Mevlana International Journal of Education (MIJE) Vol. 2(3)
Special Issue: Inquiry in Science Education & Argumentation Based Science Inquiry,
pp. 1- 32, 30 December, 2012 Available online at http://mije.mevlana.edu.tr/

INVITED ARTICLE

Discourse, argumentation, and science lessons: match or mismatch in high school students' perceptions and understanding?

Ebru KAYA*

Selcuk University, Graduate School of Natural and Applied Sciences, 42003, Konya, Turkey

Sibel ERDURAN

University of Bristol, Graduate School of Education, 35 Berkeley Square, Bristol BS8 1JA, United Kingdom

Pinar Seda CETIN

Abant Izzet Baysal University, Department of Elementary Science Education, 14280, Bolu, Turkey

Article history

Received:
18 June 2012

Received in revised form:
-

Accepted:
03 August 2012

Key words:
Argumentation,
Discourse,
Metacognitive Skills,
Science Education,
Students' Perceptions

This study investigated high school students' perception and understanding of scientific argumentation. The sample consisted of 245 high school students. Two questionnaires were administered with the sample resulting in quantitative data. Qualitative analyses of students' responses were also carried out. The results indicate that students' understanding of scientific argument particularly with respect to their differentiation of justification is quite limited. Students have difficulties in understanding types of justification. Even though students appreciate the role of argumentation and discourse in science teaching and learning, their perceptions of the use of various strategies in the implementation of argumentation were contradictory. Students' perceptions of discourse are based on categories classified as knowledge, implementation, understanding, importance of science, actions by students and teachers, and classroom management. Students' perceptions' of argumentation include similar themes as in perceptions of discourse. There were only two different themes which were related to knowledge and nature of science instead of classroom environment and importance of science, respectively. This study contributes to the evidence base for understanding the connection between students' argumentation perceptions and their improved engagement in argumentative discourse. Additionally, the study suggests the need for developing students' metacognitive skills.

Introduction

In the past decades, there has been substantial research related to argumentation in science education (e.g., Erduran & Jimenez-Aleixandre, 2012; Erduran, Simon, & Osborne, 2004; Jimenez-Aleixandre, Bugallo-Rodriguez, & Duschl, 2000; Kelly & Takao, 2002; Zohar & Nemet, 2002). Numerous studies have been carried out following primarily qualitative research methodology that focused on argumentation from different approaches, for example, students' understanding of argument (Berland & Reiser, 2009), teachers' roles in argumentative discourse (Simon, Erduran, & Osborne, 2006; McNeill, 2009), epistemological aspects of argumentation (Sandoval, 2005), methodological perspectives (Erduran et al., 2004) quality of students' arguments and perceptions of teachers on argumentation (Sadler, 2006).

Argumentation as a critical discourse process in science has been promoted as part of conceptual and epistemic goals of science learning (Duschl & Osborne, 2002). There is evidence that engaging

* Correspondence: Ebru KAYA, Telephone: +90 (332) 323 8220-5461; e-mail: ebrukaya@gmail.com

in argumentation discourse is an effective way for students' development of conceptual understanding in science (Erduran & Jimenez-Aleixandre, 2012; Driver, Newton, & Osborne, 2000; Jimenez-Aleixandre et al., 2000; von Aufschnaiter, Erduran, Osborne, & Simon, 2008). Students have the opportunity to facilitate their conceptual understanding and to justify their views in an argumentative discourse environment. The discursive practices such as "assessing alternatives, weighing evidence, interpreting texts, and evaluating the potential viability of scientific claims" (Driver et al., 2000), which constitute scientific arguments, support developments of students' epistemological understanding (Erduran & Jimenez-Aleixandre, 2008). Enhancement of students' involvement to discursive practices makes a contribution to the realization of argumentation in the science classroom (Driver et al., 2000). Hence, there is widespread consensus that argumentation which contributes to students' conceptual and epistemological development in science should be explicitly taught in science classrooms (Simon et al., 2006).

Across the world, while some science education policies highlight the importance of argumentation in science education, some do not explicitly mention about argumentation and its role in science education (Jimenez-Aleixandre & Erduran, 2008). Jimenez-Aleixandre and Erduran (2008) present some excerpts from international educational policies in which argumentation is explicitly or implicitly addressed. The policies which do not explicitly state the importance of argumentation usually highlight the role of evidence and justifications in scientific inquiry. For example, the National Curriculum for General Science in Pakistan (NCGS, 2006) promotes inquiry-based curriculum as seen from the below excerpt:

> "Inquiry requires students to describe objects and events, ask questions and devise answers, collect and interpret data and test the reliability of the knowledge they've generated. They also identify assumptions, provide evidence for conclusions and justify their work." (NCGS, 2006, p.59)

Students who engage in argumentation discourse perceive "scientific inquiry as epistemological and social processes in which knowledge claims can be shaped, modified, restructured, and at times, abandoned" (Duschl, 2008, p.159). However, there is also evidence on students' difficulties in formulating arguments (Zeidler, 1997; Kuhn, 1970). The insufficient participation of students in classroom discourse can be viewed as a reason for their difficulties in connecting theory and evidence, that is to say, in constructing arguments at the level of classroom (Driver et al., 2000). Students' active participation in a discourse in a science classroom is important in terms of development of their scientific literacy which is one of the main aims of science education (Driver et al., 2000; Sadler, 2006). In a classroom environment, encouragement of students' involvement to discourse by questioning, justifying, and evaluating both their and others' explanations support construction of knowledge in their mind (Duschl & Osborne, 2002). Therefore, students need to be supported to be engaged in classroom discourse in an active way. Students' difficulties in constructing arguments and in participating in argumentative discourse result also from teachers' limited pedagogical skills in organizing activities supporting argumentation discourse (Newton, Driver, & Osborne, 1999; Duschl & Osborne, 2002).

Despite wealth of research on both teachers' and students' understanding of argumentation, there is very limited work on how teachers and students themselves perceive argumentation in science classrooms. Some studies on teaching of argumentation indicated that teachers had difficulties managing discussions (Newton et al., 1999). Time constraints and loaded curriculum are some views that teachers tend to express in explaining the problem of organizing an argumentative discourse in science classrooms (Newton et al., 1999). Teachers sometimes also feel insufficiently equipped in terms of pedagogical skills to use argumentation in their classrooms (Newton, et. al, 1999). In terms of students' perceptions of argumentation, even though numerous researchers have addressed the quality and nature of students' argumentation (e.g., Kelly & Takao, 2002; Erduran et al., 2004), work is rather scarce in how students view argumentation as well as the teaching and learning of argumentation. Furthermore, while substantial research focused on qualitative analyses of argumentation (Kaya, Erduran, & Cetin, 2010a), there is a limited research (Cetin, Erduran, & Kaya, 2010; Kaya, Erduran, & Cetin, 2010b) conducted using quantitative methods on argumentation in science education (Erduran, 2008). The main purpose of this study is to investigate students' perceptions of argumentation and discourse in science classrooms by using both qualitative and quantitative research methods.

This paper presents a literature overview on students' perceptions in science and the relationship between students' attitude towards and achievement in science. Students' perceptions and attitudes toward science make an important impact on their learning school science. Classroom environment as a constituent of students' perceptions includes many factors such as science teacher, instructional activities, interaction among students (Cavallo & Laubach, 2001). In this framework, we view these factors as parts of classroom discourse. Therefore, we next present an overview about role of discourse and students' participation in classroom discourse with respect to students' learning and understanding of science. After reviewing about discourse in science learning, we turn our attention to the role of argumentation in science classroom and students' understanding of science concepts. The aim of this paper is to show high school students' perceptions of argumentation and the effect of such perceptions on their understanding of arguments through a study that was based on questionnaire data.

Students' Perceptions of Science and Achievement in Science

Conceptualizing Students' Perceptions

There is considerable research on students' perceptions of and attitutes towards science primarily dating from the 1990s. Students' perceptions of science play a key role in their learning and achievement in science (Koballa, Crawley, & Shrigley, 1990). Science perceptions include students' attitudes towards school science as well as views of the classroom environment (Cavallo & Laubach, 2001). According to Osborne, Simon, and Collins (2003), attitudes towards science "are 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" (p.1053). Students' attitudes towards science consist of a number of constructs (Osborne et al., 2003; Cavallo & Laubach, 2001). These constructs are anxiety towards science, motivation in science, science enjoyment, the value of science, self-concept of ability, attitudes of peers and parents toward science. For example, some research related to the relationship between anxiety and attitude showed that students with low science anxiety had more positive attitudes toward science (e.g., Atwater, Gardner, & Wiggins, 1995; Simpson & Oliver, 1990).

Classroom related variables have been advanced as being important in shaping students' perceptions of science. Students' perceptions of classroom activities and teacher's support of them during science lessons affect their attitudes towards science (Myers & Fouts, 1992; Gallagher, 1994). Simpson and Oliver (1990) found that the variables related to classroom environment were the strongest factor in affecting students' attitudes towards science. Science teaching method in the classroom is one of the variables regarding students' classroom perceptions (Ebenezer & Zoller, 1993). Science teachers also have influence on students' classroom related attitudes and their perceptions of science (Cavallo & Laubach, 2001; Myers & Fouts, 1992). Since many activities such as instructional activities, interactions among students, students' participation are guided by teachers in science classroom; science teachers play a key role in promoting students' attitudes towards science.

Myers and Fouts (1992) found that more positive attitudes of students were related to involvement, personal support, relationships with classmates, and a variety of teaching strategies and unusual learning activities. All these variables might be also thought as parts of discourse in the classroom.

According to Gee (1990), discourse with "little d" refers to only language but Discourse with "big D" means the combination of language with other social practices (behavior, values, ways of thinking, clothes, food, customs, perspectives) within a specific group. In this respect, discourse also plays a key role in developing students' perceptions of school science.

Relationship between Attitude and Achievement

The development of scientific literacy among students requires their positive attitudes toward science (Lederman, 1992; Linn, 1992). Some research indicated that there is a relationship between students' attitudes towards school science and their learning or achievement in science (e.g., Neathery, 1997; Simpson & Oliver, 1990; Osborne & Collins, 2000; Sua, 2007). These studies addressed that the students with more positive attitudes towards science would learn subjects in a better way during a science class.

Simpson and Oliver (1990) investigated the factors affecting students' attitudes towards science and their achievement in science. They found that students with low anxiety were more successful in science than students with high anxiety. Another result of their study was that there is a positive relationship between students' achievement in science classroom and their motivation towards science as a construct of attitudes toward science.

According to Koballa and Glynn (2007), *"science learning experiences that are fun and personally fulfilling are likely to foster positive attitudes and heightened motivation toward science learning and lead to improved achievement. Approaches to positively affecting student attitudes include instruction that emphasizes active learning and the relevance of science to daily life"* (p. 94-95). Students' experiences in the science classrooms also have an influence on their decision making on career choices related to science area besides their achievement in and attitudes towards science (Bevins, Brodie, & Brodie, 2005; Cavallo & Laubach, 2001).

Role of Discourse in Learning

Learning and Discourse

Over the last few decades, since language has been reported as an important factor in learning, the role of discourse has also begun to be discussed in science learning. Lemke (1995) defines discourse as "a social activity of making meanings with language and other symbolic systems in some particular kind of situation or setting" (p. 8). According to Gee (2001), discourses are social practices that combine with ways of acting to form Discourses-"ways of being in the world… forms of life which integrate words, acts, values, beliefs, attitudes, and social identities as well as gestures, glances, body positions, and clothes" (p. 526).

Kelly (2007) argues that discourse processes are effective in knowledge construction, and learning occurs through discourse in the classroom. Learning as the result of participation in particular social practices is "the acquisition of Discourses of thinking, acting, valuing, interacting, feeling that makes you a particular kind of person" (Brickhouse, 2007, p. 90). Therefore, discourse practices are socially constructed by and constituted of learning opportunities (Gee & Green, 1998). Substantial research has addressed the importance of discourse processes for understanding how scientific concept knowledge is constructed through language and how students learn science in the classroom (Dagher, 1995; Klaassen & Lijnse, 1996; Lynch & Macbeth, 1998; Macbeth, 2000).

Participation in discourse

Students should be encouraged to participate in discourse processes by questioning, justifying, and evaluating reasoning for their knowledge construction in science (Duschl & Osborne, 2002). Discourse in science classrooms enables students to understand scientific concepts

(Driver et al., 2000). "Active participation by learners in the discourse of lessons is therefore central to providing an enabling learning environment. Talking offers an opportunity for conjecture, argument and challenge. In talking, learners will articulate reasons for supporting particular conceptual understandings and attempt to justify their views. Others will challenge, express doubts and present alternatives, so that a clearer conceptual understanding will emerge" (Newton et al., 1999, p. 554). Therefore, discourse as an important factor in developing students' perceptions of school science has also an influence in developing students' understanding of science concepts.

Argumentation and Conceptual Understanding

Argumentation can be defined as connections between claims and data through the use of justification and evaluation of knowledge because knowledge construction in science is related to knowledge justification (Erduran & Jimenez-Aleixandre, 2012; Erduran & Jimenez-Aleixandre, 2008). Many researchers argue that argumentation as a part of science learning should be promoted and explicitly taught in science classrooms (e.g., Simon, Erduran & Osborne, 2006). Erduran and Jimenez-Aleixandre (2008) argue that the studies on argumentation discourse in science learning addressed two frameworks. These are the importance of discourse in the knowledge construction and socio-cultural perspective pointing to the importance of social interaction in the science classroom. Students' active participation in argumentative discourse facilitates their construction and understanding of scientific knowledge.

Argumentation as a discourse process has an important role in developing students' conceptual understanding in science considering argumentation combines the conceptual and epistemic goals of science learning by making use not only of concepts but also the epistemic criteria used in knowledge growth (Erduran et al., 2004; Duschl & Osborne, 2002). Some research investigated the effect of argumentative discourse on students' conceptual understanding of science (e.g., Aydeniz, Pabuccu, Cetin, & Kaya, 2012; Jimenez-Aleixandre, Bugallo, & Duschl, 2000; Jimenez-Aleixandre & Pereiro-Munhoz, 2002; Leach, 1999; von Aufschnaiter et al., 2008; Zohar & Nemet, 2002). The results of these studies showed that students' conceptual understanding improved through argumentation. Furthermore, particular acquisition of certain concepts were associated with particular argumentative operations (von Aufschnaiter et al., 2008): "*argumentation supports students' improvement in thinking as the evidence from the students' discourse suggests that it leads to a quicker development of specific ideas and helps to make connections across (familiar) contexts. It is this type of improvement that is the basis of further learning"* (p.121).

Methodology

Research Questions

The study reported in this paper focused on the following research questions:

- What are high school students' understandings of argumentation?
- How do high school students perceive the role as well as the teaching and learning of argumentation in science classrooms?
- How do high school students perceive the role as well as the teaching and learning of discourse in science classrooms?

In order to address these research questions, we have used both quantitative and qualitative methodologies which will be described in the following sections.

Sample

Convenience sampling method was used to select the sample of the study. The sample of the study was composed of 245 high school students (140 males, 105 females) from three different types of schools in Turkey. The schools were general high school, general high school with multiple program, and Anatolian high school. These schools are different in terms of curriculum and the way of entrance to school. For example, general high schools with multiple program are the schools where a combination of the curricula of general high school, vocational high school, and technical high school was applied. Students are registered to general high schools without exam. On the other hand, Anatolian high schools register students on the basis of the entrance exam results. The general high school and the general high school with multiple program in the study were in the east part of Turkey while the Anatolian high school was in the west part of Turkey. In addition, 45.7 % of the students were ninth grade, 15.5 % of them were tenth grade, 13.1 % of them were eleventh grade, and 25.7 % of them were twelfth grade. The ages of the students with different grade levels varied from 13 to 20.

Description of the Instruments

In this study two instruments were used: "Argumentation Test" and "Perception of Argumentation Test".

Argumentation Test

The Argumentation Test which was developed by Sampson and Clark (2006) is composed of two parts (Appendix A). In the first part, there are three questions which are designed to determine what students think counts as a good scientific argument. In each question, students are given a claim and 6 six different arguments about that claim. Students are asked to rank these arguments in terms of how convincing they think they are. In the second part of the test, there are three questions that are designed to determine what students think counts as a good challenge to a scientific argument. In each question, students were given a claim supported by an argument. Following the claim there was a challenge and six different arguments. Students are asked to rank these arguments in terms of how strong they think they are. This test was translated into Turkish by the researchers independently and any conflicts in opinion about the choice of language were resolved among three researchers who are bilingual in English and Turkish. Additionally, reliability and validity studies the adapted version of the test were conducted.

Perception of Argumentation Test

This test adapted from Chin (2008) is composed of two parts. First part of the test is related to discourse in classroom. There are four questions in this part. Two of them are open-ended questions on importance of discourse and quality of discourse. The other two questions are related to classroom activities encouraging scientific discourse. The second part of the test is related to argumentation in science and science education. There are six questions in this part. Two of them are open-ended questions about the significance of argumentation in science education and about scaffolding learning in argumentation. The other questions are related to activities for promoting argumentation in science classes and students' attitudes to these activities. This test was also translated into Turkish by the researchers independently and any conflicts in opinion about the choice of language were resolved among three researchers who are bilingual in English and Turkish. Additionally, validity issue related to the adapted version of this test was considered.

Data Analysis Approaches

Statistical analysis was applied to the data collected by the *Argumentation Test*. The correct answers were recoded as "1" and wrong answers as "0". The maximum total score that students could get in this test was 36. For the *Perception of Argumentation Test* both quantitative and qualitative analyses were carried out. In the first part of this perception test, for the analysis of the question related to classroom activities encouraging scientific discourse, frequencies of the classroom activities and student participations were determined. In the second part of this test, the frequency analyses were performed for the argumentation usage in science courses, for the activities in order to promote argumentation in the class, and for students' attitudes to these activities.

Qualitative content analysis approach was used to analyze the data from open ended questions in the *Perception of Argumentation Test*.

Findings

Quantitative Data Analysis

With respect to students' understanding of arguments, descriptive statistics of students' argumentation test total scores were determined (Table.1). Results indicate that students have a limited understanding of argument given the mean of total scores is low.

Table 1: Descriptive Statistics of Argumentation Test Scores

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Argumentation Test	245	,00	22,00	9,0980	4,70858

Following the descriptive statistics analysis, the frequency values of each question in the Argumentation Test were calculated (Table 2). This test was composed of two parts. In the first part, there were three questions designed to determine what students think counts as a good scientific argument. In each question students were given a claim and six different arguments about that claim. Students were asked to rank these arguments in terms of how convincing they thought they were. Here, "1" means the most convincing argument and "6" means the least convincing argument. An example question in the first part of the Argumentation Test is given in the following.

Question 1. Your task is to rank these 6 different arguments in terms of how convincing you think they are. *Remember that you can only rank one claim as 1, one claim as 2, one claim as 3, and so on.*

Claim: Objects that are in the same room are the same temperature even though they feel different because…	Your Ranking
…when we measured the temperature of the table, it was 23.4^{O}C, the metal chair leg was 23.1^{O}C, and the computer keyboard was 23.6^{O}C.	_______________
…good conductors feel different than poor conductors even though they are the same temperature.	_______________
…objects that are in the same environment gain or lose heat energy until everything is the same temperature. Our data form the lab proves that point: the mouse pad and plastic desk were both 23^{O}C.	_______________
…objects will release and hold different amounts of heat energy depending on how good of an insulator or conductor it is.	_______________
…our textbook says that all objects in the same room will eventually reach the same temperature.	_______________
…we measured the temperature of the wooden table and the chair leg and they were both 23^{O}C even though the metal chair leg feels colder. If the metal chair leg was actually colder it would have been a lower temperature when we compared it to the temperature of the table.	_______________

In this question students were expected to rank the first argument as 3 (evidence only), the second argument as 4 (warrant only), the third argument as 2 (explanation and evidence), the fourth argument as 6 (contradictory), the fifth argument as 5 (appeal to authority), and the sixth argument as 1 (data, explanation, rebuttal). The scale of this ranking is given in the below:

1 = the most convincing argument
2 = the 2nd most convincing argument
3 = the 3rd most convincing argument
4 = the 4th most convincing argument
5 = the 5th most convincing argument
6 = the least convincing argument

Table 2 presents the percentage values of student answers in each question in the first part of Argumentation Test. The first column of this table shows the number of the arguments in each question. For example, the second argument in the first question is represented by “1.2” as in the second row of the table. Here, the first digit presents the number of the question and the second digit presents the number of the argument. As mentioned before, the students were expected to rank the second argument in this question as “4”. Therefore, the second column of the table shows the correct ranking value. The third column shows the percentage of students who label this argument correctly. For example, 20 % of the students labeled the argument 1.2 as “4”. Then, the next column presents the wrong label value and the percentage of students who use this wrong label for the argument.

Table 2: Percentages of Student Answers in each Question “Argumentation Test” Part 1

Item Number	Correct Label	Percentage of Correct Label	1st Wrong Label	Percentage of the 1st Wrong Label	2nd Wrong Label	Percentage of the 2nd Wrong Label	3rd Wrong Label	Percentage of the 3rd Wrong Label
1.1	3	9.4	5	24.9	6	22.0	1	17.1
1.2	4	20.0	1	19.2	2	18.8	3	17.6
1.3	2	15.9	1	28.6	3	24.5	4	12.7
1.4	6	4.5	3	24.9	4	22.9	2	18.0
1.5	5	22.0	6	32.7	4	15.5	3	11.8
1.6	1	15.9	2	24.9	6	22.4	3,4,5	12.2
2.1	4	9.4	1	30.2	2	18.8	3,6	13.9
2.2	2	29.4	3	22.4	1	18.0	5	11
2.3	6	14.7	5	25.3	4	22.9	3	18.4
2.4	3	22.4	4	26.9	5	18.4	6	15.1
2.5	5	18.4	6	30.6	2	15.5	4	15.1
2.6	1	30.6	6	18.4	4	14.7	2	13.9
3.1	6	62.9	2	8.6	1	8.2		
3.2	1	32.7	2	20.8	3	18.0	4	12.7
3.3	5	28.6	3	24.1	4	20.4	2	11.8
3.4	2	30.6	1	22.9	3	15.1	4	14.3
3.5	4	21.6	3	22.9	2	19.6	5	13.5
3.6	3	11.0	5	27.8	4	20.0	1	18.4

Furthermore, the wrong labels were presented by ascending percentages of the labels. For example, the most labeling value of the second argument in the first question (1.2) is “1” as shown in the fourth column and the percentage of the students who label this argument as “1” is “19.2” as shown in the fifth column. If there is a wrong label more than three for an argument, these labeling values were presented in the eighth column, and the average percentage of the these labels were presented in the last column. For example, since the wrong label values for the sixth argument of the first question (as shown in the sixth row of the table) were “2”,”3”,”4”,”5”, and “6”, in the eighth column, the labels of “3”, “4”, and “5” which had the least percentages were presented. Lastly, if an argument was labeled wrongly in just two different values; the last two columns of that argument were blanked in the table. For example, the students labeled the first argument of the third question wrongly as either “2” or “1”.

As seen in Table 2, in the first question, students had difficulty in labeling the argument with “the explanation, data, rebuttal” as the most convincing argument. Most of them labeled this argument as either, “explanation and evidence”, as the second most convincing argument or “contradictory”, as the least convincing argument. However, in the second and third questions, most of the students correctly labeled the argument with “the explanation, data, rebuttal” as the most convincing argument. For the three questions in the first part, while the students labeling the argument with “explanation and evidence” as second convincing argument, most of them confused it with either the argument with “the explanation, data, rebuttal” (1) or the argument with “evidence only” (3).

The students also had difficulties in labeling the argument with “evidence only” as the third convincing argument. Some of them confused it with the argument with “warrant only” (4), some of them the argument with “appeal to authority” (5). In the first question, some of them labeled the second convincing argument as the argument with “contradictory”. With respect to the argument with “warrant only” as fourth convincing argument, the students labeled this argument as either “explanation, data, rebuttal” (1), or “explanation and evidence” (2), or “evidence only” (3).

In the first and second questions, most of the students labeled the argument with “appeal to authority” which is fifth convincing argument as the argument with “contradictory” (6). In the third question, although most of the students labeled this argument correctly, some of them labeled the argument with “appeal to authority” as either the argument with “evidence only” (3) or the argument with “warrant only” (4). With respect to the argument with “contradictory” as the least convincing argument, in the third question most of the students labeled it correctly. However, in the first question, most of them labeled it as either the argument with “evidence only” or the argument with “warrant only”. For the second question, they labeled the least convincing argument as either the argument with “appeal to authority” or the argument with “warrant only”.

In the second part of the test, there were three questions designed to determine what students think counts as a good challenge to a scientific argument. In each question students were given a claim supported by an argument. Following the claim there was a challenge and six different arguments. Students were asked to rank these arguments in terms of how strong they thought they were.

In this part, students were expected to label the argument with backing (rebuttal against grounds with grounds) as the strongest challenge to the argument. Although majority of the students labeled this argument correctly, in the first and second questions in this part, some of them thought that either the argument with warrant (rebuttal against grounds no grounds, the second strongest argument) or the argument with data (rebuttal against thesis with no grounds, the third strongest argument) could be the strongest challenge to the given argument. Furthermore, in the third question, some of the students thought that either the argument with claim (rebuttal against thesis no grounds, the fourth strongest argument) or the counter claim only, the fifth strongest argument, could be the strongest challenge to the given argument (Table.3).

The students were expected to label the argument with warrant (rebuttal against grounds no grounds, the second strongest argument). In the first and second question, most of the students labeled it correctly but in the second question, most of them selected the counter claim only, the fifth strongest argument, as the second strongest challenge to the given argument. In general, students thought the argument with data (rebuttal against thesis with no grounds, the third strongest argument) could be the second strongest challenge to the given argument.

The students were expected to label the argument with data (rebuttal against thesis with grounds) as the third strongest challenge to the argument. However, some of the students thought that either the argument with backing (rebuttal against grounds with grounds, the strongest argument) or the argument with warrant (rebuttal against grounds no grounds, the second strongest argument) or the argument with claim (rebuttal against thesis no grounds, the fourth strongest argument) was the third strongest challenge to the given argument. Furthermore, in the third question, most of them selected the argument with data, the third strongest argument, as the emotive argument (the weakest strongest argument).

Students were expected to label the argument with claim (rebuttal against thesis no grounds) as the fourth strongest challenge to the argument. However, in the first question, most of the students thought that the argument with data (the third strongest argument) was the fourth strongest challenge to the given argument. In the second question, most of them thought that the argument with warrant (the second strongest argument) was the argument with claim (the fourth strongest argument). In the third question, although most of them selected the argument with claim as the forth strongest argument, some of them selected it as the third strongest argument (argument with data).

Students were expected to label the counter claim as the fifth strongest challenge to the argument. While in the first and third question, most students labeled it correctly, in the second question most of them thought that the counter claim was the argument with claim (the fourth strongest argument). In addition, some students selected the counter claim as the second or third strongest argument.

Students were expected to label the emotive argument as the weakest challenge to the argument. The percentage of the students labeled this argument correctly is the highest among others. For three questions, almost half of the students selected that argument as the weakest argument. On the other hand, some students labeled it as either the counter claim (fifth strongest argument) or the argument with backing (the strongest argument).

Table 3: Percentages of the Student Answers in each Question "Argumentation Test" Part 2

Item Number	Correct Label	Percentage of Correct Label	1st Wrong Label	Percentage of the 1st Wrong Label	2nd Wrong Label	Percentage of the 2nd Wrong Label	3rd Wrong Label	Percentage of the 3rd Wrong Label
4.1	2	23.7	1	19.2	3	17.6	5	13.5
4.2	5	24.1	3	22.9	4	20.4	2	14.3
4.3	1	32.2	2	18.4	3	11.8	5	11.4
4.4	3	16.3	4	20.4	1	20.0	2	18.4
4.5	6	49.0	5	14.7	4	10.2	1	9.8
4.6	4	19.2	3	21.6	5	18.4	2	17.6
5.1	6	54.7	1	18.0	5	7.8	3	6.1
5.2	2	13.9	5	36.7	3	18.0	4	14.7
5.3	4	18.4	2	23.7	1	18.8	3	15.9
5.4	3	22.9	4	23.3	2	21.2	1	12.2
5.5	1	26.9	2	17.6	3,4	13.9	5	11.8
5.6	5	16.3	4	18.4	2	17.1	1	16.3
6.1	3	22.9	1	24.5	6	14.3	2	13.1
6.2	5	32.7	2	17.6	4	13.9	3	13.5
6.3	2	31.0	3	20.0	4	14.7	5	13.1
6.4	6	43.7	1	13.9	5	11.8	4	11.0
6.5	1	35.9	4	14.3	5	13.9	2	11.8
6.6	4	26.1	3	21.2	2	14.3	6	12.7

Since there was a big variation in the sample, the Argumentation Test scores of the students were also analyzed in terms of grade levels and school types. The descriptive statistics analysis results of Argumentation Test scores of the students over grade levels are presented in Table.4.

Table 4: Descriptive Statistics of Argumentation Test Scores on the basis of Grade Levels

Grade Levels	N	Mean	Std. Deviation
9.00	112	8.6964	5.01680
10.00	38	8.8684	4.24373
11.00	32	10.9375	4.84560
12.00	63	9.0159	4.19866
Total	245	9.0980	4.70858

In order to find out whether there was a significant difference in Argumentation Test scores of the students over grade levels; Analysis of Variance (ANOVA) statistical method was used. The results show that there was no significant difference in Argumentation Test scores of the students over their grade levels ($F(3,241) = 1.959$; $p > .05$).

The descriptive statistics analysis results of Argumentation Test scores of the students over schools are presented in Table.5.

Table 5: Descriptive Statistics of Argumentation Test Scores on the basis of Schools

Schools	N	Mean	Std. Deviation
Anatolian High School	121	11.1322	4.96646
General High School	21	10.3333	4.43095
General High School with Multi Program	103	6.4563	2.81026
Total	245	9.0980	4.70858

The results of Analysis of Variance (ANOVA) show that there was a significant difference in Argumentation Test scores of the students over schools ($F (2,242) = 36.420$; $p < .05$). The results of Post Hoc Tests indicate that the mean difference between students in anatolian high school and those in general high school with multiple program (GHSMP) is significant in favor of anatolian high school (AHS); ($\overline{X}$ (GHSMP) = 6.4563; $\overline{X}$ (AHS) = 11.1322). Also, the results show that the mean difference between students in general high school (GHS) and those in general high school with multiple program is significant in favor of general high school ($\overline{X}$ (GHSMP) = 6.4563; $\overline{X}$ (GHS) = 10.3333).

With respect to the "Perception of Argumentation Test", data were analyzed based on quantitative approach. The students were asked to select which activities encourage scientific discourse in their science classroom. According to the results of the frequency analyses of these activities, most of the students thought that exploratory and practical activities were used in their classroom as encouraging scientific discourse (Table 6). Also in students' perception, open discussion and role play were the least used activities in the classroom discourse.

Table 6: Students' Perceptions of Classroom Activities Encouraging Scientific Discourse

Activities	Percentage for Discourse (%)
Group work	34.3
Pair work	28.2
Pair discussion	29.4
Group discussion	32.2
Open discussion	8.6
Debate	15.9
Role play	9.4
Practical	44.9
Experiment	19.2
Lecture	48.6

In the Perception of Argumentation Test, the students were asked how often they participate in discourse in the science classroom. Majority of the students indicated that they participate in scientific discourse (Table 7).

Table 7: Students' Perceptions of Frequency of Participation in Science Discourse

Students' Participation	Frequency	Percentage
Never	13	5.3
Rarely	18	7.3
Sometimes	81	33.1
Often	68	27.8
Every lesson	64	26.1
Unanswered	1	.4
Total	245	100.0

The results on students' perception of use of argumentation in the classroom showed that most of the students (31.8 %) thought that argumentation was sometimes used in science lessons. 26.1 % of the students said that argumentation was used in every science lesson (Table 8).

Table 8: Students' Perceptions of the Frequency of Argumentation Use in Science Lessons

Argumentation Usage	Frequency	Percentage
Never	36	14.7
Rarely	43	17.6
Sometimes	78	31.8
Often	18	7.3
Every lesson	64	26.1
Unanswered	6	2.4
Total	245	100,0

According to the analysis result of the question emphasizing whether argumentation had been ever used in science lessons, most of the students indicated that the instruction based on argumentation was used in their science lessons (Table 9).

Table 9: Students' Perceptions of Argumentation Use in Science Lessons

Argumentation Usage	Frequency	Percentage
Yes	101	41,2
No	139	56,7
Unanswered	5	2,0
Total	245	100,0

Another question concerned which activities were thought to be used in the classroom for promoting argumentation. While most of the students said that argumentation had been used in science classroom in previous question (Table 9), they claimed that pair work, open discussion, and role play were activities that were not used in their science lessons (Table 10).

Table 10: Students' Perceptions of Activities Used for Promoting Argumentation in Science Lessons

Activities	Percentage for Argumentation (%)
Group work	21.6
Pair work	9.4
Pair discussion	15.1
Group discussion	22.9
Open discussion	9.8
Debate	11.8
Role play	3.3
Practical	28.2
Experiment	21.2
Lecture	22.4

Finally, the students were asked how they felt during classroom activities promoting argumentation in science lessons. Most of them thought that they felt enthusiastic while classroom activities based on argumentation (Table 11). That is to say, they had positive attitudes toward the activities that they perceived to be promoting argumentation.

Table 11: Students' Attitudes toward Classroom Activities for Promoting Argumentation

Attitude	Percentage for Discourse (%)
Enthusiastic	74.3
Reluctant	7.3
Bored	9.8
Irrelevant	4.9

After these quantitative analyses, we concluded that students have positive attitudes toward discourse and argumentation. However, their responses were conflicting. While they said that argumentation was used frequently in their science classrooms, they indicated that open discussion or role play were not frequently used in science lessons. Moreover, their understanding of argumentation was limited. When students' understanding of argumentation was examined with respect to their grade levels and school types, it is concluded that school type has a significant effect on students' understanding of argumentation while grade level has no significant effect on this variable.

Qualitative Data Analysis

There were four open ended questions in the Perception of Argumentation Test. Two of them were related to the discourse in science classroom and the other ones were related to the argumentation in science classroom. The students wrote their answers to these questions. By considering all these written data, the codes were categorized under particular themes. First, we assigned the codes to meaningful data segments based on the purposes of the research. Codes like "talking one by one", "doing an experiment", "group discussion", "participating in discussion", "catching students' attention", "science as subjective" were generated from the data as categories that would elicit students' perceptions about classroom activities and pedagogical approaches. Then we investigated the data also in terms of wider science and science education categories like "classroom environment", "importance of science", "nature of science", "implementation". We performed this process in order to describe students' views on both discourse and argumentation. With the qualitative data analysis, the themes produced as students' perceptions of discourse are "classroom environment", "implementation", "understanding", "importance of science", "actions by teachers", "actions by students", "classroom management" and "not important/not applicable". The codes produced as students' perceptions of argumentation are "knowledge", "implementation", "understanding", "nature of science", "actions by teachers", "actions by students", "classroom management" and "not important/ not applicable". While the discourse categories also related to classroom actions and characteristics, we wanted to highlight the particular ways in which argumentation is viewed in relation to these actions and characteristics. Therefore they were differentiated in the coding.

Upon completion of coding, in order to determine the trends under each theme, we determined the frequencies of each code. Table 12 is a summary of all codes that had more than one occurrence in the data. Table 13 illustrates those codes that occurred only once in the data. The separation of the two tables was performed for the purpose of highlighting the key trends more clearly, and also for practical reasons in difficulties experienced in capturing all codes in one table alone.

1. Discourse

1.1. Classroom Environment

Students referred to classroom environment in various ways: silent environment, respectful environment, less crowded class, and talking one by one. The codes that received the highest percentage of attributes of a classroom were 'silent' and 'respectful environment'. The students thought that students should be silent during science lessons. In their opinion, they can learn and understand science subjects better if students do not talk in science classroom. For example, students said that:

"…there should be a scientific discourse environment. There should not be much noisy for us to understand better…"

"In my opinion, the subjects are not understood in a good way by discussing. Because there is noisy inside of the classroom, anything else cannot be understood…In the classroom, there is no discussion during the lesson. If there is discussion in class, all students in my class talk at the same time. I do not want a lesson with discussion."

"…It is necessary to have an appropriate discourse environment. I mean, there should be silence. Thus, the others can understand what you say."

Table 12:. Students' Perceptions of Discourse and Argumentation I (codes that had more than one occurrence in the data)

Discourse			**Argumentation**		
Classroom Environment		Silent environment (14) Respectful environment (14) Less crowded class (2) Talking one by one (2)	**Knowledge**		Stability of knowledge (10) Improving viewpoints (3)
Implementation		Making experiment (37) Visual (13) Talking based on scientific concepts (7) Sharing the knowledge/ideas (6) Making interpretations (5) Making presentations (5) Group working (4) Discussing knowledge/reasons (4) Teaching with respect to students' level (3) Giving homework (3) Verbal communication (3) Necessary for instruction (2)	**Implementation**		Making experiment (46) Making debate (6) Giving daily life examples (5) Pair discussion (3) Open discussion (3) Visual presentation (3) Practices (3) Group discussion (3) Talking about update/interesting subjects (2) Giving feedback to homework and classroom activities (2) Explanatory teaching (2) Solving numerical problems clearly (2)
Understanding		Better understanding scientific concepts (33) Arriving a conclusion (6) Not forgetting for a long time/stability of knowledge (3) Understandable of numerical/calculation via verbal communication (3) Closing the gap in knowledge (2) Understanding logic of concepts (2)	**Understanding**		Understanding concepts (33) Understanding logic (3) Not memorizing (3)
Importance of science		Science is based on talking (2)	**Nature of science**		Proving claims/ideas (12) Science is based on argumentation (4) Scientific nature (4) Understanding/knowing history of science (3) Learning of reality/evidence (2) Science as subjective (2) Necessity of claims, ideas and proofs in science (2)
Actions	**Students**	Participation in lessons (11) Presenting ideas (6) Asking questions about unclear subjects (4) Showing own knowledge (4) Arriving solutions by himself/herself (2)	**Actions**	**Students**	Dealing with claims/counterclaims (4) Participating in discussion (4) Getting new ideas (4) Discussing/Checking correctness of ideas (2)
	Teachers	Making review before lesson (13) Making students to participate in lessons (7) More knowledgeable teachers (5) Following scientific improvements (3) Reading the science journals (2)		**Teachers**	Searching (10) Taking students' ideas (7) More knowledgeable teachers (5) Making concepts clear (5) Explaining concepts (4) Making review before lesson (3) Evaluating different viewpoints (2)
Classroom management		Leadership/importance of teacher (9) Making enjoyable lessons (8) Taking students' attention (4)	**Classroom management**		Motivating/promoting students to participate in lessons (7) Authority/importance of teacher (5) Making science lessons more enjoyable (5) Getting students' attention to lesson (2)
Not important (11)		Science is based on numerical (calculation) (3) Making exercises are more important than talking (3) Not possible in our science classes (2)	**Not important/Not Applicable (5)**		Not possible in our education system (3) Because of time restriction (2)

Table 13: Students' Perceptions of Discourse and Argumentation II (codes that occurred only once in the data)

Discourse				Argumentation			
Classroom Environment		Making classroom environment more planned Talking in a presentation room Free environment to discuss ideas Creating discussion environment Eliminating disturbing students	Discussing in the laboratory Listening others' opinions Physical environment Listening each other Considering rules of speech	**Knowledge**		Getting more trustable knowledge	
Implementation		Talking about daily life experiences Transferring knowledge to students Proving observation by sharing of ideas Solving numerical problems efficiently Giving feedback to students Watching videos about concepts Increasing session numbers of the lesson	Explanatory teaching Making repetitions Pair discussion Proving ideas Asking easy questions Making debate Group discussion Explaining concepts	**Implementation**		Giving information about scientific studies Making students' aware of the effectiveness of argumentation Making relation between concepts Presenting theories and asking their correctness Making students to present subjects Talking about researches made by scientists Starting lessons with giving claims and data	Presenting documents Not talking about grades Relating cause and effect Teaching argumentation Videos Animations Sharing ideas with trends Explaining the causes of events
Understanding		Understanding formulas/numerical expression		**Understanding**		Understanding the logic of formulation Founding ground for better understanding Knowing the reasons Meaningful learning	
Importance of science		Importance of science courses in future life Science lessons are not totally abstract Different ideas contribute to different research areas	Current issues Inefficacy of formulas	**Nature of science**		Understanding correctness of judgment Importance of claims and proofs in science Believing in the reality of scientific knowledge Science is based on theories and laws Getting certain knowledge	Proving knowledge Understanding the reasons of reality Lives of scientists Getting valid conclusion
Actions	**Students**	Increasing proficiency/quality Learning different view points Checking understanding Broadening the mind	Increasing self esteem Concentration Confusing	**Actions**	**Students**	Teaching concepts to other people Transferring of thoughts Discussing ideas independently	
	Teachers	Using known concepts Using proper vocabularies Experienced teachers Using different sources			**Teachers**	Making students to think and express their ideas Evaluating claims and counterclaims Ineffectiveness of direct teaching	Proving concepts Teaching concepts to students
Classroom management				**Classroom management**		Getting organized in classroom Behaving to students with tolerance Being positive towards students Making science lessons easy	

Students also mentioned 'respectful environment' very frequently. The students claimed that students in classroom should respect each other during discourse in science lessons. They thought when there was a respectful environment; they understood the concepts during science class. For example:

"The quality of discourse is promoted by getting information about subject, by communicating in a level of understanding of peers and in a respectful way."

"My peers should not shout all together. However, it is understood what s/he says by raising her/his hand."

"We should stand up after getting permission and talk one by one. And we should listen to the person who talks."

"Discourse environment is important in lessons. Discourse enhances science lessons to be dynamic."

Some students perceived discourse in science classes as free environment to discuss their ideas. Discourse in science classes was thought to be important because it produces discussion during science lessons. Discourse also was seen the way of ensuring the order in science classes. Some of the students pointed to physical circumstances in the class and claimed that classroom environment should be arranged by supplying some learning materials for students to understand science topics.

1.2 Implementation

In students' perceptions, implementation of discourse involved making experiments, visual, talking based on scientific concepts, daily life examples, sharing the knowledge/ideas, making interpretations, making presentations, group working, discussing knowledge/reasons, teaching with respect to students' level, giving homework, verbal communication, and necessary for instruction. Students thought that all these activities performed in science classroom increased the quality of discourse in science lessons. The highest trends related to implementation were making experiments and using visuals. For example one student said that:

"...to have instruction based on using visual elements and talking promotes more stable (meaningful) learning."

"..In a laboratory environment, many subjects of science are understood better. I mean, it should be visual."

"Discourse environment would be better with visual effects."

Students believed that talking in science lessons should be just based on scientific concepts. One student said that:

"In my opinion, talking on science subjects is important. Talking on an issue that is not related to the lesson is not good."

Some students pointed to daily life examples during the instruction as an effective way in increasing the quality of discourse in science lessons. One student said that:

"For teachers to teach the subjects based on daily life examples increases the quality of discourse in classroom. If the subjects are taught by giving examples from daily life, students can imagine them in their mind."

"Students' attention might be attracted by mentioning events we had in our daily life."

Some students claimed that discourse in science class promotes students' sharing their knowledge or ideas, and making interpretations. One student's belief about this issue is

"Discourse in science classes is important because the ideas on a subject should be shared with friends and their views should be asked, as well."

"..In my opinion, if a student has extra knowledge different from teacher's knowledge, s/he should share it with everyone in the class."

"Discourse is important because an observation can be a hypothesis or a law just by sharing ideas and making experiments."
"The quality of discourse can be increased by enhancing us to make objective interpretations."

Students also pointed to the necessity of discourse for instruction in science classes. Making presentation, group working, discussion and observations were seen as activities for increasing the quality of science discourse. Students thought that teachers transferred knowledge to the students by discourse in science lessons. They also claimed that discourse was a way of verbal communication and also helpful in solving numerical problems in science lessons. According to the students, teachers should teach by considering students' level of understanding and giving homework for increasing the quality of discourse. Students' perceptions of discourse related to implementation are as following:
"The quality of discourse can be increased by performing group working and selecting a speaker. Thus, everyone's ideas can be stated by just one voice."
"…to learn science subjects by discussing them with their reasons would be easier and more stable."
"If our teacher does not teach us by considering our levels, we do not understand those subjects."
"Discourse is important in terms of transferring knowledge to students by teacher."
"When much more observation and experiment are done, the quality of discourse increases. Thus, science is given more importance."
"Students should be given some homework which promotes students to participate in discourse in science classroom."
"Even if science lessons are based on numerical, to explain the subjects verbally is important."
"In my opinion discourse is so important. If anyone does not talk, the instruction would not perform."
"It is important because for everyone to state their ideas enhance to find different solution ways. This might also enhance us to be more practical in solving problems."
"…calculations cannot be made without talking even if this lesson is based on numerical. Some explanations should be made."
"The quality of discourse in classroom can be increased by making experiments, discussing, and proving our ideas."
"Science lessons have a provable aspect. Therefore, it is proved by experiments. We should not take everything through dominance."
"We can increase the quality of discourse by making experiments, watching videos and films related to subject, by discussing, by reading the articles about subject. Mostly, we can carry out it by presenting a wrong hypothesis and taking it to the truth."

1.3 Understanding

Understanding as another perception concerning discourse involved better understanding of science concepts, arriving at a conclusion, stability of knowledge, understanding of numerical procedures, closing the gap in knowledge, and understanding of logic of concepts. Many students claimed that discourse in science lessons enhance their understanding of the science concepts.
"I think that discourse environment is important for us in terms of comprehending and internalizing the subject."
"…For example, when we make group working or group discussion, I understand that lesson better and I do not forget for a long time."
"…because it enhances someone to see the points s/he did not see or could not notice."
"…making interpretation and thinking are necessary in order to get conclusion from data. This occurs in a discourse environment in the best way."

1.4 Importance of Science

The theme of "importance of science" relates to another perception of discourse involved science lessons. It is based on themes such as importance of science for future life, science lessons not being totally abstract and different ideas contribute to different research areas among others.
"It is so important because everything cannot be explained with formulas."
"Yes, it is important because sometimes current issues are been talking and this is very nice."
"…When different ideas are stated, new research areas might form."
"…We cannot accept science lessons as totally abstract. It is necessary in terms of stability of knowledge."
"Of course it is important. Science courses are the courses that will play an important role in our future life. Even little knowledge we can get from these courses might affect our future."

1.5 Actions by Students and Teachers

Students' perceptions of discourse as actions by students involved participation in lessons, presenting ideas, asking questions about unclear subjects, showing own knowledge, arriving solutions by him/her. The highest mentioned categories were participation in lessons and presenting ideas. Students perceive discourse as an opportunity to participate in lessons and presenting their ideas. For example:
"I think that this issue is based on teacher. Teacher more follow the improvements related his/her area and improve himself / herself, his/her students improve more."
"Discourse is important because the more we talk in science lessons, the more we show what we know."
"Discourse is important. We ask the subjects or words we wonder and we could not understand."
"Discourse is important. When the students talk in science lessons, they would be more reluctant to participate in lessons. Thus, the lesson would be understandable in a discussion."

Students' perceptions of discourse as teachers' actions involved making review before lesson, making students to participate in lessons, more knowledgeable teachers, following scientific improvements and reading the science journals. The category with the highest frequency were making review before lesson and making students to participate in lessons. Students thought that in order to increase the quality of discourse teachers should make some preparations before coming to the classroom. Students also claimed that teachers should promote students to participate in lessons for discourse in a good quality.

Some students also perceive discourse in science classroom as an environment where they could increase their proficiency, learn different viewpoints, check their understanding, broaden their mind, increase their self-esteem, and concentrate on lessons. They also thought that the teachers should use known concepts by students and proper vocabularies in the lesson and teach students by using different sources.
"In science lessons, if students talk on a subject and have enough knowledge on it, some students also learn at the end of the discussion. This might increase the quality of discourse. After the discussion students would like to participate in lesson."
"Yes, it is important because every student can understand that his/her idea is correct or wrong."
"…because student is affected from the environment. The more this environment is good the more the quality of students increases."
"…because science courses are more scientific, the terms used in the lesson should be appropriate for students' levels…If teacher teach the subjects by making experiments, making connections between concepts, using familiar vocabularies, and talking clearly, the quality of discourse would increase."

1.6 Classroom Management

Classroom management also emerged as a category in students' reflections on discourse. This perception involved leadership/importance of teacher, making science lessons enjoyable and catching students' attention. Students believed that the quality of discourse in science lessons were based on their science teachers. For example:

"Teacher is main factor. It is totally based on his/her. A qualified and conscious teacher can transfer science subjects and everything to their students."

"…To cause students to like science lessons increases students' participation in lessons."

"The lesson can be made more enjoyable. It should not be always based on explaining of concepts. A sort of activities can be performed as well."

"...Discourse should be based on drawing students' attention. In my opinion, it is necessary in terms of education."

1.7 Discourse Not Important

According to some students discourse in science classroom was not important. The key reason was that science is based on numbers and calculations. Some students claimed that making exercises in science lessons was more important than talking.

"The important thing is observation. Talking environment is not required."

"In my opinion, discourse is not important because the understanding levels of students are different."

"…in my opinion, because science is science, there is only one truth. Even if it is discussed the result does not change."

"It is not so much important because science lessons are based on concrete knowledge. It is not possible to arrive at a conclusion with talking."

2. Argumentation

2.1 Knowledge

Knowledge in students' perception of argumentation involved stability of knowledge, improving viewpoints, and getting more trustworthy knowledge. Most students thought that argumentation ensures the knowledge to be stable for them.

"It is important. But we do not do this (argumentation) unconsciously. I believe that the knowledge we will learn would be more stable because of argumentation."

"Of course it is important. A lesson which is performed in a discussion environment is the hardest one to forget. Also it draws students' attention to the lesson."

"It (argumentation) is important because listening to a lesson and comprehending the truth and improving viewpoints are based on argumentation."

2.2 Implementation

Similar to the trends in students' perceptions of discourse, implementation involved doing experiment, debating, giving daily life examples, pair discussion, open discussion, visual presentation, practices, group discussion, talking about update/interesting subjects, giving feedback to homework and classroom activities, explanatory teaching, and solving numerical problems clearly. The highest frequency category was doing experiments. Many students claimed that teachers should make experiments in science classes to promote argumentation.

"The teacher can show some materials such as experiments, writings, or pictures. Especially s/he can show experiments and explain the subjects by the experiments."

"The teacher should make experiment, take our thoughts about that experiment, and ensure us to make experiment as well."

According to students, giving information about scientific studies, making students' aware of the effectiveness of argumentation, making relation between concepts, presenting theories and asking their correctness, making students to present subjects, talking about research conducted by scientists, starting lessons with giving claims and data, presenting documents, talking about grades, relating cause and effect, teaching argumentation, videos, animations, sharing ideas with trends, explaining the causes of events were other activities performed during instruction to promote argumentation in science classrooms.

"The teacher can promote argumentation by presenting theories to us, asking our thoughts on these theories and reality of them."

"The lessons should not be based on memorizing. We should learn subject with its logic and evidence. Thus the subjects learned might be stable in the minds…all subjects are related with each other but the teachers do not relate them at all."

"It can be made activities such as experiments, group discussion, debate, practices."

"The teacher can connect cause and effect and give examples from daily life and nature."

"The teacher can form groups in the class and enhance us to make debate on a subject or can form pair groups. Or s/he can put forth an idea and then s/he can ask for us to prove it."

2.3 Understanding

This perception involved understanding concepts, understanding logic, not memorizing, understanding logic of formulation, founding grounds for better understanding, knowing the reasons and meaningful learning. Many students claimed that argumentation is important because it enhances their understanding of the science subjects. Some examples from their thoughts with respect to understanding as a perception of argumentation are as following:

"In my opinion, it (argumentation) is important. Knowing how formulas were formed promotes to understand them in a stable way."

"Argumentation in science education is important because it is founded ground for better understanding subjects."

"It (argumentation) is important because to know the reasons ensures to keep them in mind."

2.4 Nature of Science

Students' perception of argumentation related to their understanding of the nature of science involved proving claims/ideas, science is based on argumentation, scientific nature, understanding/knowing history of science, learning of reality, science as subjective, necessity of claims, ideas and proofs in science, understanding correctness of concepts, importance of claims and proofs in science, getting valid conclusion, believing in the reality of scientific knowledge, getting certain knowledge, science is based on theories and laws, proving knowledge, understanding the reasons of reality, and lives of scientists. Here the category with the highest frequency was proving ideas and claims. Students believed that argumentation was a way to prove ideas and claims. They also connected argumentation with certain knowledge and reality.

"It (argumentation) is important. In fact, the science lessons are based on argumentation. Thus the lessons get more efficient and more stable."

"Yes, it is important because even if the different views are correct or wrong, certain knowledge is arrived at due to argumentation."

"It (argumentation) is certainly important because we as students accept all knowledge presented to us without any questioning. For example, we do not know and learn how buoyancy force is formed. Our teachers do not promote us to see this."

"It is certainly important. All subjects in science lessons are subjective. All knowledge presented us are required to be provable. Science teachers should be present convincing knowledge to us."

"Yes, we should know how the knowledge we would learn was found."

"In my opinion, it is important because we can prove and justify an idea. Thus we can tell it to people confidently."

"…to be assertive and to prove the claims are important in science lesson."
"It is important. The person can transfer own thought to the other persons. The correctness of this is discussed and taught in class environment. Thus, we can think that knowledge is proved in our minds."
"Of course. In fact, science lessons are based on theories and laws. A phenomenon is put forward and discussed. In my opinion, research, theories are the main parts and important."
…important because in order to be scientific, an idea should be seen in a same way by everyone and should believe in its reality."

2.5 Actions by Students and Teachers

Actions by students and teachers involved dealing with claims/counterclaims, participating in discussion, getting new ideas, discussing/checking correctness of ideas, teaching concepts to other people, transferring of thoughts, discussing ideas independently. Students perceived argumentation as dealing with claims or counterclaims. Some examples of their thoughts with respect to this perception were given in the following:
"…yes because I think that counterclaims point the people to think correctly."
"…yes because sometimes we want to learn counterclaims as well. Therefore, argumentation is of importance."
Some students claimed that students participate in argumentation in science classrooms. For instance one student said that:
"…Science lessons are so important. In science lessons, students always participate in discussion."

Students also thought that argumentation in science lessons provide them to get new ideas. For example one student said that:
"In my opinion, it (argumentation) is important. To mention about different ideas about a subject and listen to them enhances for us to get new ideas."
"Argumentation in science education is important. Thus, new and original ideas appear."

Argumentative discourse was seen as a tool in checking for the accuracy of ideas and in transferring ideas to other students. For example:
"…it is important because I can understand how much my knowledge is correct scientifically. Thus we evaluate the correctness of our thoughts."
"… important. The person can transfer own thought to the other persons. The correctness of this is discussed and taught in class environment. Thus, we can think that knowledge is proved in our minds."

Actions by teachers involved searching, taking students' ideas, more knowledgeable teachers, making concepts clear, explaining concepts, making review before lesson, promoting students to discuss and evaluating different viewpoints. Students thought that teachers should search about subjects they would teach to promote argumentation in their science classes. They claimed that more knowledgeable teachers are necessary for applying argumentation in science lessons. For example:
"The teacher should search subjects from every kind of source and then s/he should present them by making experiments or presentation to the students."
"Instead of teaching with just the knowledge they learnt at the universities, they should always improve themselves and also they should be supported to improve. They should take some courses for effective talking."
"In my opinion, the teacher should search from a lot of sources and know everything about the subjects. They should give supportive examples related to the subject but these examples should be appropriate for our levels so that we can understand them."
"…If a subject is wanted to be taught to students efficiently, it is necessary to remedy all dark points in students' mind related to the subject. Thus, arguments are necessary in order to prove

subjects."
"The teacher might promote argumentation by making review before lesson and making preparation for lesson, improving himself/herself consistently."

For some students, their ideas should be asked in the classroom during science classes and also different viewpoints of the students should be evaluated by teachers. The students thought that direct teaching in science lessons were not effective for their understanding of the subjects and that teachers should evaluate claims and counterclaims, prove concepts, teach concepts to students, and support students to think and explain their ideas in order to promote argumentation in science lessons.

2.6 Classroom Management

This perception involved motivating/promoting students to participate in lessons, authority/importance of teacher, making science lessons more enjoyable, getting students' attention to lesson, getting organized in classroom, behaving to students with tolerance, being positive towards students and making science lessons easy. Students especially pointed to the role of science teachers as authority in the classroom. They thought that teachers should teach science subjects in an enjoyable way in order to promote argumentation in science lessons:
"I wish, the teachers give some topics to us, we search them, and then we present them in the classroom environment, our willingness to participate in lessons increase and the lessons become more enjoyable."
"The teacher should use argumentation in order to ensure science lessons to be better, more enjoyable and to prevent for students to be bored."

2.7 Argumentation Not Important/Not Applicable

Some students perceived argumentation as not important because of some reasons. These reasons were that it is not possible to implement argumentation in our education system, because of time restriction, because of talking about nonsense subjects, because science is a kind of numerical area and because of difficulty of science.
"We do not have time for this. The system should be changed before changing the teacher."
"It cannot be said that it (argumentation) is always important because sometimes what's talked about is nonsense."
"It is important but I do not think it can be applied because our session numbers are not sufficient."
"Science lessons are difficult. Even if teachers teach much more students do not understand. But this is not teachers' wrong-doing."

Conclusions and Discussion

Despite vast emphasis on argumentation in science education in recent years, the focus on (a) students' understanding of argumentation, (b) students' perceptions of argumentation, and (c) students' perceptions of discourse have been overlooked in the research literature. The study reported in this paper aimed to provide some insight into these aspects of argumentation work in science education. Overall the results indicate that students' understanding of arguments particularly with respect to their differentiation of justification tools is quite limited. Students have difficulties in understanding of the type of justification. For example, in the first question in Argumentation Test, the students labeled the argument with "warrant only" which is the fourth convincing argument, as either "explanation, data, rebuttal", or "explanation and evidence", or "evidence only". This evidence support that students do not understand epistemological criteria and the difference in the status of this criteria.

Furthermore, even though students appreciate the role of argumentation and discourse in science teaching and learning, their perceptions of the use of various strategies in the implementation of argumentation were rather contradictory. For example, on the one hand, they claimed that they were not engaged in tasks that promote argumentation (e.g. pair discussion), and on the other, they claimed that they were doing argumentation in science lessons. Since the students of all grade levels in three types of schools participated in this study, the sample was varied in terms of grade levels and school types. When the physical conditions, school properties, and student profiles in these schools were taken into consideration, it is not surprising that the students in Anatolian high school had the highest mean score with respect to understanding of argumentation. It can be concluded that the students in the other schools do not seem to be aware of their learning environment because they have more conflicting perceptions of argumentation than those in Anatolian high school. Students' contradictory perceptions of argumentation imply that they are not enhanced to think through more metacognitive tasks. Therefore, teachers need to develop students' metacognitive skills which would enable students to evaluate their own thoughts, learning, etc. as well. Teachers can develop students' metacognitive skills by asking students what they did or which activities they involved in the previous lesson. Thus, teachers enforce students to think about their thoughts related to the lesson.

Qualitative in-depth analysis of students' references to discourse and argumentation illustrate that they are able to articulate a range of issues, spanning classroom environmental factors to understanding of argumentation and nature of science. The qualitative component of the study provides insight into the particular ways in which discourse and argumentation is positioned within students' perceptions.

Future studies in argumentation in science education will benefit from articulation of not only students' but also teachers' perceptions of discourse and argumentation. Explicit examinations of these perceptions are likely to inform researchers on how best to maximize the learning and teaching of argumentation in the science classroom. Without a sense of understanding of how students and teachers perceive argumentation, educational reform is likely to be limited.

References

Aydeniz, M., Pabuccu, A., Cetin, 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, 1303-1324.

Atwater, M. M., Gardner, C. M., & Wiggins, J. (1995). A study of urban middle school students with high and low attitudes toward science. *Journal of Research in Science Teaching, 32*, 665-677.

Berland, L. K. & Reiser, B. J. (2009). Making sense of argumentation and explanation. *Science Education, 93*(1), 26-55.

Bevins, S., Brodie, M. & Brodie, E. (2005). *Engineering a better future: UK secondary schools pupils'perceptions of science and engineering.* Paper presented at The European Conference on Educational Research, 7-10 September, Dublin.

Brickhouse, N. W. (2007). *Scientific literates: What do they do? Who are they?* Proceedings of the Linnaeus Tercentanary 2007 Symposium Promoting Scientific Literacy: Science Education Research in Transaction. Uppsala, Sweden.

Cavallo, A. M. L. & Laubach, T. A. (2001). Students' science perceptions and enrollment decisions in differing learning cycles classrooms. *Journal of Research in Science Teaching, 38*(9), 1029-1062.

Cetin, P. S., Erduran, S. & Kaya, E. (2010). Understanding the nature of chemistry and argumentation: The case of pre-service chemistry teachers. *Kırşehir Üniversitesi Eğitim Fakültesi Dergisi (KEFAD), 11*(4), 41-59.

Chin, C. S. (2008). *Current practices of scientific discourse and argumentation in science education: a mixed methods investigation based in Brunei Darussalam.* Unpublished MSc Dissertation, University of Bristol, UK.

Dagher, Z. R. (1995). Analysis of analogies used by science teachers. *Journal of Research in Science Teaching, 32,* 259-270.

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

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

Duschl, R. A. (2008). Quality argumentation and epistemic criteria. Chapter in S. Erduran & M.P. Jimenez-Aleixandre (Eds.), *Argumentation in Science Education: Perspectives from Classroom-Based Research.* Dordrecht: Springer.

Ebenezer, J. V. & Zoller, U. (1993). Grade 10 students' perceptions of and attitudes toward science teaching and school science. *Journal of Research in Science Teaching, 30*, 175-186.

Erduran., S., & Jimenez-Aleixandre, J. M. (2012). Research on argumentation in science education in Europe. In, D. Jorde, & J. Dillon (Eds.), *Science Education Research and Practice in Europe: Retrospective and Prospective*, pp. 253-289. Sense Publishers.

Erduran, S. (2008). Methodological foundations in the study of argumentation in science classrooms. Chapter in S. Erduran & M.P. Jimenez-Aleixandre (Eds.), *Argumentation in Science Education: Perspectives from Classroom-Based Research.* Dordrecht: Springer.

Erduran, S. & Jimenez-Aleixandre, M. P. (Eds.) (2008). *Argumentation in Science Education: Perspectives from Classroom-Based Research.* Dordrecht: Springer.

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*(6), 915-933.

Gallagher, S. A. (1994). Middle school classroom predictors of science persistence. *Journal of Research in Science Teaching, 31,* 721-734.

Gee, J. P. (1990). *Social linguistics and literacies: Ideology in discourses. Critical perspectives on literacy and education.* London: Falmer Press.

Gee, J. P. & Green, J. L. (1998). Discourse analysis, learning, and social practice: A methodological study. *Review of Research in Education, 23*, 119-169.

Gee, J. P. (2001). Literacy, discourse, and linguistics: Introduction and what is literacy? In E. Cushman, E. R. Kintgen; B. M. Kroll; M. Rose (Eds.), *Literacy: A critical sourcebook.* Bedford: St. Martins.

Jimenez-Aleixandre, M. P. & Erduran, S. (2008). Argumentation in science education: an overview. Chapter in S. Erduran & M.P. Jimenez-Aleixandre (Eds.), *Argumentation in Science Education: Perspectives from Classroom-Based Research.* Dordrecht: Springer.

Jimenez-Aleixandre, M. P. & Pereiro-Munhoz, C. (2002). Knowledge producers or knowledge consumers? Argumentation and decision making about environmental management. *International Journal of Science Education, 24*(11), 1171-1190.

Jimenez-Aleixandre, M., Rodriguez, A., & Duschl, R. (2000). "Doing the lesson" or "doing science": Argument in high school genetics. *Science Education, 84*(6), 757-792.

Kaya, E., Erduran, S., & Cetin, P. S. (2010a). High school students' perceptions of argumentation. *Procedia - Social and Behavioral Sciences, 2*(2), 3971-3975.

Kaya, E., Erduran, S., & Cetin, P. S. (2010b). *Assessing understanding of argument: Investigating pre-service science teachers' arguments and implications for classroom practice.* Paper presented at the Annual Conference of the National Association for Research in Science Teaching, Philadelphia, PA.

Klaassen, K. & Lijnse, P.L. (1996). Interpreting students' and teachers' discourse in science classes: an underestimated problem? *Journal of Research in Science Teaching*, *33, 2*, 115-134.

Kelly, G. (2007). Discourse in science classrooms. Chapter in S. K. Abell & N. G. Lederman (Eds.), *Handbook of Research on Science Education*. Mahwah, NJ: Lawrence Erlbaum Associates.

Kelly, G. & Takao, A. (2002). Epistemic levels in argument: An analysis of university oceanography students' use of evidence in writing. *Science Education, 86*(3), 314-342.

Koballa, Jr., T. R., Crawley, F. E., & Shrigley, R. L. (1990). A summary of science education-1988. *Science Education, 74*(3), 369-381.

Koballa, Jr., T. R. & Glynn, S. M. (2007). Attitudinal and motivational constructs. Chapter in S. K. Abell & N. G. Lederman (Eds.), *Handbook of Research on Science Education*. Mahwah, NJ: Lawrence Erlbaum Associates.

Leach, J. (1999). Students' understanding of the co-ordination of theory and evidence in science. *International Journal of Science Education, 21*(8), 789-806.

Lederman, N. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching, 29*, 331-359.

Lemke, J. L. (1995). *Textual Politics: Discourse and social dynamics.* London: Taylor and Francis.

Linn, M. C. (1992). Science education reform: Building the research base. *Journal of Research in Science Teaching, 29*, 821-840.

Lynch, M. & Macbeth, D. (1998). Demonstrating physics lessons. In J. Greeno & S. Goldman (Eds.) *Thinking Practices in Mathematics and Science Learning*. Mahwah, NJ: Lawrence Erlbaum Associates.

Macbeth, D. (2000). On the apparatus of conceptual change. *Science Education, 84*, 228-264.

McNeill, K. L. (2009). Teachers' use of curriculum to support students in writing scientific arguments to explain phenomena. *Science Education, 93*(2), 233-268.

Ministry of Education, Pakistan. (2006). National Curriculum for General Science. Grades IV–VIII. Islamabad: Author.

Myers, R. E. & Fouts, J. T. (1992). A cluster analysis of high school science classroom environments and attitude toward science. *Journal of Research in Science Teaching, 29*, 929-937.

Neathery, F. M. (1997). Elementary and secondary students' perceptions toward science and the correlation with gender, ethnicity, ability, grade, and science achievement. *Electronic Journal of Science Education, 2*(1).

Newton, P., Driver, R., & Osborne, J. (1999). The place of argumentation in the pedagogy of school science. *International Journal of Science Education, 21*(5), 553-576.

Osborne, J. F. & Collins, S. (2000). *Pupils' and parents' views of the school science curriculum* (London: King's College London).

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

Sadler, T. D., (2006). Promoting discourse and argumentation in science teacher education. *Journal of Science Teacher Education,* 17, 323-346.

Sampson, V. & Clark, D. (2006). The development and validation of the nature of science as argument questionnaire (NSAAQ). Paper presented at the Annual Conference of the National Association for Research in Science Teaching, San Francisco, CA.

Sandoval, W. A. (2005). Understanding students' practical epistemologies and their influence on learning through inquiry. *Science Education, 89*(4), 634-656.

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.

Simpson, R. D. & Oliver, J. S. (1990). A summary of the major influences on attitude toward and achievement in science among adolescent students. *Science Education*, *74*, 1-18.

Sua, T. Y. (2007). Attitudes and achievement orientations of students towards learning of science and mathematics in english. Kajian Malaysia, Jld. XXV, 1, 15-39.

Kuhn, T. S. (1970). *The Structure of Scientific Revolutions*; Second Edition; University of Chicago Press, Chicago.

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.

Zeidler, D. L. (1997). The central role of fallacious thinking in science education. *Science Education*, *81*, 483-496.

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.

APPENDIX A
ARGUMENTATION TEST (from Sampson & Clark, 2006)
Part I: Making a Scientific Argument

Introduction: Once a scientist develops an explanation for why something happens, he or she must support their claim with some type of reason. The explanation and the supporting reason is called an argument. Scientists use arguments to convince others that their claim is indeed true. How do you think scientists create a convincing argument?

Directions: The first three questions are designed to determine what you think counts as a good *scientific* argument. In each question you will be given a claim. Following the claim are 6 different arguments. Your job is to rank the arguments in order using the following scale:

1 = This is the **most** convincing argument
2 = This is the **2nd most** convincing argument
3 = This is the **3rd most** convincing argument
4 = This is the **4th most** convincing argument
5 = This is the **5th most** convincing argument
6 = This is the **least** convincing argument

Your task is to rank the 6 different arguments in terms of how convincing you think they are. *Remember that you can only rank one argument as 1, one argument as 2, one argument as 3, and so on.*

Question #1. Objects sitting in the same room often feel like they are different temperatures. Suppose someone makes the following claim about the temperature of various objects sitting in the same room, which reason makes the most convincing argument?

Claim: Objects that are in the same room are the same temperature even though they feel different because…	**Your Ranking**
…when we measured the temperature of the table, it was 23.4^{O}C, the metal chair leg was 23.1^{O}C, and the computer keyboard was 23.6^{O}C.	________________
…good conductors feel different than poor conductors even though they are the same temperature.	________________
…objects that are in the same environment gain or lose heat energy until everything is the same temperature. Our data form the lab proves that point: the mouse pad and plastic desk were both 23^{O}C.	________________
…objects will release and hold different amounts of heat energy depending on how good of an insulator or conductor it is.	________________
…the textbook says that all objects in the same room will eventually reach the same temperature.	________________
…we measured the temperature of the wooden table and the chair leg and they were both 23^{O}C even though the metal chair leg feels colder. If the metal chair leg was actually colder it would have been a lower temperature when we compared it to the temperature of the table.	________________

____

Question #2. A pendulum is a string with a weight attached to one end of it. Suppose someone makes the following claim about pendulums, which reason makes the most convincing argument?

Claim: The length of the string determines how fast a pendulum swings back and forth regardless of the weight on the end of the string because…	**Your Ranking**
…the weight on the end of a long string has a longer distance to travel when compared to a weight on a short string. As a result, pendulums with shorter swings make more swings per second than pendulum with longer strings.	_______________
…pendulums with different string length have different swing rates. We measured the swing rate of a pendulum with a 10 cm string and a pendulum with a 20 cm string, The 10 cm pendulum had swing rate of 2 swings per second and the 20 cm pendulum has a swing rate of 1 swing per second.	_______________
…a pendulum with a 14 cm string had a swing rate of 1 swing per second and a pendulum with a 15 cm string had a swing rate of 1 swing per second.	_______________
…a pendulum with a 10 cm string had a swing rate of 2 swings per second and a pendulum with a 15 cm string had a swing rate of 1 swing per second.	_______________
…our textbook says that the weight on the end of the string has nothing to do with how fast a pendulum swings.	_______________
…we tested the swing rate of three pendulums, one with a 10 gram weight and 10 cm string, one with a 10 gram weight and 20 cm string, and one with 20 gram weight and a 20 cm string. The two pendulums with the 20 cm string had the same swing rate (1 swing per second) and were slower the pendulum with the shorter string (2 swings per second). If the weight on the end of the string mattered these two pendulums would have had different swing rates but they were the same.	_______________

Question #3. Scientists often use animals in their research. Suppose someone makes the following claim about the use of animals in scientific research, which reason makes the most convincing argument?

Claim: Scientists should be allowed to use animals for research because…	**Your Ranking**
…a computer or other non animal model can be used instead.	_______________
…animals are susceptible to many of the same bacteria and viruses as people, such as anthrax, smallpox, and malaria. Even though animals differ from people in many ways, they also are very similar to people in many ways. An animal is chosen for research only if it shares characteristics with people that are relevant to the research.	_______________
…public opinion polls have consistently shown that a majority of people approve of the use of animals in biomedical research that does not cause pain to the animal and leads to new treatments and cures.	_______________
…animal research was essential in developing many life-saving surgical	_______________

procedures once thought impossible. For example the technique of sewing blood vessels together was developed through surgeries on dogs and cats by Alexis Carrel, for which he was awarded a Nobel Prize in 1912. _______________

…infecting animals with certain microbes allows researchers to identify the germs that cause different types of diseases. Once discovered scientists can develop vaccines to test the effectiveness of these vaccines without harming any people in the process. _______________

…humans have 65 infectious diseases in common with dogs, 50 with cattle, 46 with sheep and goats, 42 with pigs, 35 with horses, and 26 with fowl. _______________

Part II. Challenging an Argument

Introduction: Once a scientist develops an explanation for why something happens, he or she must support the explanation with the reasons for why they think their explanation is correct. The explanation along with its supporting reasons is called an argument. Sometimes other scientists agree with the argument; sometimes they do not. When they disagree, they challenge the accuracy of the argument. How do you think scientists challenge the arguments of other scientists? The last three questions on this test are designed to determine what you think counts as a good <u>challenge</u> to a s*cientific* argument.

Directions: In each question you will be given an argument. Following the argument are 6 different challenges. Your job is to rank the challenges using the following scale:

1 = This comment is the **strongest** challenge to this argument
2 = This comment is the **2nd strongest** challenge to this argument
3 = This comment is the **3rd strongest** challenge to this argument
4 = This comment is the **4th strongest** challenge to this argument
5 = This comment is the **5th strongest** challenge to this argument
6 = This comment is the **weakest** challenge to this argument

Question #4—Jason, Angela, Sarah, and Tim are in physics class together. Their teacher asked them to design an experiment to determine if all objects in the same room are the same temperature even though they feel different. After they designed and carried out an experiment to answer this question on their own, they met in a small group to discuss what they have found out. Suppose Jason suggests that:

> *"I think that all objects in the same room are always different temperatures because they feel different and when we measured the temperature of the table, it was 23.4^{O}C, the metal chair leg was 23.1^{O}C, and the computer keyboard was 23.6^{O}C."*

Angela disagrees with Jason. Your task is to rank the 6 different challenges given by Angela in terms of how strong <u>you think</u> they are.

Angela: I disagree… **Your Ranking**

…because your evidence does not support your claim. All of the objects that you measured were within one degree of each other. That small of difference is just measurement error. _______________

…I think that all objects in the same room are the same temperature even though they feel different _______________

…if those objects were really different temperatures their temperature would have been much different. For example, when I measured the temperature of my _______________ arm it was 37^{O}C while the temperature of the table was 23^{O}C that is a difference of 14 degrees. Everything else was right around 23^{O}C. ________________

...I think all objects become the same temperature even though they feel different because objects that are good conductors feel colder than objects that are poor conductors because heat transfers through good conductors faster. ________________

...because I know you always rush through labs and never get the right answer. ________________

...I think all objects become the same temperature because the temperatures of all those objects you measured were within 1 degree. ________________

Question #5—Tiffany, Steven, and Yelena are in the same science class. Their teacher asked them to design an experiment to determine what makes some objects floats and some objects sink. After they designed and carried out an experiment to answer this question on their own, they met in a small group to discuss what they have found out. Suppose Steven suggests that:

> *"I think heavy objects sink and light objects float. This is true because when I put the 10 gram plastic block in the tub of water it floated while the 40 gram metal block sank."*

Tiffany disagrees with Steven. Your task is to rank these 6 different challenges given by Tiffany in terms of how strong you think they are.

Tiffany: I disagree...	**Your Ranking**
...because Yelena is always right and she disagrees with you.	________________
...because you did not test enough objects. How can you be sure that it is the weight of an object that makes it sink or float if you only tested two things?	________________
...the metal block sank because it is very dense not because it is heavy and the plastic block floated because it has density that is less than water not because it is light.	________________
...because light objects can sink too. A paper clip only weighs one gram and it sinks. According to you claim all light objects should float. How can a paper clip that is lighter than a piece of plastic sink while the heavier piece of plastic floats?	________________
...The plastic block may have been lighter than the metal block but that is not why it floated. The metal block has a density of 2.5 g/cm^3, which is more than water so it sinks. The plastic block has a volume 16 cm^3 which means its density is .6 g/cm^3 which is less than water so it floats.	________________
...I think objects that have a density greater than water sink and objects that have a density less than water float.	________________

Question #6— Elana, Shauna, and Sam are in a science class together. At the beginning of class, their teacher poses the following question: *"Should scientists be able to use animals in medical research?"* The teacher then asked Elana, Shauna, and Sam to discuss what they think about the issue in a small group. Suppose Shauna begins the conversation by saying:

> ***"I think using animals in medical is a bad idea because people and animals suffer from different disease and the bodies of animals and humans are completely different. So how can scientists justify performing painful experiments on animals if they are so different?'***

Sam disagrees with Shauna. Your task is to rank these 6 different challenges given by Sam in terms of how strong you think they are.

	Your Ranking
Sam: I disagree…	
…even though animal and human bodies are completely different like you say, I think using animals in medical research is a good idea because it would be impossible to prove that a specific germ is responsible for a disease without the use of laboratory animals.	________________
…I think using animals in medical research is good idea and very useful.	________________
…animals are not that different from humans. Animals and humans have similar organs and animals suffer from many of the same diseases that we do.	________________
…because you don't know what you are talking about. You just care more about animals then you do about people.	________________
…an animal is only chosen for research if it shares characteristics with people that are relevant to the research. For example; animals share many of the same organs as people so they can be used to develop new surgical techniques. Organ transplants, open heart surgery, and many other procedures that are common today were developed by experimenting with animals.	________________
…how can using animals in research be a bad idea if it allows scientists to do research without having to conduct painful experiments on people?	________________

APPENDIX B
PERCEPTION OF ARGUMENTATION TEST (from Chin, 2008)

PART I (Classroom Discourse)

1. What are the different kinds of activities used in your classroom in order to encourage scientific discourse inside the classroom?
   You are allowed to tick more than one.
   - ☐ Group work
   - ☐ Pair work
   - ☐ Pair discussion
   - ☐ Group discussion
   - ☐ Open discussion
   - ☐ Debate
   - ☐ Drama (Role Play)
   - ☐ Practical
   - ☐ Experiment
   - ☐ Lecture
   - ☐ Other activities *(please state:____)*

2. How often do you participate in the talks inside the classroom in science courses?
   - ☐ Every lesson
   - ☐ Often
   - ☐ Sometimes
   - ☐ Seldom
   - ☐ Never
   - ☐ Others *(please state:____)*

3. From your view of point, is discourse important during science lessons? Please explain.
   ____
   ____
   ___

4. How can be increased the quality of the talks that take place inside the classroom?
   ____
   ____
   ____

PART II (Argumentation in Science and Science Education)

Argumentation is a scientific process among discourse, which involve activities such validating claims, justifying evidences, addressing to counterclaims, assessing alternatives and interpreting justifications. Inside the classroom, it is a process in which students justify their ideas through the use of evidences and reasoning power to produce strong arguments or well-justified claims. For example, Toulmin's argumentation pattern is widely used to evaluate scientific arguments and its main components are: 1. *Claim* – idea, conclusion, hypothesis, or opinion 2. *Data* – scientific evidences or facts that support the claim 3. *Warrants* – scientific reasoning of how the data support the claim 4. *Backings* – commonly agreed assumptions that help justify warrants 5. *Rebuttals* – providing evidence to contradict or nullify other presented evidences 6. *Qualifiers* – recognizing where there are limitations or restrictions on a claim. 7. *Counterclaim* – opposing claim to the initiation An argument should comprise of one or more of the components above. Good quality arguments are said to be accompanied by *qualifiers* and strong *rebuttals* against *counterclaims*.

Complete this section based on your understanding on what argumentation is.

1. How often is argumentation used during science lessons?
   - ☐ Never
   - ☐ Seldom
   - ☐ Sometimes
   - ☐ Once every week
   - ☐ Every lessonOthers *(please state:____)*

2. Has a lesson been used especially to incorporate argumentation in science lessons?
   - ☐ Yes
   - ☐ No

   If yes, what are the kinds of activities used during science lessons to support argumentation?

   - ☐ Group work
   - ☐ Pair work
   - ☐ Pair discussion
   - ☐ Group discussion
   - ☐ Open discussion
   - ☐ Debate
   - ☐ Drama (Role Play)
   - ☐ Practical
   - ☐ Experiment
   - ☐ Lecture
   - ☐ Other activities *(please state:_______________________________________)*

3. How do you feel when a collaborative work to support argumentation is carried out in science lessons?
   - ☐ Enthusiastic
   - ☐ Reluctant
   - ☐ Bored
   - ☐ Unwillingness
   - ☐ Others *(please state: ____)*

4. What is your average level of involvement to talk activities in science lessons?
   - ☐ 100%
   - ☐ 75%
   - ☐ 50%
   - ☐ 25%

5. From your point of view, is argumentation an important process in science education? Please explain.

   ____
   ____
   ____

6. From your point of view, what can a teacher do in order to support argumentation in science lessons?

   ____
   ____
   ____