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The effects of argumentation model on students' achievement and argumentation skills in science

Seda Okumus[a] *, Suat Unal[b]

[a]*Kazım Karabekir Education Faculty , Atatürk University, Erzurum, 25240, Turkey*
[b]*Fatih Education Faculty, Karadeniz Technical University, Trabzon, 61100, Turkey*

Abstract

The aim of this study is to investigate the effects of argumentation model on students' achievement on the unit of "States of Matter and Heat", and also to determine how to change students' argumentation skills during the instruction through argumentation model. Semi-experimental design was used in this study. The sample was comprised of totally 40 eight grade students from two different classes in a primary school. An achievement test and semi-structured interviews were used to collect data. The achievement test was implemented to both experimental and control groups as pre- and post-tests. Semi-structured interviews were conducted with students to determine students' views about the lessons in which argumentation model was used. Also, all discussions in the science lessons were audio recorded to determine how to change students' argumentation skills during the instruction of the unit. Results showed that argumentation model had positive effects on students' achievement and conceptual understanding on the unit, and there was a significant difference between experimental and control groups in favor of the experimental group. Moreover, the analyses of the data obtained from the interviews and audio recordings clearly indicated that experimental group students' argumentation skills were improved gradually during the instruction.

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1. Introduction

Recently, with advance of teaching and learning science as inquiry, numerous studies have focused argumentation in science education (e.g., Driver, Newton, & Osborne, 2000; Duschl, Ellenbogen & Erduran, 1999; Erduran, & Jiménez-Aleixandre, 2007; Kelly & Takao, 2002; Linn, 2003; Osborne, Erduran, & Simon, 2004; von Aufschnaiter, Erduran, Osborne, & Simon, 2008). In societies that want to be pioneering in the field of science and technology, it is need to people who should have critical thinking and reflective thinking ability. For this reason, it seen that argumentation is so important for advancement. It is taken into account science generally advances with arguments and discussions therefore the significance of argumentation is being understood once again in science education.

Science learning is a process that contains implementations of nature of universe. Therefore, in this process argumentation is an important requirement to developing scientific knowledge because scientific learning is not only includes how natural laws occurred or how the universe was existed but also focuses some explanations about how is universe going to be in the future. Thus, scientific learning starts a discussion about main reasons of these facts and natural theories (Erduran, Simon, & Osborne, 2004). With reference to this mean, argumentation is a central role for science learning. Argumentation is an implementation of constructivism and according to constructivism,

*Seda Okumuş. Tel.: +90-442-2314205
E-mail address :seda_okumus @windowslive.com

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using argumentation provides to query both student's own ideas and their friends' ideas. From this point of view, in order to improve inquisition and discussion in science learning, there should be a science program that includes the implementations of argumentation (Driver et al., 2000; Millar & Osborne, 1998). However it is known that argumentation applications are not used so much in science classes because of some reasons (Driver et al., 2000). Moreover, due to the teachers' lacking of the abilities starting and maintaining discussions, argumentation can not be carry out rightly in their classes (Driver et al., 2000).

In this study, the effects of argumentation model on students' achievement on the unit of "States of Matter and Heat" were investigated, and also it was determined how to change students' argumentation skills during the instruction through argumentation model.

1.1. Argument in science learning

There are many studies about using argumentation in science teaching and learning. These researches mention to facilitate student-student and student- teacher discourse (von Aufschnaiter et al., 2008) and provide advancement of students' argumentation skills (e.g. Zohar & Nemet, 2002). These studies also based on Toulmin (1958) argument model. According to Toulmin's argumentation main elements are these:

Claim: Claim is an idea that is put forward about a notion, an opinion or a result (explanations searching to interpret natural phenomena compose a special sort of claim).

Data: It is a fact that is based on realities and it used for supporting claims.

Warrant: It explains relationships between claim and data. It is an explanation that how data support claim.

Backings: It is main assumption that supports warrant's acceptability. It is necessary when warrants are not accepted.

Rebuttal: It is used in the even that claim is not acceptable.

Qualification: Express the grade of certainty or uncertainty of an argument, for instance "probably", "for sure", "it depends" (Jimenez-Aleixandre et al., 2002).

According to most of these researches, using video or audio in order to record discourses and students' and teachers' argumentation skills have been investigated. Results indicate that learning and teaching argumentation model, increase the quality of students' argument, so that students use arguments frequently (Osborne et al., 2004; Zohar & Nemet, 2002). Argumentations are examined at five levels with regard to its quality (Erduran et al., 2004).

Level 1: Argumentation at this level consists of arguments that are a simple claim versus a counterclaim or a claim versus claim.

Level 2: Argumentation at this level consists of claims with data, warrants, or backings, but do not contain any rebuttals.

Level 3: Argumentation at this level consists a series of claims or counterclaims with data, warrants, or backings with the occasional weak rebuttal.

Level 4: Argumentation at this level consists a claim with a clearly identifiable rebuttal. Such an argument may have several claims and counterclaims as well, but this is not necessary.

Level 5: Argumentation at this level displays an extended argument with more than one rebuttal.

A simple argument consists a claim. Zohar & Nemet (2002) would not wish to recognize claims without justifications as meriting any significance. Besides, Osborne et al. (2004) believe they are important because they are the first step toward initiating the process of establishing difference (Osborne et al., 2004). Arguments that consist rebuttals are higher in quality than the others. Sections with rebuttals are, however, of better quality than those without, because facing sections without rebuttals have to potential to continue forever with no change of mind or evaluation the quality of the substance of an argument (Osborne et al., 2004). According to Kuhn (1991) the ability to use rebuttals is the most complex skill because, an individual must provide an original and alternative theory, arguing that the original theory is more correct. So, rebuttals are needed element of arguments of better quality and prove a higher level capability with argumentation (Osborne et al., 2004). For these reasons using arguments consisting of claims, data, warrants, backings, and rebuttals in classes positively affects science learning and teaching.

2. Method

In order to investigate argumentation model's effectiveness on students' achievement and their argumentation skills in the unit of "States of Matter and Heat", semi-experimental design was used in this study. The sample was

comprised of totally 40 eight grade students from two different classes in a primary school at Erzurum in Turkey. While experimental group were thought with teaching/learning activities based on argumentation model, no intervention was made in control group. Implementations continued for five weeks in both control and experimental groups. An achievement test and semi-structured interviews were used to collect data. The achievement test was implemented to both experimental and control groups as pre- and post-tests. Semi-structured interviews were conducted with experimental group students to determine students' views about the lessons in which argumentation model was used. It is wanted to explain from students how argumentation model affect their learning.

In the experimental group, students divided into six groups for argumentation study. In the teaching of the subject in the experimental group, both small group discussions and class discussions were done. Also, all discussions in the science lessons were audio recorded to determine how to change students' argumentation skills during the instruction of the unit. It is used these materials for argumentation in the science classroom:

1.Competing theories-story: Students were given a story about heat and its diffusion and they were asked for discussing it.
2.Table of statements: Students were given a table containing some true and false statements and they were asked to discuss them.
3.Competing theories-cartoons: It was given a cartoon containing some true and false statements about specific heat and they were asked to discuss them.
4.Predicting, observing, and explaining: It was given an analogy about states of matter and accordingly this analogy it was given some questions about a predicting, observing, and explaining activity and wanted to discuss from students.
5.Competing theories-ideas and evidence: It was given some statements about melting, heat and evaporation heat and they were asked to discuss them.
6.Evidence cards: Students were given two diagrams about heating ice to steam and some evidence cards related to transforming of ice into steam by heating and they were asked to discuss them.
7.Argumentation with models: Students were It is given four questions about gravitational force between matters' particles and they were asked to draw a figure or a model. Afterwards, they were asked to discuss their models.
8.Concept map of student ideas: Students were given a concept map consisting of the concepts involving in the selected subject and they were asked to discuss the relationships among these concepts.

3. Findings

3.1. The findings related to students' achievement

The achievement test was implemented to both experimental and control groups as pre- test. According to the statistical analyses of the data in pre-test, it was not found a significant difference between experimental and control groups ($p=0.32$; $p>0.05$).

Table 1. Pre-tests results

	Class	N	X	SD	t	p	s
Pre-test	C	20	51.05	16.741	1.007	.320	3.743
	E	20	45.20	19.854			4.439

The achievement test was also implemented as post- test to both groups. According to the statistical analyses of the students' scores in post-test, it was found a significant difference between experimental and control groups ($p=0.03$; $p<0.05$).

Table 2. Post-tests results

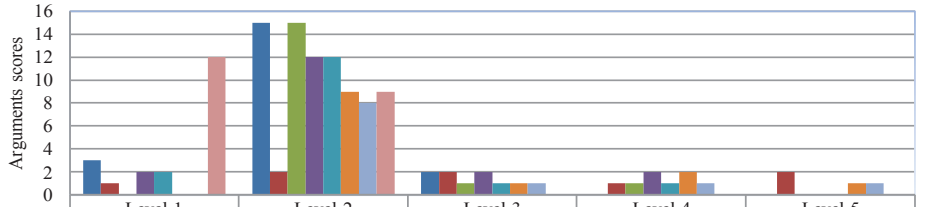
	Class	N	X	SD	t	p	s
Post-test	C	20	70.10	13.022	3.134	.003	2.912
	E	20	54.20	18.577			4.154

3.2. The findings related to students' argumentation level

In this study, all discussions were audio recorded to determine how to change students' argumentation skills during the instruction of the selected subject. It is determined that students formed 1-5 level arguments. It is presented below some examples about students' argumentation in different levels.

Level 1: When relationship between matter and states of matter (solid, liquid, and gas) are clarified:
D1: When a matter is state of gas, the space of it's' particles are more than liquids and solids (claim).
Level 2: A2: The aim of pouring salts on the iced road is to make freezing be late (claim). Because the specific heat of salt is too much (warrant). So, if you pour salts on the iced roads, water freeze late. Because, if a matter's specific heat is high, it freezes late and it boils late (data).
Level 3: D1: If the mass of a matter is too much, it is needed to give more heat in order to reach the same temperature (claim). It is needed to heat in order to warm water particles (data). If a matter is heavy than the others, this means there are more particles to warm up (warrant). Two glasses of water includes more particles than a glass of water (backing). They are not at the same temperature because the mass of two glasses of water volume is more than that of a glass of water (rebuttal).
Level 4: A1: If you compare sand and water including equal numbers of particles , we can say that sand warms up more quickly (claim). Because the specific heat of sand is smaller than that of water (warrant). So, the sand warm up quickly. At the last experiment, we heated up water and oil. Because the specific heat of oil smaller than water, it warmed up more quickly than water (backing).
C1: If water warms up quickly than sand, our feet will be burned when we go to the beach (rebuttal).
Level 5: "If temperature is 0^0C, the energy of molecules must be zero."
A5: It is not true (claim). Because, when temperature is zero, heat is not zero (backing). Heat is energy and at 0^0C, energy is not zero at 0^0C (rebuttal). Heat is particles' total energy so it might be negative (warrant). When temperature is negative, heat is being (rebuttal). It is also an account (data). The temperature of a molecule can also be negative (backing).

It is given a table at below about students' progress at argumentation levels and it also mentions students' using argument levels frequency.



	Level 1	Level 2	Level 3	Level 4	Level 5
CTS	3	15	2	0	0
TS	1	2	2	1	2
CTC	0	15	1	1	0
POE	2	12	2	2	0
CTIE	2	12	1	1	0
EC	0	9	1	2	1
AM	0	8	1	1	1
CM	12	9	0	0	0

Figure 1. The levels of students' argumentions in the activities

CTS: Competing theories-story, TS: Table of statements, CTC: Competing theories-cartoons, POE: Predicting, observing, and explaining, CTIE: Competing theories-ideas and evidence, EC: Evidence cards, AM: Argumentation with models, CM: Concept map of student ideas

3.3. The analysis of semi-structured interviews

Semi-structured interviews are conducted with three students in the experimental group. Students were asked to explain how argumentation model used in their science classes has affected their learning. When students were asked whether or not they were pleased to learn science with argumentation, they said that they were generally pleased with argumentation model in their science class, except for the noise which sometimes occurred in the class because of the all students' discussions. When students were asked to say the part in which they were having

difficulty, they generally declared that they had difficulty in especially finding warrant. Also, it was determined that they had difficulty in forming arguments because some students had never participated in such an activity including argumentation process. In the other interview question students were asked to whether their science lessons were more enjoyable with argumentation model than the earlier science lessons. All students in the experimental group stated the science lessons in which argumentation model was used were more enjoyable than the earlier ones. The last interview question was whether they were pleased from studying with groups. It was determined that most students were very pleased with their friends in a group work, but some of them complained about their friends who did not join into the discussions. They pointed out that science lessons with argumentation provide them to learn different ideas of their friends, so that they were able to test their ideas.

4. Conclusion and Suggestions

Results showed that argumentation model had positive effects on students' achievement and conceptual understanding on the unit. As shown in Table 1 and Table 2, experimental group students have greater scores than control group students on the post- test. Moreover, there is a significant difference between experimental and control groups in favor of the experimental group in terms of achievement on the unit. Results of the study have showed that students have difficulty in forming arguments because they had never participated in such an activity including argumentation process. This result is also in consistent with the researchers' observations in the experimental group. Because students' lack of knowledge about forming argumentation model, it was explained to the students in experimental group in the first science class. Students had difficulty in forming argumentation especially in the first activities because it was the first they had encountering with such an activity. In the first activities, students' argumentation levels were very low. However, they improved their argumentation skills through the instruction with argumentation model. They were able to use rebuttals effectively and related claims and warrants. They could also use backings and data in their arguments. Therefore, it can be deduced that experimental group students' argumentation skills were improved gradually during the instruction. Although students in the experimental group have improved their argumentation skills during the instruction with argumentation model, the levels of argumentations of most of the students are at second level as seen in Figure 1. This result shows that most students in the experimental group could not formed argumentations including claims, counterclaims, rebuttals, etc. With regard to this result, it can be deduced that most students can suggest a claim and support it with data and backings. However, they are not good at using rebuttals at opposite claims. If we ask our students to form argumentations at higher levels, it would be useful to use argumentation models in our science classes more frequently and give our students enough time and chance to adopt discussions and argumentations. With regarding the students' answers in the interviews about the science classes with argumentation model in this study, it can be suggested that the science lessons including such activities would be useful for students in terms of realizing the others' ideas about science, testing their ideas, making their learning more permanent in an enjoyable learning environment.

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