ahi Evran University Kırşehir Education Faculty*, *17*(2), 223-242.

Çinici, A., Özden, M., Akgün, A., Herdem, K., Deniz, Ş. M., & Karabiber, H. L. (2014). The examine the effectiveness of argumentation-based applications supported by concept cartoon. *Adıyaman University Journal of Social Science Institute*, *2014*(18), 571-596.

Demirel, R. (2015). Implementation of argumentation activities regarding the solid pressure. *Journal of Activity Based on Research*, *5*(2), 70-90.

Demirel, R. (2015). The effect of ındıvıdual and group argumentatıon on student academıc achıevement ın force and movement ıssues. *Journal of Theory & Practice in Education (JTPE)*, *11*(3), 916-948.

Demirel, R. (2016). Impact of argumentation-supported teaching on students' conceptual understanding and willingness to discuss. *Journal of Kastamonu Education*, *24*(3), 1087-1108.

Ersoy, N. (2014). *The effect of group-based case study to students' understand and to use scientific evidence, argumentation skills and their conceptual understanding* (Unpublished master's thesis). Dokuz Eylül University, Institute of Education Sciences, İzmir.

Evagorou, M., & Osborne, J. (2013). Exploring young students' collaborative argumentation within a socioscientific issue. *Journal of Research in Science Teaching*, *50*(2), 209-237. doi:10.1002/tea.21076

Foong, C. C., & Daniel, E. G. (2010). Incompetent grounds in science students' arguments: What is amiss in the argumentation process?. *Procedia-Social and Behavioral Sciences*, *9*, 1198-1207. doi:10.1016/j.sbspro.2010.12.307

Foong, C. C., & Daniel, E. G. (2013). Students' argumentation skills across two socio-scientific ıssues in a Confucian classroom: Is transfer possible?. *International Journal of Science Education*, *35*(14), 2331-2355. doi:10.1080/09500693.2012.697209

González-Howard, M., & McNeill, K. L. (2016). Learning in a community of practice: Factors impacting english-learning students' engagement in scientific argumentation. *Journal of Research in Science Teaching*, *53*(4), 527-553. doi:10.1002/tea.21310

Hand, B., Norton-Meier, L. A., Gunel, M., & Akkus, R. (2016). Aligning teaching to learning: A 3-year study examining the embedding of language and argumentation into elementary science classrooms. *International Journal of Science and Mathematics Education*, *14*(5), 847-863. doi:10.1007/s10763-015-9622-9

Harris, C. J., Phillips, R. S., & Penuel, W. R. (2012). Examining teachers' instructional moves aimed at developing students' ideas and questions in learner-centered science classrooms. *Journal of Science Teacher Education*, *23*(7), 769-788.

Hasançebi, F. (2014). *The effect of argumentation-based approach to learning science on students science achievements, argument-building skills and personal development* (Doctoral dissertation). Atatürk University, Institute of Education Sciences, Erzurum.

Herrenkohl, L. R., & Cornelius, L. (2013). Investigating elementary students' scientific and historical argumentation. *Journal of the Learning Sciences*, *22*(3), 413-461. doi:10.1080/10508406.2013.799475

Hong, Z. R., Lin, H. S., Wang, H. H., Chen, H. T., & Yang, K. K. (2013). Promoting and scaffolding elementary school students' attitudes toward science and argumentation through a science and society intervention. *International Journal of Science Education*, *35*(10), 1625-1648. doi:10.1080/09500693.2012.734935

Hsu, P. S., Van Dyke, M., Chen, Y., & Smith, T. J. (2016). A cross-cultural study of the effect of a graph-oriented computer-assisted project-based learning environment on middle school students' science knowledge and argumentation skills. *Journal of Computer Assisted Learning*, *32*(1), 51-76. doi:10.1111/jcal.12118

Jönsson, A. (2016). Student performance on argumentation task in the Swedish National Assessment in science. *International Journal of Science Education*, *38*(11), 1825-1840. doi:10.1080/09500693.2016.1218567

Kaya, O. N., & Kılıç, Z. (2008). Development of elementary school students' argumentativeness in science courses. *Ahi Evran University Kırşehir Faculty of Education Journal (KEFAD)*, *9*(1), 87-95.

Khishfe, R. (2014). Explicit nature of science and argumentation ınstruction in the context of socio-scientific issues: An effect on student learning and transfer. *International Journal of Science Education*, *36*(6), 974-1016. doi:10.1080/09500693.2013.832004

Kind, P. M., Kind, V., Hofstein, A., & Wilson, J. (2011). Peer Argumentation in the School Science Laboratory-Exploring effects of task features. *International Journal of Science Education*, *33*(18), 2527-2558. doi:10.1080/09500693.2010.550952

Knight, A. M. (2015). *Students' abilities to critique scientific evidence when reading and writing scientific arguments* (Doctoral dissertation). Boston University, Boston.

Kong, Y. T., & Kang, M. J. (2016). Case study of science writing with Argumentation on Biological ethics (I). *International Journal of Applied Engineering Research*, *11*(7), 4731-4735.

Küçük, H. (2012). *The effect of the use of scientific debate aided classroom activities in primary students' to conceptual understanding, inquiry learning skills, perceptions and attitudes towards science and technology* (Unpublished master's thesis). Muğla Sıtkı Koçman University, Institute of Education Sciences, Muğla.

Larrain, A., Freire, P., & Howe, C. (2014). Science teaching and argumentation: One-sided versus dialectical argumentation in Chilean middle-school science lessons. *International Journal of Science Education*, *36*(6), 1017-1036. doi:10.1080/09500693.2013.832005

Lazarou, D., Sutherland, R., & Erduran, S. (2016). Argumentation in science education as a systemic activity: An activity-theoretical perspective. *International Journal of Educational Research*, *79*, 150-166.

Maloney, J., & Simon, S. (2006). Mapping children's discussions of evidence in science to assess collaboration and argumentation. *International Journal of Science Education*, *28*(15), 1817-1841. doi:10.1080/09500690600855419

McNeill, K. L. (2011). Elementary students' views of explanation, argumentation, and evidence, and their abilities to construct arguments over the school year. *Journal of Research in Science Teaching*, *48*(7), 793-823. doi:10.1002/tea.20430

Memiş, E. K. (2014). The views of primary school students about the argumentation-based approach to learning science applications. *Kastamonu Education Journal*, *22*(2), 400-418.

Mork, S. M. (2012). Argumentation in science lessons: Focusing on the teacher's role. *Nordic Studies in Science Education*, *1*(1), 17-30.

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*(5), 1111-1133. doi:10.1007/s10763-010-9250-3

Namdar, B., & Demir, A. (2016). Örümcek mi böcek mi? 5. sınıf öğrencileri için argümantasyon tabanlı sınıflandırma etkinliği. *Journal of Activity Based on Research*, *6*(1), 1-9.

Naylor, S., Keogh, B., & Downing, B. (2007). Argumentation and primary science. *Research in Science Education*, *37*(1), 17-39. doi:10.1007/s11165-005-9002-5

Nichols, K., Gillies, R., & Hedberg, J. (2015). Argumentation-based collaborative inquiry in science through representational work: Impact on primary students' representational fluency. *Research in Science Education*, *46*(3), 343-364. doi:10.1007/s11165-014-9456-4.

O'Hallaron, C. L., & Schleppegrell, M. J. (2016). "Voice" in children's science arguments: Aligning assessment criteria with genre and discipline. *Assessing Writing*, *30*, 63-73.

Okumus, S., & Unal, S. (2012). The effects of argumentation model on students' achievement and argumentation skills in science. *Procedia-Social and Behavioral Sciences*, *46*, 457-461.

Osborne, J. F., Henderson, J. B., MacPherson, A., Szu, E., Wild, A., & Yao, S. Y. (2016). The development and validation of a learning progression for argumentation in science. *Journal of Research in Science Teaching*, *53*(6), 821-846. doi:10.1002/tea.21316

Osborne, J., Simon, S., Christodoulou, A., Howell-Richardson, C., & Richardson, K. (2013). Learning to argue: A study of four schools and their attempt to develop the use of argumentation as a common instructional practice and its impact on students. *Journal of Research in Science Teaching*, *50*(3), 315-347. doi:10.1002/tea.21073

Özkara, D. (2011). *Pressure subject to be taught to eighth grade students with activities based on scientific argumentation* (Unpublished master's thesis). Adıyaman University, Institute of Nature and Applied Science, Adıyaman.

Russ, R. S., Coffey, J. E., Hammer, D., & Hutchison, P. (2009). Making classroom assessment more accountable to scientific reasoning: A case for attending to mechanistic thinking. *Science Education*, *93*(5), 875-891. doi:10.1002/sce.20320

Ryu, S. (2011). *The appropriation and argumentation norms in a classroom community* (Doctoral dissertation). California University, Los Angeles.

Ryu, S., & Sandoval, W. A. (2012). Improvements to elementary children's epistemic understanding from sustained argumentation. *Science Education*, *96*(3), 488-526. doi:10.1002/sce.21006

Sadler, T. D., Romine, W. L., & Topçu, M. S. (2016). Learning science content through socio-scientific issues-based instruction: A multi-level assessment study. *International Journal of Science Education*, *38*(10), 1622-1635. doi:10.1080/09500693.2016.1204481

Shemwell, J. T., & Furtak, E. M. (2010). Science classroom discussion as scientific argumentation: A study of conceptually rich (and poor) student talk. *Educational Assessment*, *15*(3-4), 222-250. doi:10.1080/10627197.2010.530563

Shoulders, C. W. (2012). *The effects of a socio-scientific issues instructional model in secondary agricultural education on students' content knowledge, scientific reasoning ability, argumentation skills, and views of the nature of science* (Doctoral dissertation). Florida University, Florida, ABD.

Skoumios, M. (2009). The effect of sociocognitive conflict on students' dialogic argumentation about floating and sinking. *International Journal of Environmental and Science Education*, *4*(4), 381-399.

Song, D., Karimi, A., & Kim, P. (2015). A remotely operated science experiment framework for under-resourced schools. *Interactive Learning Environments*, *24*(7), 1706-1724. doi:10.1080/10494820.2015.1041407

Squire, K. D., & Jan, M. (2007). Mad city mystery: Developing scientific argumentation skills with a place-based augmented reality game on handheld computers. *Journal of Science Education and Technology*, *16*(1), 5-29. doi:10.1007/s10956-006-9037-z

Triantafillou, C., Spiliotopoulou, V., & Potari, D. (2015). The nature of argumentation in school mathematics and physics texts: The case of periodicity. *International Journal of Science and Mathematics Education*, *14*(4), 681-699. doi:10.1007/s10763-014-9609-y

Tsai, C. Y., Jack, B. M., Huang, T. C., & Yang, J. T. (2012). Using the cognitive apprenticeship web-based argumentation system to improve argumentation instruction. *Journal of Science Education and Technology*, *21*(4), 476-486. doi:10.1007/s10956-011-9339-7

Ulu, C., & Bayram, H. (2015). The effect of argumentation-based approach to learning activities based on laboratory science to seventh grade students learn concepts: Electrical unit in our lives. *Pamukkale University Faculty of Education Journal, 37*, 61-75.

Uluçınar-Sağır, Ş., & Kılıç, Z. (2013). The effect of the scientific debate focused on education to understanding the nature of science to the level of primary school students. *Hacettepe University Faculty of Education Journal*, *44*, 308-318.

Wang, J., & Buck, G. (2015). The relationship between Chinese students' subject matter knowledge and argumentation pedagogy. *International Journal of Science Education*, *37*(2), 340-366. doi:10.1080/09500693.2014.987713

Yang, W. T., Lin, Y. R., She, H. C., & Huang, K. Y. (2015). The effects of prior-knowledge and online learning approaches on students' inquiry and argumentation abilities. *International Journal of Science Education*, *37*(10), 1564-1589. doi:10.1080/09500693.2015.1045957

Yeh, K. H., & She, H. C. (2010). On-line synchronous scientific argumentation learning: Nurturing students' argumentation ability and conceptual change in science context. *Computers & Education*, *55*(2), 586-602.

Yeşildağ-Hasançebi, F., & Günel, M. (2013). Effects of argumentation based inquiry approach on disadvantaged students' science achievement. *Elementary Education Online*, *12*(4), 1056-1073.

Yun, S. M., & Kim, H. B. (2015). Changes in students' participation and small group norms in scientific argumentation. *Research in Science Education*, *45*(3), 465-484. doi:10.1007/s11165-014-9432-z