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The Impact of Argumentation on High School Chemistry Students' Conceptual Understanding, Attitude towards Chemistry and Argumentativeness

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Abstract

Argumentation activities, which have become prominent in the education literature, are an important process to improve conceptual understanding. According to researchers there is a relationship between the argumentation and conceptual change, and thus argumentation enhances conceptual understanding since an argument deals with disagreement, which is the first step of conceptual change. The purpose of this research is to explore the impact of classroom-based argumentation on high school students' conceptual understanding of chemistry concepts, their attitude towards chemistry, and argumentativeness when compared to traditional teaching approach. A quasi-experimental, pretest-posttest, control group design was used. The study was conducted with 53 students in Grade 9 and with the same students in the Grade 10. Implementations lasted 13 weeks in the first year and 8 weeks in the second year. The concept tests, attitude scale towards the chemistry, and argumentativeness scale were applied on both groups. Interviews to reveal the level of student understandings not defined by the concept tests were conducted at the end of each year with 6 students from each group. According to multivariate analysis of variance results, it was found that the experimental group students' conceptual understanding, attitude toward chemistry, and argumentativeness were significantly higher than those of the control group students.

Keywords: Argumentation, Argumentativeness, Attitude, Conceptual Understanding, High School Chemistry Students

Introduction

Scientific argumentation has a significant role in science learning for students since it is sometimes seen as a learning process and sometimes as the witnessing of the construction process of scientific information (Bricker & Bell, 2008). Therefore, scientific argumentation is considered as either a teaching approach or a tool for science education (Osborne, Erduran & Simon, 2004). A significant benefit of argumentation is that it allows students to consolidate existing knowledge and construct new knowledge for themselves based on the ideas of others; it also improves students' conceptual understanding and helps them realize that science is a social implementation (Driver, Newton, & Osborne, 2000).

Students' attitudes play a critical role in fostering deep understanding (Hong, et al., 2013). Does argumentation affect students' attitudes toward science courses? If so, is there anything that affects argumentation? Studies about argumentation have ignored the differences between students' argumentation skills (Lin & Mintzes, 2010). For instance, argumentative behavior like argumentativeness affects the argumentation process and vice versa (Infante & Rager, 1982). According to Infante (1982), there is a positive significant

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relationship between the amount of students' high school training in argumentation and their argumentativeness. Therefore, argumentation activities, aimed at improving students' conceptual understanding and attitude toward a subject affects argumentativeness as well.

This study will explore whether scientific argumentation affects activities on students' conceptual understanding, their attitude towards chemistry, and their argumentativeness through an experimental methodology.

Argumentation and Conceptual Understanding

In recent years, studies on the importance of argumentation in science education have become popular. According to new approaches, argumentation is an assistant tool to develop scientific knowledge (Erduran, Simon & Osborne, 2004) that plays an important role in developing new models and theories. Argumentation is also part of the social practice of scientists and, for this reason, many science educators should try to teach students how to construct and evaluate scientific arguments (Driver, Newton & Osborne, 2000). The relationship between argumentation and conceptual understanding is not clear so far as which one is the cause for the other (Venville & Dawson, 2010; Zohar & Nemet, 2002). Although research results sometimes can be different depending on whether argumentation topics are scientific or socio-scientific; the degree of understanding a topic may cause an increase in the quality and complexity of the argument (e.g. von Aufschnaiter, Erduran, Osborne & Simon, 2004; Sadler & Fowler, 2006; Skoumios, 2009), or conversely, engaging argumentation may positively influence understanding of a topic (e.g. Albe, 2008; Asterhan, 2008; Bell & Linn, 2000; Cross, Taasoobshirazi, Hendrick & Hickey, 2008;Eskin & Ogan-Bekiroglu, 2007; Lin, Hong, Wang, & Lee, 2011; Niaz, Augilera, Maza & Liendo, 2002; Nussbaum & Sinatra, 2003; Sampson & Gleim, 2009; Skoumios, 2009; Uluçınar Sağır & Kılıç, 2012; Venville & Dawson, 2010; Zhou, 2010). For example, Sadler and Fowler (2006) found that content knowledge affected argumentation quality. In their research, they interviewed 45 participants (i.e., high school students with variable genetics knowledge, college science major with advanced genetic knowledge, and college non science major with little genetic knowledge about gene therapy and cloning) to explore how they used scientific knowledge during argumentation. According to their results, the science major students whose content knowledge differed significantly from other groups had higher argumentation quality.

The researches that tried to reveal whether argumentation had an impact on conceptual understanding, they especially found, it had an important effect. For instance, Venville and Dawson (2010) studied four Grade 10 grade classes to determine the effect of argumentation on the students' conceptual understanding of genetics. Two classes were designated as the experimental group and the other two classes were the control group. A knowledge test was administered as a pre- and post-test. Although, the implementation consisted of only three lessons, they reported that the experimental group's mean genetic scores were significantly higher than the control group's mean genetic scores.

Aydeniz, Pabuccu, Çetin, and Kaya (2012) conducted a study with college students to investigate the effect of argumentation activities on their conceptual understanding of the properties and behavior of gases. An instructor taught the chemistry topic by lecture to the control and experimental groups, then five written and verbal argumentation activities took place in the experimental group. The impact of argumentation activities on students' understanding of chemistry concepts were searched with pre-post concept tests; the results indicated that the argumentation-based instruction had a positive impact on students' conceptual understanding of properties and behavior of gases.

Kaya (2013) conducted a similar study on the impact of argumentation practices on conceptual understanding of a chemistry topic. Her study had a quasi-experimental design with Grade 1 pre-service elementary science teachers. Chemical equilibrium was taught through argumentation-based practices to the experimental group and was taught through traditional design to the control group. In the experimental group, students completed five tasks about chemical equilibrium. In each task, pre-service teachers were asked to either answer the questions by justifying their answers or select one situation from two choices and justify their answer. A concept test was administered as pre and post test to both groups. The experimental group students attained higher scores than the control group.

Cross, Taasoobshirazi, Hendrick, and Hickey (2008) discussed whether argumentation promotes conceptual understanding; they proposed that engaging in argumentation causes understanding of pre-existing concepts, allows students to combine new knowledge with existing ones, and eliminates misconceptions.

Argumentation, Argumentativeness, and Attitude

Communication behaviors are affected by individual characteristics and situational factors, therefore, whatever the reason might be, sometimes students keep away from arguing, which affects their argumentation processes (Nussbaum & Bendixen, 2003). Conceptualizing and measuring students' tendencies to approach or avoid argumentative discourse is called argumentativeness which was described argumentativeness as "a general stable trait which predisposes the individual in communication situations to advocate positions on controversial issues and to attract verbally the position which other people take on these issues" (Infante & Rancer, 1982, p. 72). After an argument, some people feel invigorated and satisfied, and some people feel tense and nervous. Highly argumentative persons are happy during and after argumentation, low argumentative ones try to keep arguments from happening and feel relieved when an argument was avoided. (Infante & Rancer, 1982).

The influence of argumentativeness in a variety of communication contexts and the factors that affect argumentativeness has been established in studies (Infante, 1982; Levine & Boster, 1991; Rancer, Kolsberg, & Baukus, 1992). Levine and Boster (1991) showed that argumentativeness influenced the number of arguments during argumentation while Infante (1982) found a relationship between students' amount of high school training in argumentation and argumentativeness. Argumentativeness can be improved by training; thus, argumentation activities affect students' argumentativeness (Nussbaum & Bendixen, 2003).

It is useful to be aware of argumentative behavior for predicting student behavior in argumentative situations; and it is important to examine individual students' argumentativeness differences and to consider these differences when designing learning environments (Lin & Mintzes, 2010; Nusbaumm & Bendixen, 2003).

According to psychologists, attitude is an internal state and cannot be observed directly (Cheung, 2009). Attitude can be defined as positive or negative feelings about something; for instance, attitude toward science can be defined as "the feelings, beliefs and values held about an object that may be the enterprise of science, school science, the impact of science on society or scientists themselves" (Osborne, Simon, & Collins, 2003, p. 1053). Although there are some studies about constructivist design principles to facilitate students' attitude toward chemistry (Su, 2008), there are very few studies about the impact of argumentation on their attitude. In Ogunniyi and Hewson's (2008) study nine science teachers participated in a course based on argumentation to investigate their knowledge about the nature of science and an indigenous knowledge system; after six months, these teachers showed more positive attitudes and inclinations toward a science curriculum. In an important study about argumentation and attitude, Walker, Sampson, Grooms, Anderson, and Zimmerman (2012) compared the impact of an Argument Driven Inquiry (ADI) model on students' attitude toward a chemistry laboratory with a more traditional instructional approach. They found that the students in the ADI sections had a more positive attitude toward the chemistry laboratory than the students in the traditional laboratory sections.

Purpose and Significance of the Study

The objective of this study is the comparative investigation of the impact of classroom-based argumentation activities on high school students' conceptual understanding of chemistry concepts, attitude toward chemistry, and argumentativeness. The chemistry course unit "Nature of Matter" was taught to the Grade 9 students and the Gases" unit was taught to the same group of students in the Grade 10 through an argumentation-based approach. The students subjected to this method (experimental group) was compared with other students (control group), who learned the same topics through traditional education approaches in terms of conceptual understanding, their argumentativeness, and their attitude toward chemistry.

When the science education literature was reviewed, an increasing number of studies aimed to reveal the importance of argumentation was seen. Generally, such studies have been conducted with student and teacher groups and their results have been declared as qualitative or quantitative (e.g. Cross et al., 2008; Klosterman & Sadler, 2010). Among these, only a few studies tested students' pre and post understanding of relevant science conceptual knowledge and compared it with a control group (e.g. Aydeniz et al., 2012; Kaya, 2013; Venville & Dawson, 2010).

Some studies on this topic focused on the effect of argumentation on one dependent variable, such as conceptual understanding, critical thinking, argumentation quality or informal reasoning. Current study looked into the effects of an argumentation-based approach on three different dependent variables: students' conceptual understanding, their attitude toward chemistry, and their argumentativeness.

According to Nussbaum (2008), experimental research needs to be conducted about the effect of argumentation, but the experiments should use long-term interventions and assess outcomes using delayed post-tests. However, when the argumentation studies are reviewed, it is seen that the implementation period is limited to a few sessions or weeks (e.g. Jimenez-Aleixandre, Rodriguez, & Duschl, 2000; Niaz et al., 2002; Nussbaum & Sinatra, 2003; Venville & Dawson, 2010). Specifically, Nussbaum and Sinatra's (2003) research continued for only four discussion periods in a section; Niaz et al. (2002) had arguments with six relevant items in one session; and Venville and Dawson (2010) studied high school students for three courses that lasted for 50 minutes each. In this study, the same participants were engaged in argumentation during their Grades 9 and 10 for 21 weeks duration in total.

Furthermore, argumentation implementation in the aforementioned studies was limited one or two topic. (Asterhan, 2008; Sadler & Zeidler, 2005; Skoumios, 2009). Specifically, Skoumios (2009) used dialogic argumentation strategy to improve students' understanding of floating and sinking objects, and Sadler and Zeidler (2005) investigated the significance of knowledge during argumentation on cloning scenarios. In the current study, two chemistry units were included. Since the implementation periods and topics are limited, whether an actual change in students occurred due to argumentation activities or a different implementation brought success to students bored with traditional methods, or whether it caused a placebo effect in students, cannot be totally discounted. Also, argumentation is not a process that is easily understood; becoming familiar with the process takes time. Ogan-

Bekiroglu and Eskin (2012) stated that knowledge development in the argumentation process takes time. By establishing a longer implementation period in this study, the reliability of the study's results has been strengthened.

Research Design and Methodology

The study was conducted at an urban public high school in Çankırı, Turkey. Students were accepted to this school based on the results of an examination at the end of Grade 8. There were four Grade 9 classes in this school; students were distributed to these classes homogeneously in terms of their success by the school administration. Two of the four classes were picked randomly: one as the experimental group and the other as the control group. The school was selected by convenience sampling. The study had a quasi-experimental model with a pretest-posttest, control group design (Cohen & Manion, 1998; Fraenkel & Wallen, 1996).

Sample

The students were in Grade 9 at the start of the study and in Grade 10 at the completion of the study. Initially, there were 26 students (10 girls, 16 boys) in the experimental group and 27 students (13 girls, 14 boys) in the control group. Of these 53 students, some left the school, and some had a high absence rate; these students were removed from the study. In the Grade 10 sample, there were 22 students (10 girls, 12 boys) in the experimental group and 24 students (10 girls, 14 boys) in the control group. The ages of participants ranged from 13-15 years. The same qualified and experienced chemistry teacher taught all students. In the experimental group, students were separated into smaller groups of 4-5 people to carry out the argumentation activities. Since assigning individuals to the same gender group does not influence the overall performance of the argumentation (Chang & Chiu, 2009; Sampson & Clark, 2009), the gender issue was disregarded in groupings.

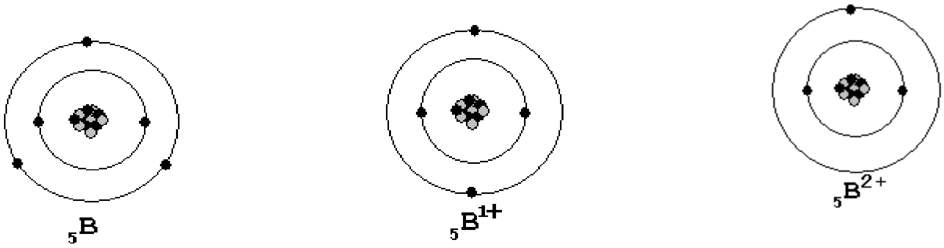
Data Collection

Throughout the study in Grades 9 and 10, three instruments were administered. Interviews were conducted to reveal the level of student understandings that were not defined by the concept tests. Descriptions of the instruments and interview processes used in the study are in the following sections.

Concept Tests (CT): Two concept tests (CT) were prepared for the study; the first CT was administered in Grade 9 and the second CT in Grade 10. Three university professors of chemistry education and four high school chemistry teachers checked both tests. Their responses provided scientifically correct answers and content validation for the instrument. The Nature of Matter Concept Test (CT1) consisted of 15 diagnostic questions in two phases. In the first phase, students were given three figures and were asked to decide which one best represented the related question or the incident. In the second phase, the students were asked to defend their earlier decision. The test was implemented upon 214 students before the current study, and the reliability coefficient (KR 20) was calculated as 0.89. An example question from CT1 was given below.

Which particles (atom or ions), given below, would it be harder to remove an electron from?

A) **B)** **C)**



Which sentence given below does support your answer?

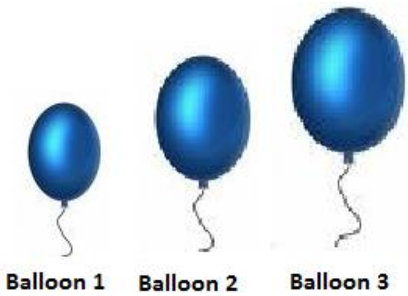
A) Because, it is harder to remove an electron from this particle due to the strength of attraction, if proton numbers are more than electron numbers
B) Because, it is more harder to remove an electron from atoms than from cations
C) Because, an atom becomes more stable when it loses an electron
D) Because, this ion has a filled shell electron configuration stability

The Gases Concept Test (CT2) consisted of 25 diagnostic questions in two phases. In the first phase, students were given five options for each question and were asked to mark the most probable correct option. In the second phase, they were asked to express the reason for their answer. The test was applied upon 280 students before the current study, and the reliability coefficient (KR 20) was calculated as 0.95. While both phases of the Grade 9 CT1 had multiple choices, the Grade 10 CT2 had multiple choices only in the first phase; the second phase was open-ended. The premise for this design was that Grade 10 students could express themselves better than Grade 9 students. An example question from CT2 was given below.

Not equal mass of gas were added to three identical elastic balloons: The balloon 1 had the smallest mass, balloon 2 had more than balloon 1 and, balloon 3 had the biggest mass. Compare the pressure of three balloons. Ignore the pressure of balloons due to elasticity.

a) Balloon I> Balloon II> Balloon III
b) Balloon III> Balloon II> Balloon I
c) Balloon I> Balloon II > Balloon III
d) Balloon I= Balloon II = Balloon III
e) Balloon II> Balloon III > Balloon I

Explain why you choose it:



Attitude toward Chemistry Scale: The attitude toward chemistry scale (AS) tested the students' attitude toward chemistry (Geban, Aşkar, & Özkan, 1992). The 5-point Likert scale test consisted of 15 items. Correnbach alpha reliability coefficients (α) of the scale was 0,82. It was calculated as 0.897 for Grade 9 and as 0.903 for Grade 10 for the current study.

Argumentativeness Scale: The argumentativeness scale (A) defined students' willingness for or avoidance of scientific debate (Infante & Rancer, 1982). This 5-point Likert scale test consisted of 20 items. Correnbach alpha reliability coefficients (α) of the scale was 0.86. It was calculated as 0,88 for Grade 9 and as 0.85 for Grade 10 for the current study.

Interviews: After implementation of the instruction and after the post CT in both Grades 9 and 10, semi-structured interviews with open-ended questions were conducted with 24 students in total; 6 students from each group (experimental and control) each year. Students were selected according to post CT results as “good,” “average,” and “bad”; two students from each category were selected. These categories were defined by dividing the range between minimum and maximum of CT scores into three equal parts. The parts which contained the highest scores called as good category, and which contained the lowest scores called as bad category. The goal of these interviews was to define the level of understanding missed by the CT. Think-aloud protocol was used in the interviews. In this protocol, an interview question was asked and participants were asked to verbalize their thoughts or solutions loudly. Each interview took approximately 30 minutes in each grade. Each interview was audio taped and later transcribed by the researchers.

Implementation

Students were accustomed to the traditional chemistry instructional approach, which sometimes utilizes confirmatory laboratory activities and video demonstrations. Although these students had no previous experience with or information about scientific argumentation, the chemistry teacher was familiar with argumentation. She was a chemistry teacher for 12 years, a doctoral student in chemistry education and had taken a semester-long course during her PhD education.

The Turkish educational system does not offer frequent argumentation activities to students. In order to familiarize students with argumentation and to reveal what they know about argumentation, an activity was held at the beginning of the implementation in the experimental group. In this activity, a student wants to improve his/her grades. To achieve that goal, he/she must pick one of three homework assignments but cannot decide which one to pick. The students were asked to help this undecided student by arguing the situation. No intervention was made to the students in this process. Later, Toulmin’s (2003) scientific argumentation pattern was explained. This pattern contains 6 components as data, claim, warrant, backings, qualifiers and rebuttals. These components of this pattern were explained to the students before the implementation. They were told that scientific argumentation is not only the expression of an idea but also supports the idea by justifications and, if possible, refutes the counter-argument. After the explanation of the scientific method, the students were given a few minutes to argue about the previous issue. In the early weeks of the implementation, the teacher frequently reminded the students of Toulmin’s argumentation pattern (TAP). In the current study, this pattern was used because it emerges as an effective strategy to improve the quality of arguments (Dawson & Venville, 2010) and also because the strategy is very useful for teaching argumentation (Osborne et al., 2004; Simon, 2008).

The study lasted 13 weeks in Grade 9 and 8 weeks in Grade 10. The groups were subjected to pretests in early weeks and to posttests and interviews after the implementation. In the experimental group, students were taught through an argument-based approach; in the control group, students were taught with a traditional instructional approach. In both groups, the courses were 3 hours in a week in Grade 9 and 2 hours in 2 days of a week in Grade 10 or 4 hours. Depending on the topic, students were encouraged to argue at least 2 times a week using TAP. Throughout this process, arguments were sometimes started by students’ questions, although rarely and sometimes ignited by questions thrown out by the teacher, but usually the activities prepared by the researchers were employed. Each activity was prepared as a written activity in order to helping students generate and connect their thoughts and ideas and consolidate their thinking (Cross, 2009). Each written activity was planned, revised, and discussed how it could be implemented with the teacher before the instruction. During application of activities, one of the researchers was in the classroom as well.

In the experimental group, students were separated into subgroups of 4-5 students, taking into account their achievement at chemistry and the suggestions of the teacher. Thus, each group was at similar level relative to each other, but the level of each student was different in the same group. In each written argumentation activity, students first studied individually, defined their claims, and then argued them. Later on, they held a dialogical argument with another student within their group, and finally they argued it as a group and defined the group's claims, warrants, and rebuttals. After concluding the argument within the group, students were given the same activity with instructions to complete it as a group. After the group argument ended and the activity papers collected, a few students from each group went to a different group, laid out their defenses, and performed the class argument activity. A sample from written argumentation activity was given as follow (Yalcin-Celik, Bektas, & Kilic, 2008).

Question: Which properties of elements are considered while the periodic table is formed?

Theory-1: We should think about three elements which resemble their properties each other. Average of the atomic masses first and third element is equal to those of second element. Periodic table was built by taking into account this theory.

Theory-2: The elements are arranged in increasing order of atomic mass in the periodic table.

Theory-3: The elements are arranged in increasing order of atomic number in the periodic table.

Evidence:

1- Lithium, sodium, and potassium are placed on same group, respectively. Hence, they have similar chemical properties. The approximately atomic mass of lithium is 7 and 39 that of potassium. Consequently, the atomic mass of sodium is 23 ((39+7)/2).

2- The atomic number of lanthanum and cerium is, respectively, 57 and 58. Also, lanthanum is d-block element and cerium is f-block element.

3- Copper and zinc are placed on side by side in the periodic table (first is copper, and then zinc). The atomic mass of copper is 63,546 g and that of zinc is 65, 39 g.

4- The atomic number of potassium is 19 and the atomic mass of potassium is 39, 0983 g. Likewise, the atomic number of calcium is 20 and the atomic mass of that 40,078 g. These two elements are placed on periodic table as side by side. (First element is potassium and then calcium).

5- The atomic number of titanium is 22, and that of vanadium is 23. These two elements are placed on periodic table as side by side.

6- Tin, antimony, and tellurium are placed on the periodic table as side by side. The atomic mass of the tin is 118 g and that of the tellurium is 125 g. Consequently, the atomic mass of antimony is 122 g ((125+118)/2).

7- Tellurium occurs before the iodine in the periodic table. While the atomic number of tellurium is 52 and the atomic mass of that is 127,60 g, the atomic number of iodine is 53 and the atomic mass of that 126,90 g.

8- Explain your own evidence if you have different evidence
Answer: Theory (…) is true since (…)

This written argumentation activity's structure was prepared according to a material named "competing theories with evidence and ideas" (Osborne et al., 2004) by one of the researchers. The activity includes one question-"Which properties of elements are considered while the periodic table is formed?"-, three theories which can be answers of the question, and evidence that support each theory. These theories were used to classify elements in the historical development of the periodic table. Students, initially, were asked to select one theory which can be an answer of the question. Then, they were asked to select evidence which support their theories and to refute the other theories (Osborne et al., 2004).

Chemistry topics for Grade 10 are suitable for experimenting. This unit consisted of behavior of gases, gas laws, and kinetic gas theory. As the experiments took a long time and class time was limited, the students were asked to argue individually; later they were given time to argue in groups. In both grades, written argumentation activities of individuals and groups were collected.

During implementation of the scientific argumentation activities, the teacher had an important role. The teacher listened to all the group arguments and asked many open-ended questions like "How do you know?", "Can you give any appropriate evidence?", "How do you support your claim?" or "Is there anyone who can refute this group's claim?" Then, she encouraged students to use evidence, support their claim, and rebut other claims. Sometimes the teacher acted as a member of a group and gave wrong evidence on purpose to deceive the group. During implementation in the experimental group, students applied important pedagogical tasks as individual written assignments, discussions between pairs of students, group discussions, and whole-class discussions.

In the control group, courses were conducted with a traditional approach. At the beginning of each lesson, the teacher asked questions about the previous course topic so that students could refresh their minds and be better prepared for that day's scheduled topic. In this phase, only a few students tried to answer the questions about nature of matter in Grade 9 and about gasses in Grade 10; others either approved or just listened. In the lessons, the teacher gave the lecture on the topics, gave examples from daily life, especially about gasses in Grade 10, to make it easier to understand, solved related problems, and if available showed slide presentations which were prepared by the teacher or movies about gas laws from internet, or pictures to make the relevant topics more visual. Students took notes, tried to solve the given problems, and watched the slide presentations. After teaching the preplanned topic for that particular lesson, the teacher spared time for students to ask the points that they could not understand. If students did not ask anything, the teacher concluded the lesson by solving test questions from preparation books for university examination. Although there were spontaneously developing discussions, the teacher did not teach or apply Toulmin's argumentation pattern in the control group.

Results

The level of prior knowledge of a subject is an important factor in students' ability to engage in effective argumentation (Koslowski, 1996, as cited in Cross et al., 2008). So, when engaging students in argumentation, their prior knowledge should be taken into account. Since the experimental and control groups could not be selected by random sampling, students' prior knowledge was controlled at the beginning of the implementation. To determine the difference in chemistry prior knowledge between groups, the chemistry success rate of the students was added to the research data.

In order to find out whether the experimental and control group students showed any difference in terms of dependent variables at the beginning of the implementation, *t*-test analysis were applied to the pretest (CT1, AS1, A1) and chemistry success scores (Table 1). The result of t-test analysis show that there was no statistically significant difference between the Grade 9 experimental and control group students in terms of dependent variables at the beginning of the implementation.

Table 1. Results of t-test Analyses of Both Group in Grade 9

Grade	Scale	Group	N	$\overline{X}$	S	df	t	p
9	CT1-pre	Experimental	26	4.04	1.69	51	0.16	0.87
		Control	27	4.11	1.63			
	AS-pre	Experimental	26	54.35	6.07	51	0.20	0.85
		Control	27	53.85	12.72			
	A_pre	Experimental	26	11.81	6.54	51	-0.35	0.73
		Control	27	12.41	7.62			
	Chemistry Success Scores	Experimental	26	65.81	11.37	51	1.49	0.15
		Control	27	60.85	13.11			

Multiple Analysis of Variance (MANOVA) was used to determine whether there was a significant difference between the control and experimental groups' posttest. For Grade 9, the preliminary assumption was conducted to check for normality, linearity, univariate and multivariate outliers, homogeneity of variance-covariance matrices, and multicollinearity. There were no serious violations noted. There was a statistically significant difference between the Grade 9 experimental and control groups on the combined dependent variables, [$F(3, 46) = 8.025$, $p = 0.000$; Wilks' $\lambda = 0.671$; $\eta^2 = 0.33$]. When the results for the dependent variables were considered separately, there were significant differences between conceptual understanding of chemistry concepts, [$F(1, 48) = 13.29$, $p = 0.000$, $\eta^2 = 0.21$]; attitude toward chemistry, [$F(1, 48) = 11.67$, $p = 0.000$, $\eta^2 = 0.19$]; and argumentativeness, [$F(1, 51) = 5.96$, $p = 0.000$, $\eta^2 = 0.11$], using a Bonferroni adjust alpha level of .087. An inspection of the mean scores (Figure 1) indicated that the experimental group scores were higher than the control group scores for conceptual understanding of chemistry concepts ($M = 9.00$, $SD = 1.83$ and $M = 7.22$, $SD = 1.72$, respectively), attitude toward chemistry ($M = 64.19$, $SD = 6.57$ and $M = 54.59$, $SD = 12.79$, respectively), and argumentativeness ($M = 17.54$, $SD = 5.70$ and $M = 13.00$, $SD = 7.65$ respectively).

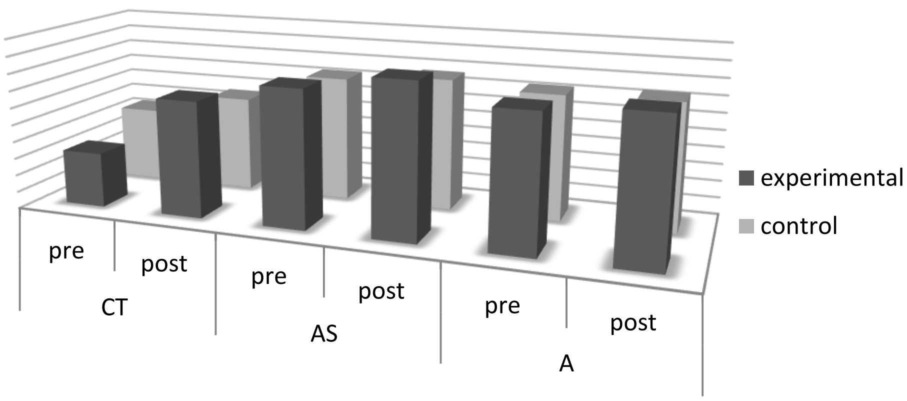


Figure 1. Changes of pre-post tests results of both groups in the Grade 9

According to the Grade 9 results, the argument-based approach was more effective when compared to the traditional approach in terms of understanding of nature of matter unit, increasing attitude toward chemistry, and argumentativeness.

For the Grade 10 results, a *t*-test was applied to CT2, AS2, and A2 pretest scores; a statistically significant difference in conceptual understanding and attitude toward chemistry scores was noticed between the experimental and control group (Table 2). For this reason, MANCOVA was applied to CT2, AS2, and A2 post-test scores by controlling the pre-test scores. The preliminary assumption was conducted, and there were no serious violations noted. According to the analysis results, there was a statistically significant difference between the Grade 10 experimental and control groups on the combined dependent variables, [$F(3, 39) = 34.66$, $p = 0.000$; Wilks' $\lambda = 0.273$; $\eta^2 = 0.73$].

Table 2. Results of *t-test* Analyses of Both Group in Grade 10

Scale	Group	N	$\overline{X}$	s	df	t	p
CT2-pre	Experimental	22	8.23	2.64	44	3.97	0.000
	Control	24	11.13	2.31			
AS-pre	Experimental	22	60.55	6.58	44	2.38	0.021
	Control	24	55.92	6.57			
A-pre	Experimental	22	18.27	7.35	44	1.95	0.057
	Control	24	13.00	0.53			

When the results for the dependent variables were considered separately, there were significant differences between conceptual understandings of chemistry concepts, [$F(1, 41) = 65.45$, $p = 0.000$, $\eta^2 = 0.62$]; attitude toward chemistry, [$F(1, 41) = 35.53$, $p = 0.000$, $\eta^2 = 0.46$]; and argumentativeness, [$F(1, 44) = 8.68$, $p = 0.005$, $\eta^2 = 0.18$] using a Bonferroni adjust alpha level of 0.17. An inspection of the mean scores (Figure 2) indicated that the experimental group scores were higher than the control group scores for conceptual understanding of related chemistry concepts ($M = 17.05$, $SD = 3.33$ and $M = 14.21$, $SD = 3.00$, respectively), attitude toward chemistry ($M = 67.41$, $SD = 5.44$ and $M = 58.29$, $SD = 6.62$, respectively), and argumentativeness ($M = 22.41$, $SD = 5.64$ and $M = 14.00$, $SD = 8.87$, respectively). According to these analysis results, argumentation has a profound effect on conceptual understanding, attitude toward chemistry, and argumentativeness with a large effect ($\eta^2 = 0.18$–0.62) (Cohen, 1988).

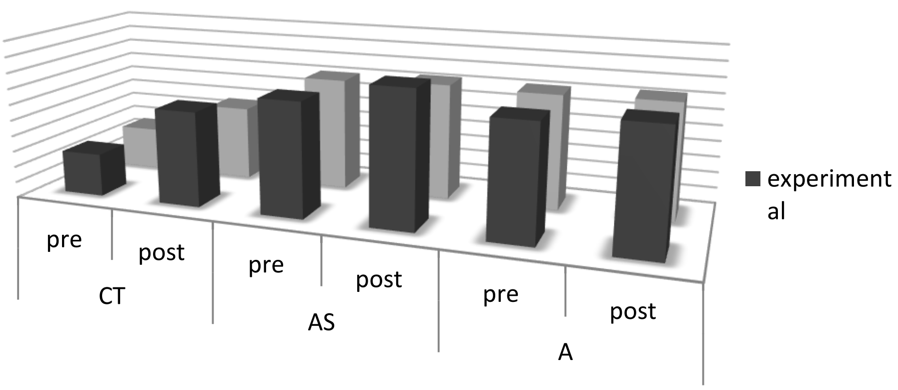


Figure 2. Changes of pre-post tests results of both groups in the Grade 10

Interviews

In this study, it has been understood that the experimental group students were more successful than the control group students in conceptual understanding of the two chemistry units. Interviews supported this result as well. In the Grade 9 interviews, 33% of the control group and 87% of the experimental group gave the right answers to the questions; in the Grade 10 interviews, 60% of the control group and 87% of the experimental group gave the right answers. While experimental group students backed their answers with scientific statements, control group students used memorized cliché sentences devoid of cause and effect relationship.

For example, in the Grade 9 interviews, students were asked to compare the radius of given atoms. The control group students said statements like *radius increases as one goes down the periodic table, and decreases as one goes right* while the experimental group students said *in the same period, since the atomic number is bigger, the effective force per electron increases and electrons are pulled stronger, and therefore the radius decreases*, and *the effective force applied by proton on the electron is bigger, because it has the smallest radius*.

In the Grade 10 interviews, students were asked a conceptual question: “If you would have an imaginary magnifying glass enabling you to see particles, what would you see when you look through the glass of a container having a mixture of CO_2 and O_2 gases in room temperature and in -50C degrees?” A student from the control group drew a figure to answer this question (Figure 3) and said *in room temperature, the gases would surround the container, the center would be empty ... it would take the shape of the container ... in -50C degrees, particles would get closer to each other because their attraction forces would increase.* It is a common misconception due to the thought gasses do not spread out homogenous.

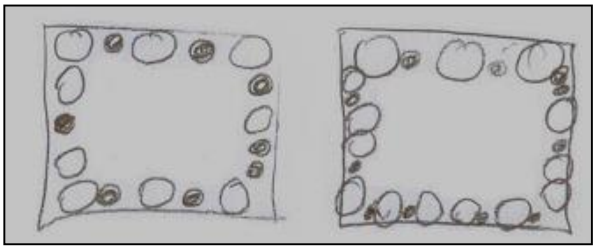


Figure 3. Student’s drawing 1

In interview, while control group students had misconceptions about gasses, experimental group students did not. However, some experimental group students showed the same misconception during argumentation activities in class. In the argumentation activity about how the physical features of gases would change with temperature, a student from experimental group thought that the gasses surround the container, did not spread out homogenous in room temperature and drew Figure 4a. After the group argumentation, the same student changed his misconception and thought gasses spread out homogenous in all temperatures (Figure 4b). This change in the student took place because of the argumentation activities.

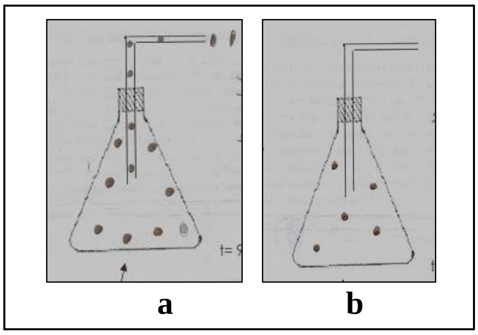


Figure 4. Student’s drawing 2

According to the interview results, it can be said that the Grades 9 and 10 experimental group students’ views on the nature of matter and gases units are much closer to the scientific view than those of the control group students.

Conclusion

The impact of argumentation on high school students’ conceptual understanding, attitude toward chemistry, and argumentativeness has been investigated in this study. According to the research results, an argumentation-based approach is more effective than the traditional approach for the aforementioned variables. The positive effect of an argumentation based approach on students’ conceptual understanding has been previously shown in the literature as well (e.g. Clark & Sampson, 2007; Driver et al., 2000; Duschl & Osborne, 2002; Nam, Choi & Hand, 2011; Niaz et al., 2002; Zohar & Nemet, 2002). In order to achieve conceptual change, new concepts should be compared with the students’ current concepts, new concepts should be taught in detail, arguments for the situation should be built, and the proper learning environment that helps thinking about counter-arguments should be provided (Dole & Sinatra, 1998; Nussbaum & Sinatra, 2003). In the current study, argument based approach might have provided a proper learning environment like that for conceptual understanding**.**

Another reason for enhanced conceptual understanding could be related to peer collaboration during argumentation since peer collaboration has been proven as a powerful way to improve conceptual understanding (Asterhan & Schwarz, 2009). Argumentation involves dialogue between at least two sides that have different opinions. During argumentation, students have opportunities to present and justify their ideas. This provides students the awareness of a thought that might be different from the commonly accepted scientific understanding of the term. Also, argumentation does not force students to get the scientific understanding but encourages them to learn and use them (Zhou, 2010).

Analysis of the scores showed that an argument-based approach had a significant effect on students’ attitudes toward chemistry. Also, the chemistry teacher explained the change observed in students as “students, who used to be passive in my class, became more participant after the argumentation activities and they became more self-confident [and] a group of students began to present the right attitude in supporting their own ideas.” There are not many studies investigating the effects of an argument-based approach on students’ attitudes; however, one study conducted in Turkey found that students resisted the approach and a long time was required for an attitude change (Uluçınar Sağır, 2008). Considering that the present study lasted for 21 weeks, it can be said that the effects of argumentation activities on students’ attitudes could be observed.

Another contributing factor for attitude development is that during the argumentation activities the classroom atmosphere turned into a place where students could easily express themselves without worrying about making mistakes. Students enjoyed this aspect; they were able to make a connection between knowledge and the course content, which increased their self-confidence.

One other result of this study is that argumentativeness was improved by an argument-based approach. Although argumentativeness is considered by some as a personality trait (Infante & Rancer, 1982), Nussbaum and Bendixen (2003) considered it as a behavioral disposition. Thus, one's level of argumentativeness can be increased with training (Rancer, Whitecap, Kolsberg, & Avtgis, 1997). One reason for the argumentativeness difference between the experimental and control group students might be due to the fact that experimental group students attended argumentation activities for 21 weeks.

There is a moderate and positive correlation between argumentativeness avoidance with communication apprehension (Infante & Rancer, 1982; Rancer & Infante, 1985). Communication apprehension is defined as "an individual's level of fear and anxiety associated with either real or anticipated communication with other person or persons" (McCroskey, 1977, p. 78). Being able to express themselves freely and openly throughout the implementation and frequent involvement in dual, triple, and class arguments might have helped the students to overcome their fears. Generally, students are unwilling to rebut the ideas of their friends; not only undergraduates but also upper-elementary level students resist challenging the ideas of their friends. This problem can arise from the belief that criticism may disrupt their friendship (Nussbaum & Bendixen, 2003). The experience that students defended totally opposing ideas with their closest friends and did not cause any problem in their friendships might have contributed to overcoming the fear that leads to improvement in argumentativeness.

Implications

In studies aiming to gather the misconceptions of students, usually the misconceptions are revealed through a multiple-choice concept test. Multiple-choice tests limit the students and prevent the real results from coming out. Students' mental models can easily be detected through their statements, while setting forth their arguments and presenting proof and support or while they try to rebut the counter argument during argumentation activities (Abi-El-Mona & Abd-El-Khalick, 2006). Since students are supposed to use their knowledge in justifying their arguments, misconceptions can be easily gathered. Even in current study, from the answers of students to written activities, some misconceptions were identified. Therefore, argumentation is one of the strong strategies that can be applied to identify the misconceptions. Studies including written argumentation activities might be made in identifying students' current misconceptions.

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References

Albe, V. (2008). When scientific knowledge, daily life experience, epistemological and social considerations intersect: Students' argumentation in group discussion on a socio-scientific issue. *Research in Science Education, 38*(1), 67-90

Asterhan, C.S.C. (2008). Process of Argumentation and explanation in conceptual change: Results from protocol analyses of peer-to-peer dialogue. *ICLS'08 Proceedings of the 8th International conference for the learning sciences - Volume 1.*Utrecht University Press.

Asterhan, C.S.C. & Schwarz, B.(2009). Argumentation and explanation in conceptual change: Indications from protocol analyses of peer-to-peer dialog. *Cognitive Science, 33*(3), 374-400.

Aydeniz, M., Pabuccu, A., Çetin, P.S. & Kaya, E. (2012). Impact of argumentation on college students' conceptual understanding of properties and behaviors of gases. *International Journal of Science and Mathematics Education, 10*(6), 1303-1321.

Bell, P. & Linn, M. (2000). Scientific arguments as learning artifacts: Designing for learning from the web with KIE. *International Journal of Science Education, 22*(8), 797-817.

Bricker, L.A. & Bell, P. (2008). Conceptualizations of argumentation from science studies and the learning sciences and their implications for the practices of science education. *Science Education, 92*(3), 473-498.

Chang, S.-N., & Chiu, M.H. (2008). Lakatos' scientific research programmes as a framework for analysing informal argumentation about socio scientific issues. *International Journal of Science Education*, *30*(13), 1753-1773.

Cheung, D. (2009). Developing a scale to measure students' attitudes towards chemistry lessons. *International Journal of Science Education, 31*(6), 2185-2203.

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

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum.

Cohen, L. & Manion, L. (1998). *Research Methods in Education*. (Fourth Edition). Routledge. London and New York.

Cross, D.I. (2009). Creating optimal mathematics learning environments: Combining argumentation and writing to enhance achievement. *International Journal of Science and Mathematics Education*, *7*(5), 905-930.

Cross, D.I., Taasoobshirazi, G., Hendrick, S. & Hickey, D. (2008). Argumentation: A strategy for improving achievement and revealing scientific identities. *International Journal of Science Education, 30*(6), 837-861.

Dawson, V.M. & Venville, G. (2010). Teaching strategies for developing students' argumentation skills about socioscientific issues in high school genetics. *Research in Science Education, 40*, 133-148.

Dole, J.A. & Sinatra G.M. (1998). Reconceptualizing change in the cognitive construction of knowledge. *Educational Psychologist, 33,* 109-128.

Driver, R., Newton, P. & Osborne, J. (2000). Establishing the norms of scientific argumentation in classroom. *Science Education*, *84*(3), 287-312.

Duschl, R.A. & Osborne J. (2002). Supporting and promoting argumentation discourse in science education*. Studies in Science Education 38*, 39-72.

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.

Eskin, H. & Ogan-Bekiroglu, F. (2007). Effects of promoting argumentation on students' reasoning physics. Paper presented at the annual international conference of the National Association for Research in Science Teaching. New Orleans, Louisiana.

Fraenkel, G.R. & Wallen, N.E. (1996). *How to Desingn and Evaulate Research in Science Education*. (Third Edition). McGraw-Hill, Inc. USA.

Geban, Ö., Aşkar, P. & Özkan, İ. (1992). Effects of computer simulations and problem-solving approaches on high school students, *Journal of Educational Research*, *86*(1), 5–10.

Hong, Z., Lin, H., Wang, H.H., Chen, H. & Yang, K. (2013). Promoting and scaffolding elementary school students' attitudes towards scince and argumentation through a science and society intervention. *International Journal of Science Education, 35*(10), 1625-1648.

Infante, D.A. (1982). The argumentative student in the speech communication classroom: An investigation and implications. *Communication Education, 31*,141-148.

Infante, D.A. & Rancer, A. S. (1982). A conceptualization and measure of argumentativeness. *Journal of Personality Assessment, 46,* 72–80.

Jimenez-Aleixandre, M.P., Rodriguez, B.A. & Duschl, R.,A. (2000). "Doing the lesson" or "doing science". Argument in high school genetics. *Science Education, 84*, 757-792.

Kaya, E. (2013). Argumentation practices in classroom: Pre-service teachers' conceptual understanding of chemical equilibrium. *International Journal of Science Education*. Advance online publication. doi:10.1080/09500693.2013.770935

Klosterman, M.L. & Sadler, T.D. (2010). Multi-level assessment of scientific content knowledge gains associated with socio scientific issues based instruction. *International Journal of Science Education, 32*, 1017-1043.

Levine T.R. & Boster, F.J. (1991). The impact of self and other's argumentativeness on talk about controversial issues. Paper presented at the meeting of the International Communication Association, Chicago, Illinois..

Lin, H.-S; Hong, Z.-R; Wang, H.-H. & Lee, S.-T. (2011). Using reflective peer Assessment to promote students' conceptual understanding through asynchronous discussions. *Educational Technology & Society, 14*(3), 178-189.

Lin, S-S & Mintzes, J.J. (2010). Learning argumentation skills through instruction in socioscientific issues: the effect of ability level. *International Journal of Science and Mathematics Education, 8*(6), 993-1017.

McCroskey, J.C. (1977). Oral communication apprehension: A summary of recent theory and research. *Human Communication Research, 4***,** 78-96.

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.

Niaz, M., Augilera, D., Maza, A. & Liendo, G. (2002). Arguments, contradictions, resistances, and conceptual change in students' understanding of atomic structure. *Science Education, 86*(4), 505-525

Nussbaum, E.M. (2008). Collaborative discourse, argumentation, and learning: Preface and literature review. *Contemporary Educational Psychology, 33,* 345-359.

Nussbaum, E.M. & Bendixen, L.D. (2003). Approaching or avoiding arguments: The role of epistemological belief, need for cognition, and extraverted personality traits. *Contemporary Educational Psychology, 28*, 573-595.

Nussbaum, E.M. & Sinatra, G.M. (2003). Argument & conceptual engagement. *Contemporary Educational Psychology, 28*, 384-395.

Ogan-Bekiroglu, F. & Eskin, H. (2012). Examination of the relationship between engagement in scientificargumentation and conceptual knowledge. *International Journal of Science and Mathematics Education, 10*(6), 1415-1443.

Ogunniyi, M.B., & Hewson, M.G. (2008). Effect on argumentation-based course on teachers' disposition towards a science-indigenous knowledge curriculum. *International Journal of Environmental & Science Education, 3*(4), 159-177.

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.

Osborne, J., Simon, S., & Collins, S. (2003). Attitude towards science: A review of the literature and its implications. *International Journal of Science Education, 25*(9), 1049-1079.

Rancer, A.S. & Infante, D.A. (1985). Relations between motivation to argue and argumentativeness of adversaries. *Communication Quarterly, 33*, 209-218.

Rancer, A.S, Kolsberg, R.L. & Baukus, R. A. (1992). Beliefs about arguing as predictors of trait argumentativeness: Implications for training in argument and conflict management. *Communication Education, 41*, 375-387.

Rancer, A.S., Whitecap, V.G., Kosberg, R.L. & Avtgis, T.A. (1997). Testing the efficacy of a communication training program to increase argumentativeness and argumentative behavior in adolescent. *Communication Education, 46,* 273-286.

Sadler, T.D. & Fowler, S.R. (2006). A threshold model of content knowledge transfer for socioscientific argumentation. *Science Education, 90*(6) 986-1004.

Sadler, T.D. & Zeidler, D.L. (2005). The significance of content knowledge for informal reasoning regarding socio scientific issues: Applying genetic knowledge to genetic engineering issues. *Science Education. 89*(1), 71-93.

Sampson, V. & Clark, D.B. (2009). The impact of collaboration on the outcomes of argumentation. *Science Education, 93*(3), 448-484.

Sampson, V. & Gleim, L. (2009). Argument-driven inquiry to promote the understanding of important concepts and practices in biology. *The American Biology Teacher, 71*(8), 465-472.

Simon, S. (2008). Using Toulmin's argumentation pattern in the evaluation of argumentation in school science. *International Journal of Research & Methods in Education, 31*(3), 277-289.

Simon, S., Erduran, S. & Osborne, J. (2006). Learning to teach argumentation: Research and development in the science classroom. *International Journal of Science Education. 28*(2-3), 235-260.

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

Su, K-D. (2008). The effects of a chemistry course with integrated information communication technologies on university students' learning and attitudes. *International Journal of Science and Mathematics Education, 6*(2), 225-249.

Toulmin, S.E. (2003). *The uses of argument* (updated ed.). Cambridge, England: Cambridge University Press.

Uluçınar Sağır, Ş. (2008). *The effect of argumentation-based teaching approach on elementary students' science course achievement* (Unpublished doctoral dissertation). Gazi University, Ankara, Turkey.

Uluçınar Sağır, Ş. & Kılıç, Z. (2012). Analysis of the contribution of argumentation based science teaching on students' success and retention. *Eurasian Journal of Physics and Chemistry Education, 4*(2), 139-156.

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

Von Aufschnaiter, C., Erduran, S., Osborne, J., & Simon, S. (2008). Arguing to learn and learning to argue: Case studies of how students' argumentation relates to their scientific knowledge. *Journal of Research in Science Teaching, 45*(1), 101-131.

Walker, J.P., Sampson, V., Grooms, J., Anderson, B. & Zimmerman, C.O. (2012). Argument-driven inquiry in undergraduate chemistry labs: The impact on students' conceptual understanding, argument skills, and attitude toward science. *Journal of College Science Teaching, 41*(4), 74-81.

Yalcin-Celik, A., Bektas, O., & Kilic, Z. (2008). *The understanding of the nature of science and overcoming misconceptions by using the course material activity: Competing theories with evidence and ideas.* Paper presented at the annual international conference of the International Organization of Science and Technology Education. Kusadasi, Izmir.

Zhou, G. (2010). Conceptual change in science: A process of argumentation. Eurasia *Journal of Mathematics, Science and Technology Education, 6*(2), 101-110.

Zohar, A. & Nemet, F. (2002). Fostering students' knowledge and argumentation skills through dilemmas in human genetics. *Journal of Research in Science Teaching, 39*(1), 35-62.