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DELVING INTO the EFFECT of ARGUMENTATION BASED INQUIRY APPROACH on LEARNING SCIENCE from MULTIPLE PERSPECTIVES

FARKLI PERSPEKTİFLERDEN ARGÜMANTASYON TABANLI ÖĞRENME YAKLAŞIMININ BİLİM ÖĞRENME ÜZERİNE ETKİLERİNİN DERİNLEMESİNE İNCELENMESİ

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Öz
Bu araştırma Argümantasyon Tabanlı Bilim Öğrenme Yaklaşımı (ATBÖ) uygulamalarının öğrencilerin fen başarıları üzerine etkisinin öğrenci ve öğretmen gözünden derinlemesine ve boylamsal değerlendirilmesini hedeflemektedir. Araştırmada karma araştırma yöntemlerinden açıklayıcı desen kullanılmıştır. Araştırmanın örneklemini, amaçsal örnekleme yöntemi ile seçilen Türkiye'nin kuzeydoğusunda yer alan bir il merkezindeki ortaokulda öğrenim gören toplam 39 öğrenci ve bu öğrencilerin fen bilgisi öğretmeni oluşturmaktadır. Araştırmada aynı öğrencilerin 7. sınıf ve 8. sınıf uygulamalarına yer verilmiştir. Veriler; ünite tabanlı fen başarı testi ve yarı yapılandırılmış görüşmeler yolu ile elde edilmiştir. Araştırmanın sonunda öğretmen ve uygulama grubundan 10 öğrenci ile yarı yapılandırılmış görüşme yapılmıştır. Araştırma sonuçları, ATBÖ yaklaşımının öğrencilerin ünite tabanlı fen başarılarının istatistiksel anlamlı düzeyde artmasına kakı sağladığını göstermiştir. Öğrenci ve öğretmen görüşmelerinden elde edilen sonuçlar paralelinde öğrencilerin öğrenmelerini sağlayan etkenler; öğrencilerin kendi sorularını oluşturmaları, araştırmalar yapıp deneyler tasarlamaları, yaptıkları gözlem ve deneylerden veriler toplamları ve bulduklarından yola çıkarak iddia ve deliller oluşturmaları yolu ile sürece yaparak ve yaşayarak katılmalarıdır.

Anahtar Kelimeler: Argümantasyon, Öğrenme, Fen Eğitimi, Argümantasyon Tabanlı Bilim Öğrenme

Abstract
The purpose of the study was to investigate the impact of implementing Argument Based Inquiry (ABI) Approach on students' science achievements from students' and teacher's perspectives through quantitative and qualitative data analyses. In the research, explanatory design within mixed methods has been implemented. The study involved 7th and 8th grade students and their science teacher from northeast of Turkey. A total of 39 students participated in this study were randomly assigned to the comparison and treatment groups. As data collection tools science achievement test and semi-structured interviews from students and teacher were used in the research. While science achievement tests were implemented at the begging and the end of the unit, the semi-structured interviews were conducted upon completion of the unit with teacher and 10 students in the treatment group. The results revealed that the ABI approach had significant impact on treatment group students' conceptual understanding of science when it is compared to those in the comparison group. The factors affecting student learning within the ABI process was outlined as follows: student involvement in the hands-

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on process with the generation of own questions, making investigations and designing experiments, collecting data through the observations and experiments, and generation of claims and evidence based on the findings.

Keywords: Argumentation, Learning, Science Education, Argument-Based Inquiry

Introduction

Science is not only a collection of facts about the natural world but a process of thinking and investigation on the basis of empirical evidence, logical reasoning and questioning through making observations, constructing hypothesis, testing, gathering, and interpreting data and proposing explanations (Ministry of National Education [MEB], 2006). The science curriculum aims to enable individuals to possess acquired skills and knowledge as well as to develop positive attitudes, perceptions and values toward science. Besides, the science curriculum is designed to educate scientifically literate individuals who are self-confident, collaborative and capable of involving in effective communication, decision-making, and problem-solving processes. In this context, science education reforms pointed out the importance of inquiry as both outcomes of science learning and teaching strategies (Hohenshell, & Hand, 2006). The current science curriculum emphasized the design of inside and outside learning environments in accordance with the inquiry-based learning strategy as a means of promoting meaningful and permanent science learning (MEB, 2013). The curriculum handles inquiry as not only a process of "exploration and experimentation" but also a proposing "explanation and argument" in which students desire to explore the surrounding environment, propose strong arguments by generating evidence based explanations about the physical and natural world, and get excited about the science. That is, inquiry-based learning is defined as a student-centered approach that provides individuals with experience of hands-on, minds-on science in the growth of scientific knowledge.

Within the process of inquiry, students should be provided opportunities to think over/reflect on what they are doing while communicating, reasoning, analyzing, writing, and sharing findings (Choi, Notebaert, Diaz, & Hand, 2010). Basing upon the scientific inquiry, argumentation-based inquiry is an approach that assists learners to construct scientific knowledge through querying (Cavagnetto, Hand, & Norton-Meier, 2010; Hand, & Keys, 1999). Therefore, argumentation-based science learning approach is able to offer students with the defined opportunities.

Argumentation-Based Inquiry Approach

Argumentation-based science learning approach is developed by Hand and Keys (1999) as a framework that attaches the importance of the use of language in learning and portrays argument as an embedded component to scientific inquiry. The ABI is an instructional approach designed to assist student learning in science (Cavagnetto et al., 2010). It aims to support student negotiation in science through argument structures (Hand, & Norton-Meier, 2011) and help students to construct arguments (especially arguments in written forms) within a process of scientific inquiry (Choi et al., 2010).

The ABI as a successful approach to increase student voice and scientific reasoning (Martin, & Hand, 2007) reflects the argument and dialogue processes that scientists apply to construct theories or laws (Burke, Greenbowe, & Hand, 2006). Furthermore, the approach incorporates learning and teaching theories such as constructivist learning, extended content science literacy, understanding the nature of science and suitable forms of writing and scientific argumentation (Keys, Hand, Prain, & Collins,1999).

Argument-Based Inquiry Learning Approach and Learning

Learning is not simply participation in the learning process but an act of practicing mental abilities, thinking, making interpretations on the acquired knowledge, and decision-making in which learners actively take role of the responsibility of their own learning, directing the self-learning process, collaborating with each other, and experience higher order thinking skills (Kalem, & Fer, 2003). Within this process, individuals are required to take the responsibility of their own learning and improve higher order thinking skills. Dewey asserted that thinking can be initiated only when someone is confronted with problems and then, the brain construct hypothesis to solve the problems so that resulting problem solution process stimulates learning (Philips, & Soltis, 2004/2005). Therefore, mental constructions of the items to be learned are initiated by the individuals on their own (Arkun, & Askar, 2010). In this context, students require learning environments in which they are able to improve the interpretation and problem solving skills as well the ability of explaining the phenomena (Ozden, 2011).

Emerging hands-on science, thinking and writing activities, ABI approach offers opportunities to students to ask a question, gather evidence, propose claims in the light of testing the evidence and making decisions by the comparison of the prosed claims with other sources of information (Hand, Wallace, & Yang, 2004; Hand, 2008; Martin, & Hand, 2007). The approach provides students with opportunities on the basis of its nature to generate own research questions, proposing strategies to answer the questions and conducting investigations (Martin, & Hand, 2007). Students generate their own questions; test the questions; and present their experimental results along with the proposed claims to each other. Within this process, students argue about their own knowledge; and they require developing an understanding of the knowledge by testing it (Burke et al., 2006). In addition to satisfying the needs of students, the ABI approach construct understandings through the comparison of constructed claims with the existing knowledge as well as through the social construction of knowledge by presenting the proposed claims to each other (Hand et al., 2004). Through the end of the ABI process, students have to test the constructed knowledge by the help of the peer reviews to provide better information to target audience. Moreover, they can revise the testing procedure and reconsider what they have learned with the help of writing the claims and evidence within ABI reports written throughout the process (Burke et al., 2006). A session of the ABI report allowing students to reflect how their ideas have changed provides them with opportunities to recognize what they did throughout the process. Students view the reflections as an important means to understand the topic, recognize what they did and most importantly make connections between the self-understanding of the topic and negotiated meaning (Burke et al., 2006). The above mentioned stages of ABI approach develop student understanding of nature of science and science subjects (Keys et al., 1999).

Within last years, many studies have been conducted to investigate the effect of ABI approach on learning in national and international contexts (Cavagnetto et al., 2010; Chin, & Osborne, 2010; Gunel, Kingir, & Geban, 2012; Hand, & Norten-Meier, 2011; Kingir, 2011; Nam, Choi,& Hand, 2011). The common findings of the studies revealed that ABI approach has a positive impact on learning-teaching in the construction of scientific knowledge. However, the research outcomes have not focused on how ABI approach provides learning, which aspects of the ABI approach facilitate learning, and the examination of the learning environment from the teacher and student perspectives. However those available research findings are limited in terms of providing reach evidences about why and how the ABI approach scaffolds science understanding. In this regard, the aims of the current study are first, to investigate the effect of Argumentation-Based Inquiry (ABI) approach on student science achievement in 7^{th} and 8^{th} grade science classrooms and second, to examine the grounds of the success from the teacher and student perspectives. In this context, the study addressed the following research questions:

I. How does the ABI approach affect students' unit-based science achievements on "human and environment" unit of the 7th grade and "force and motion" and "structure and properties of matter" units of the 8th grade?

II. According to teachers and students, which aspects of ABI approach promote learning of science subjects?

Method

A type of mixed-methods design, explanatory research design, was used in the study. Explanatory design requires first carrying out a quantitative method and then using a qualitative method to clarify and elaborate the quantitative findings (McMillan, & Schumacher, 2010). Since the research requires conducting semi-structured interviews in order to elaborate the quantitative findings collected through pre-post tests and to evaluate the ABI process from the teacher and student perspectives, explanatory research design was preferred in the study.

Participants

Participants of the study were selected with purposeful sampling method. Purposeful sampling requires in-depth investigation of the information-rich cases regarding to purpose of the study (Buyukozturk et al., 2010). Since the participant teacher had experienced the ABI approach as a voluntary teacher within a comprehensive project and has lived in a same city with the researcher, purposeful sampling method was preferred to use in the study.

The participants in this study were a total of 39 students and their science teacher working in 7th and 8th grade classrooms in a city located in the north-east region of Turkey. While a total of 19 students were participated in the experimental group, 20 of them were assigned to comparison group. Students lived in a low socio-economic status households and communities. Some of them work outside of the school environment to financially help to their parents. The school that was located in a region allowing immigrants from the surrounding cities has offered limited opportunities to students (The school has not got any science laboratory or library). The science teacher had 5 years of teaching experience. The teacher had experienced the ABI process through The Scientific and Technological Research Council of Turkey (TUBITAK) funded project. Within the scope of the project, she had experienced the ABI approach in her own classroom for 2 years and also, participated in the professional development workshops regarding to ABI approach for 3 times.

Implementation process

The study was first, launched with students at 7th grade and continued with the same students at 8th grade, covering a period of one year. The activities applied in the classroom were in the scope of “Human & Environment” unit of the 7th grade and “Force & Motion”, and “Structure and Properties of Matter” units of the 8th grade. Implementation and comparison groups were randomly selected among students having the same science teacher. Implementation group students experienced ABI approach, working on investigation and inquiry-based activities in groups of three or four. In this context, each group first collectively generated questions on the subject and then performed experiments, made observations and investigational activities so as to collect data. These experiments were completely designed by the students and modified through the interaction between the teacher and students or discussions among the group members. The role of the teacher during these small group discussions is to visit each group and take part in the conversation, asking questions on what and how they are doing, and on their findings and interpretations. That way, the teacher directed students towards the big idea of the subject and tried to prevent misconceptions. Within this process, students interpreted the collected data and made observations in their small group discussions so as to propose arguments. Then, large group discussions followed where each group presents their arguments together with their evidences. The teacher again took part in these discussions by asking questions that guided students around the big idea of the subject and complementing the missing information as well as enhancing inter-student interaction. Following these discussions, each student individually completed the ABI reports written throughout the process. This report includes students’ view of initial thoughts on the subject, research questions, designed experiments, findings/observations, claims, evidences, information from the written resources and possible changes in their thoughts throughout the process. To summarize, the teacher included students in the discussions considering the conceptual structures and objectives of the subject throughout the process that began with the determination of questions and lasted with the discussion of the claims and evidences. The teacher structured the relationship between conceptual components and parts of each unit with the help of student-centered questions, observations, research techniques, discussions, claims and evidences.

Within the comparison group, students were generally in a listener position, answering questions of the teacher and rarely asking to the teacher. The teacher used the same pedagogy as he/she used to, teaching the lessons with direct instruction method and at times applied to questioning and demonstration strategies. Moreover, the teacher made demonstrations that he/she has designed or taken from the textbook and conducted other textbook activities to inform the students on the subject

Class hours and the teacher were controlled as the same for implementation and comparison groups; the major difference was the differing roles of the teacher in both groups. The major difference between the teacher roles of implementation and comparison groups can be briefly outlined as follows: As compared to the usual practices of the comparison group, the teacher involved in a different preliminary process for the implementation group classroom (preparing a concept map to determine big and sub ideas of the unit, preparing activities for each sub ideas). Moreover, differently from the comparison group, the teacher created a learning environment in which students engaged in question-claim-evidence triangles, small and large group discussions and written evaluation of the process by leading them as a guide.

Data collection tools

Data were collected through unit-based science achievement tests and semi-structured interviews. The achievement tests were assigned as pre and post-tests. At end of the implementation process, semi-structured interviews were conducted with the teacher and 10 students were selected among implementation group students.

The unit-based science achievement tests were developed by the collaboration of science teachers (n=15) considering the views of the teacher in the study. For each unit, a total of three achievement tests were developed. The tests were assigned to different student groups before the main study to make the reliability analysis. Cronbach alpha reliability coefficient was found to be 0.63 in “Human and Environment” unit comprising 15 multiple choice and 3 open-ended questions; 0.71 in “Force and Motion” unit comprising 17 multiple choice and 4 open-ended questions, and 0.71 in “Structure and Properties of Matter” unit. Cronbach alpha value of .70 and above is acceptable to determine the instrument as reliable. However, in case of consisting of small number of questions, the instrument is reliable with a Cronbach alpha value of at least .60 (Sipahi, Yurtkoru & Cinko, 2008).

Interview questions were developed by receiving the opinion of 2 instructors that are expert in the field of ABI approach. As asking the questions to students and teacher, intelligibility of the conversation was assured by using the comprehensible terms. Furthermore, since the same question can have different meanings for different individuals, alternative questions were prepared to elaborate what they mean (E.g.: How did you do that? Can you give one of your friends name to exemplify this situation?). In order to assure the reliability and validity of the in-depth information gathered through the interviews, face to face interviews were conducted within the school environment (Yildirim & Simsek, 2005). Within the data analysis part, direct quotations from the interviews were given. Data were analyzed by coding each response into several categories on the basis of common attitude, thoughts and opinions. Each response was coded two times with 3 weeks in between. The consistency of the two coding for each response was found to be 95%. After this process, codes, themes and sub-themes were generated.

Data analysis

The quantitative data of the study were analyzed by using SPSS packet program. Since the number of participants was not so large to assure normality assumption (n<30), non-parametric test was conducted in the study (Howell, 2010; Sipahi et al., 2008). In order to compare achievement test results for each three units of the implementation and comparison group students, Mann Whitney U Test was conducted.

The qualitative data were gathered through semi-structured interviews first, transcribed and then, transferred to electronic environment. Main themes and sub-themes were generated by the analysis of the interview transcripts.

Results

1- Analysis of unit-based science achievement tests

The mean along with standard deviation values regarding to pre-post unit test results of the implementation and comparison group students are presented in Table 1.

Table 1.
Arithmetic Means of Pre-Post Unit-Based Test Results of the Implementation and Comparison Groups

			Human and Environment Unit			Force and Motion Unit			Structures and Properties of Matter Unit		
	Pre-Post Test	Group	n	X	Ss	n	X	ss	n	X	ss
Pre Test	Multiple Choice	Imp.	17	5.41	1.22	18	7.00	1.93	18	4.83	2.35
		Comp.	14	3.28	1.54	20	5.69	2.38	20	5.10	1.58
	Open-Ended	Imp.	17	6.35	3.29	18	1.59	1.06	17	0.00	0.00
		Comp.	14	6.00	4.80	20	1.31	1.13	19	0.00	0.00
	Pre Test Total	Imp.	17	11.76	3.45	18	8.59	2.64	17	4.94	2.38
		Comp.	14	9.28	5.15	20	7.00	2.47	19	5.16	1.60
Post Test	Multiple Choice	Imp.	19	3.84	1.38	17	7.18	2.24	15	10.20	2.70
		Comp.	18	3.72	1.67	16	7.44	2.33	19	6.00	2.58
	Open-Ended	Imp.	19	10.68	5.98	17	8.76	3.64	15	4.67	2.69
		Comp.	18	9.50	4.71	16	3.19	3.16	19	0.53	1.21
	Post Test Total	Imp.	19	14.52	6.56	17	15.94	4.78	15	14.87	4.20
		Comp.	18	13.22	5.29	16	10.63	4.54	19	6.53	3.27

n: Number of Students, X: Arithmetic Mean, ss: Standard Deviation, Imp.: Implementation Group, Comp.: Comparison Group

As seen in Table 2, within the first unit, Human and Environment, while pre-test results regarding to multiple choice questions showed differences between implementation and comparison groups (U= 31.50, *z*= -3.54, *p*< .01, *r* =-.64), there was no significant difference within pre-test open-ended questions (U= 107.00, *z*= -.48, *p*> .01, *r*= -.09) and pre-test total scores (U= 83.50, *z*= -1.41, *p*> .01, *r* = -.25) of the groups. The total post-test score of multiple choice questions (U= 161.00, *z*= -1.41, *p*> .01, *r* = -.23), and open-ended questions (U= 144.00, *z*= -.824, *p*> .01, *r* = -.14) and thus, total post-test scores (U= 152.50, *z*= -.56, *p*> .01, *r* = -.09) did not show any significant difference between the implementation and comparison groups.

Table 2
Mann Whitney U Test Results of the Implementation and Comparison Groups within the Scope of Human and Environment Unit

	Pre-Post Test	Group	N	Mean Rank	Rank-sum	*U*	*p*
Pre Test	Pre Test Multiple Choice	Implementation	17	21.15	359.50	31.50	.000
		Comparison	14	9.75	136.050		
	Pre Test Open-Ended	Implementation	17	16.71	284.00	107.00	.630
		Comparison	14	15.14	212.00		
	Pre Test Total	Implementation	17	18.09	307.50	83.50	.150
		Comparison	14	13.46	188.50		
Post Test	Post Test Multiple Choice	Implementation	19	19.53	371.00	161.00	.750
		Comparison	18	18.44	332.00		
	Post Test Open-Ended	Implementation	19	20.42	388.00	144.00	.410
		Comparison	18	17.50	315.00		
	Post Test Total	Implementation	19	19.97	379.50	152.50	.570
		Comparison	18	17.97	323.00		

As seen in Table 3, within the scope of the second unit, "Force and Motion", there was no significant difference between implementation and comparison groups in terms of the total pre-test scores regarding multiple choice questions (U= 131.00, *z*= -1.45, *p*> .01, *r* = -.24), open-ended questions (U= 163.00, *z*= -.60, *p*> .01, *r* = -.09) and thus, total pre-test scores (U= 130.50, *z*= -1.47, *p*> .01, *r* = -.24). This resulting data revealed that the groups were similar to each other. When the post-test results were examined, it was seen that there was no significant difference within total scores of multiple choice questions (U= 97.50, *z*= -1.40, *p*> .01, *r* = -.24). However, total scores of open-ended questions (U= 35.50, *z*= -3.68, *p*< .01, *r* = -.64) and total post-test scores (U= 48.00, *z*= -3.18, *p*<.01, *r* = -.55) revealed significant differences between the implementation and comparison groups. The corresponding results are presented in Table 4.4.

Table 3

Mann Whitney U Test Results of the Implementation and Comparison Groups within the Scope of Force and Motion Unit

	Pre-Post test	Group	N	Mean rank	Rank-sum	*U*	*p*
Pre Test	Pre Test Multiple Choice	Implementation	18	22.22	400.00	131.00	.147
		Comparison	20	17.05	341.00		
	Pre Test Open-Ended	Implementation	18	20.44	368.00	163.00	.545
		Comparison	20	18.65	373.00		
	Pre Test Total	Implementation	18	22.25	400.50	130.50	.142
		Comparison	20	17.02	340.50		
Post Test	Post Test Multiple Choice	Implementation	17	19.26	327.50	97.50	.162
		Comparison	16	14.59	233.50		
	Post Test Open-Ended	Implementation	17	22.91	389.50	35.50	.000
		Comparison	16	10.72	171.50		
	Post Test Total	Implementation	17	22.18	377.00	48.00	.000
		Comparison	16	11.50	184.00		

As seen in Table 4, within the scope of the third unit, "properties and structure of matter", there was no significant difference within the total pre-test scores regarding multiple choice questions (U= 162.00, *z*= -.53, *p*> .01, *r* = -.08), open-ended questions (U= 161.50, *z*= .00, *p*> .01, *r* = -.00), and thus total pre-test scores (U= 150.00, *z*= -3.37, *p*> .01, *r* = -.56) between implementation and comparison groups. This resulting data revealed that the groups were similar to each other. When the post-test results were examined, it was seen that there was significant differences within total scores of multiple choice questions (U= 39.50, *z*= -3.59, *p*< .01, *r* = -.62), open-ended questions (U= 31.00, *z*= -4.11, *p*< .01, *r* = -.76) and thus, total post-test scores (U= 23.00, *z*= -4.16, *p*<.01, *r* = -.77) between the groups. The results are presented in Table 4.

Table 4

Mann Whitney U Test Results of the Implementation and Comparison Groups within the Scope of Structure and Properties of Matter Unit

	Pre-Post Test	Group	N	Mean rank	Rank-sum	*U*	*p*
Pre Test	Pre Test Multiple Choice	Implementation	18	18.50	333.00	162.00	.593
		Comparison	20	20.40	408.00		
	Pre Test Open-Ended	Implementation	17	18.50	314.50	161.50	1.00
		Comparison	19	18.50	351.50		
	Pre Test Total	Implementation	17	17.82	303.00	150.00	.712
		Comparison	19	19.11	363.00		
Post Test	Post Test Multiple Choice	Implementation	15	24.37	365.50	39.50	.000
		Comparison	19	12.08	229.50		
	Pro Test Open-Ended	Implementation	15	24.93	374.00	31.00	.000
		Comparison	19	11.63	221.00		
	Post Test Total	Implementation	15	25.47	382.00	23.00	.000
		Comparison	19	11.21	213.00		

2- Interview results

Examining the student interviews, 3 themes were emerged. The emerging themes are presented in Table 4.8.

Table 5
The emerging themes of the student interviews

Themes	Frequency
Student generation of own questions, design of experiments, making investigations, data gathering, participating in generation of claim and evidence processes promote learning.	10
Student sharing of ideas, making discussions with each other promote learning.	10
Writing the ABI reports makes student learning permanent.	9

Considering student statements, three themes contributing to student learning were emerged. These are student making observations, investigations and experiments, sharing of ideas with their friends through discussions and writing ABI reports. The first one of these themes is that "student generating of their own questions, design of experiments, making investigations, data gathering, participating in generation of claim and evidence processes" help them in their learning process. Sample statements related to this theme are given below:

FD: Here, we do things that we did not think we could. We also discuss on them. That makes us learn better.

HE: Experiments, for instance. I get things better that way. It feels like we produce something.

SD: They ask us about evidences. We make preparations so that we can explain. It helps. We comprehend better.

SY: We come up with questions, perform experiments and obtain results. We discuss the parts that we don't get. That way, we learn better.

The second theme, which is "student sharing of ideas, making discussions with each other" requires some explanation. There are two types of discussions in the process; small group and large group discussions. Students were asked to evaluate these two separately. Student evaluations on small group discussions pointed out that small group discussions contribute their learning, make them cooperate, help them investigate and evaluate both own and their friends' ideas and enable them to convince each other.

SY: We conducted experiments and discussed as a group. That way we got things better. Our teacher listened to us and in case of conflicting opinions we discussed and trying to find the right one. That was good.

HÜ: It helps emerging of several ideas. In case of opposite opinions, we discuss and investigate so as to select the reasonable one. The bad side is that quarrels emerge at times. But they don't last long.

HE: There is no such thing as "what I say is true". Discussing as a group makes me realize when I am wrong. My friends tell me the correct one and help me learn. When there are different opinions, we try to get the reasonable one. There is no need for studying individually.

FE: We discuss what we discover. We think of what other groups may ask us. We get things better when we discuss. Everyone puts forth own opinions and tries to support it. Without group-working, we cannot discuss. This lets us understand better and provides us with a more efficient studying.

YD: It is helpful since we ourselves tell our friends. That way, friends who did not know can learn, too.

When asked for evaluating the large group discussions, students state that the process makes learning easier and makes them contribute to each other's learning by emergence of more ideas, learning to consider events and situations from their friends' perspectives.

DD: We are trying to prove our claims. Other groups ask us questions and we discuss on them. It is constructive since we tell our friends their mistakes. I learn from them, too. Each group investigates a different subject so I learn their subject, too.

ŞÇ: We pay more attention since the other group will ask the reason behind our actions. It is constructive. When I get my friends' point of view, I realize that they may be right, too. When they explain what they did in their turn, then we ask them how and they explain to us. It is better this way. It has even affected my daily life. I try to prove things on regular occasions. I think it is effective.

HE: This one is better than the small group discussion since there are more people involved. It is something like brain-storming. All suggest their own claims.

EÇ: Our friends ask about the point that they could not get and we explain them. We learn better.

Examining student statements, small and large group discussions contribute to learning of science subjects by making students express their opinions, try to persuade others, share their knowledge and thus learn from each other.

The ABI reports written by students during the process constitute another theme. When asked for their opinion on this process, they state that they prepare the reports in light of group decisions that come out of group discussions, the process makes them comprehend easier and that it makes what they have learnt permanent.

> DD: I think it is helpful. It is necessary since we are writing down the experiments, findings and our claims. Writing helps us comprehend the subject. We discuss as a group and write the common decision.
>
> SY: I think it is necessary. We write about our claim, evidence and what we learnt. It made us learn better since we thought twice when we were to write what we did. It helped us remember later.
>
> HA: We discuss to find some common ground and then write it down in the report. Writing makes it more memorable, I don't forget it.
>
> YD: Writing the report makes me review the subject.
>
> EÇ: I get things better by writing the report.

Interviews with the teacher revealed four themes. These themes are as follow:

a. Student involvement in the ABI process by doing and experiencing themselves, contribute to student learning.
b. Developing an investigative identity through the ABI process contributes to student learning.
c. Students' curricular discussions and expressing themselves contribute to student learning.
d. Improvement of student-student and student-teacher interaction enhance student learning.

When asked for evaluating the ABI process during the interview, the teacher stated that ABI practices make students' learning of science easier, offer an enjoyable lecture that provides permanent learning and improve class interaction.

R: How would you assess ABI process?

T: The lecture turns into a more enjoyable, more sociable process where students are more active and learn better. Permanent learning of students is available. The practices make students talk and investigate during the lecture.

R: Are there any differences between the classroom that you applied ABI and the two others?

T: I think that students in my ABI class had a more permanent learning and they have better communication skills. I have seen them researching in groups and preparing for the class even outside lecture hours. I mean that they are concerned with the lesson even outside lecture hours. I cannot say so for the other classes.

When asked for the conditions that make student learning easier in this process, four sub-themes were determined according to the teacher's answers. First of these themes is that *student involvement in the process by doing and experiencing provides student learning.* The teacher's opinion on this matter is as follows:

T: One of the most important factors is that, the students learn by doing and experiencing. That is, determining questions, deciding on what experiment to conduct and which tools to use, performing those experiments by themselves and bringing out things by using simple material make them learn. This way, it is also possible to transfer the science lesson to daily life. For example, diapason and xylophone are available in the science laboratory in the scope of "The Sound" unit. However, students bring strings of different size and thicknesses taken from music instruments from their daily lives and set up a mechanism in the classroom. They construct a music instrument themselves and compare sounds of different strings, demonstrating how good they comprehended the subject. I hear from them that they feel like as if they were scientists. To give another example, it is one thing that a student brings sand to the class and measures how much a book is buried for its different positions so as to draw conclusions, and another that the teacher gives real life examples like snow shoes and tracked vehicles. Student learning in the former case is more permanent since students themselves make connections with the daily life.

The second sub-theme that provide student learning is that *students' developing an investigative identity during the ABI process contribute to their learning.* The teacher mentions that students have learnt how to do research and resulting gain of an investigative identity contributes their learning of science subjects.

> *T: Secondly, students develop an investigative identity. In the scope of the new system we assign performance and project assignments, asking them to do research. However, student perception of them is usually looking up on the internet and bringing printouts. It is not so for the ABI class. I find it easier to direct students to research. Students learn how to do research and how to draw conclusions with what they found, and this contributes to their learning. Moreover, I assign writing and research assignments more easily and they return assignments of better quality.*

Our third sub-theme is that *students' curricular discussions and expressing themselves contribute to their learning.* The teacher states that, with ABI practices, students' talking on subject matter as well as participation in the classroom increased and their ability to express themselves has been improved so that they learnt better.

> *T: Another factor is students' talking on the subject matter during the class and their expressing themselves. For example, I had this student who had trouble putting into words what he thought as in saying "the thing makes us that" instead of "skeleton system holds our body up". I witnessed that student expressing his thoughts smoothly at the end of ABI process. I observed that students, who originally had no interest in the class, want to talk during the lecture and try to participate in classroom and so study for that reason.*

The teacher emphasizes that among the factors that provide learning, the relationship between improved self-expression skills and learning is the most effective one. The teacher expressed the situation as follows:

> *T: If I were to compare these factors, I would rank the improvement of self-expression skills as the most important. For instance, today's students have grown up striving in a system of multiple choice tests. Therefore, they normally cannot answer open-ended questions. This year in particular, the last exam was composed of open-ended questions, only. I observed that the ABI class was more successful and that they were trying to put down something. They are trying somehow to express themselves, to understand the question and to comment on it.*

Another influential factor is that *improvement of student-student and student-teacher interaction enhance student learning.* The teacher expressed that classroom interaction has been enhanced together with ABI implementations, resulting in a chance for students to learn from others so that they would contribute to learning of each other.

> *T: The most intense communication is within groups; however there is an interaction also between different groups. Students share opinions, cooperate with each other. Conflicts arise between groups; they try to refute each other's claims while arguing their own. That way, they learn from each other and that is favorable for the class since they learn better. Besides, they also communicate with me more comfortably which helps them ask easily what they couldn't get or what troubles them. Still, student dialog is the more effective one on their learning.*
>
> *R: Why is student-student dialog so important?*
>
> *T: Unfortunately, our educational system is not one that encourages students to talk and to think. That is why students' dialog with each other is more effective for them to get to be sociable and to learn how to think. To achieve a better environment where students improve their conversation skills, think and express themselves better, they need to enhance their dialog with each other, respect each other and learn how to listen to others. They should learn how to behave while listening and how to refute claims of each other. Likewise, they develop the ability to learn from another, when he/she comes up with some argument. This, then, affects the learning process positively.*

Discussions

The study was conducted aiming to investigate the effect of ABI activities on student learning of science subjects from the teacher and student perspectives and on student unit-based science achievements. By analyzing the first research question asking "How does the ABI approach affect students' unit-based science achievement?", a significant difference was found in favor of the implementation group. This difference showed an increase throughout the time and thus, implementation group was demonstrated to be more successful in terms of learning of the science subjects. Therefore, the study has revealed that the ABI approach provided significant contribution to student science achievements. The teacher and students stated that the ABI approach contributed to student science learning as well as promoted permanent science learning. Considering the analysis of the achievement test results and teacher and student opinions on the process, it is inevitable to state that the ABI approach contributes to development of science learning. Research in this area emphasized the importance of argumentation-based learning environments in the development of student conceptual and in-depth understandings (Chin, & Osborne, 2010; Driver et al., 2000; Keys et al., 1999). The ABI implementations positively affect science achievements of students in different grade levels (Driver et al., 2000; Kaya, & Kilic, 2008; Gunel et al., 2010; Hand et al., 2004; Yesildag-Hasancebi, & Gunel, 2013). However, the research has not focused on which aspects of the ABI approach provides student learning. Within the current study, the aspects of ABI approach contributing to student learning were investigated from the teacher and student perspectives.

Both the teacher and students agree on the contribution of the ABI process to student science learning. Considering the teacher and student opinions, the factors affecting student learning within the ABI process was outlined as follows: student involvement in the hands-on process with the generation of own questions, making investigations and designing experiments, collecting data through the observations and experiments, and generation of claims and evidence based on the findings. The ABI approach provides students with opportunities to generate own questions regarding to problem situation, develop strategies to answer the questions and make investigations (Martin, & Hand, 2007). These opportunities are important for learning. Thinking can be initiated by the confrontation of problems so that learning is promoted with the construction of hypothesis and testing of them to solve the problem situations (Philips, & Soltis, 2004/2005). Within this process, individuals are required to generate knowledge by data processing, finding a meaning to new data and embedding them into their own thinking system (Ozden, 2011). Therefore, it can be stated that the ABI process in which students have opportunities to learn by doing contribute to student learning.

While students are trying to propose solutions to own generated questions, they make observations and experiments within an investigation process. As the teacher indicated, this process develops an investigative identity and correspondingly, contributes to student learning. Argumentation-based activities make students active and curious about science, encourage them to provide explanations and develop their research skills (Driver et al., 2000; Kaya, & Kilic, 2008). The development of investigation skills contributes to student learning by providing them opportunities with the construction of own knowledge.

The ABI report in which students write the investigation results and resulting inferences is another factor contributing to student learning. At the end of each activity, students individually write the ABI reports. When asking for the evaluating report writing process, students stated that the process was effective, facilitated their understanding and made what they learned permanent. Based on these, students think that the process contributes to their learning. The reasons behind the student opinions can be the report writings that provide opportunities to revise the findings and investigations conducted throughout the process (Burke et al., 2006).

Furthermore, the writing process develops student understanding of science subjects (Keys et al., 1999). The writings are not simply transfer of information from the textbook or blackboard, but outcomes of students own efforts (Choi et al., 2010). This indicates that the writing process that students involved in the ABI process is a writing to learn activity. This type of writing activity not only provides construction of conceptual knowledge but also serves as an epistemological tool to enhance science literacy (Hand, Prain, Lawrence, & Yore, 1999). This explains the positive effect of the process on student learning.

Within the ABI process, students are provided opportunities to discuss with each other while making experiments/observations/investigations and writing the ABI reports. The discussion process is another factor affecting student learnings. Considering the student statements, it can be determined that small group discussions provides opportunities to collaborate with others, query the own and peer opinions, persuade each other and contribute to development of friendships. Large group discussions offer emerging of many different ideas and provide opportunities to learn how to consider events or situations from others perspectives and to improve each other's learning. In this context, it is possible to state that the ABI approach provides learners with opportunities to learn from each other because they discuss about their own knowledge and require testing, understanding as well of share of the generated knowledge (Burke et al., 2006). Social construction of knowledge by presenting the generated claims to others constructs understandings (Hand et al., 2004). Additionally, within the large group discussions, peer reviews contribute to student learning from each other by the review of own knowledge to provide better information to target audience. Because, in course of the communication during the discussions, each individual is subject to effects of others and they influence each other (Hesapcioglu, 2008).

Another factor contributing to student learning is that students express their opinions comfortably by the help of an increase in student-teacher interactions. Each classroom has its own communication pattern created by the teacher-student and student-student interactions (Gozutok, 2007). Within the classrooms, an intensive communication is generally experienced between teacher and student (Demiray, 2012). Within the scope of the current study, the teacher stated that students comfortably communicated with her and expressed themselves in a better way after the ABI practices, and this situation contributed to student learning. Student asking a question in a comfortable way indicates a healthy communication between the teacher and student (Taspinar, 2005). Teacher-student interaction also contributes to student learning since it has a significant effect on student participation and motivation (Demiray, 2012; Tan, 2007). Learning described as an effort of cooperation and collaboration, is dependent on the effective communication between the teacher and student (Tan, 2007). By the help of an effective communication with the teacher, students develop positive attitudes by receiving the required feedbacks (Demiray, 2012). The achievement of the educational aims is affected by the teacher-student communication (Demiray, 2012). Within the learning process, student-student interaction is as important as student-teacher interaction (Gozutok, 2007). At this point, it can be stated that the ABI practices provides opportunities with students establishing healthy communications with each other. During the interviews, students emphasized the importance of communication within group works and discussions as stating that they learned better by expressing themselves better. Students think that asking questions to peers in a comfortable way and expressing the ideas based on the given responses offers opportunities to eliminate deficiencies as well as to correct the mistakes. Peer discussions about any subject matter provide students with emergence of the thoughts on the matter, construction of new knowledge and learning from each other (Akpinar & Ergin, 2005). Therefore, classroom interaction is important to ensure the learning from each other.

Considering the teacher and student statements, the ABI approach contributes to student learning by providing a learning environment in which students learn by doing, discuss in small and large groups, develop investigative identity, acquire skills to express themselves better and involve in writing activities as well as in increasing classroom interaction (student-student and teacher-student interaction). In this regard, the teacher and students commonly expressed that the ABI process increased the participation of students that had not generally paid attention to classes before. During the ABI practices, these students were interested in the subject matter and started to engage in the discussions about the topic. Additionally, some students made preparations regarding to lesson even outside of the classrooms.

The current science education curriculum specifies the teacher role as sharing the value, importance of science as well as the enthusiasm and responsibility of accessing to scientific knowledge with the students. Moreover, they should serve as a guide for the student investigation process and encourage them so as to improve research enthusiasm and scientific way of thinking, and to internalize the principles of the scientific ethics during the implementations. The student role was defined as communicating and collaborating effectively while inquiring the knowledge with their peers. In this context, the ABI approach provides opportunities with teachers to implement inquiry-based activities within the classroom environments.

Within the scope of this study, recommendations for future research are as follows: investigating how the ABI approach affects teacher pedagogy and resulting effects of a change in the teacher pedagogy; examining the ABI process, impacts of it, confronted difficulties, and possible solutions by longitudinal studies; and investigation of the effect of ABI process on students within different grade levels, and from different socio-economic and socio-cultural status. Possible suggestions for the researcher and teachers practicing the ABI approach are as follows: Ensuring the sustainability of the teacher ABI implementations to reflect the practices into learning environments effectively and teacher writing of reflections of an implementation to better organize subsequent ABI practices. Additionally, teachers should pay attention to whether student questions generated at the beginning of the process are clear, intelligible and feasible. This will provide achievement of the educational goals and effective functioning of the process.

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