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Overview of Obstacles in the Implementation of the Argumentation Based Science Inquiry Approach and Pedagogical Suggestions

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The aim of this study is to investigate the possible problems confronted in implementing Argumentation Based Science Inquiry (ABI) approach. In addition, the ways that teacher used to deal with those problems were further investigated in this study. For this purpose, this study utilized a case study methodology. The participant was a teacher at a primary school located in the eastern part of Turkey. The teacher took part in a project1 related to ABI. Data were collected through classroom videotape recordings and semi-structured interviews. The results indicated problems in grasping the ABI by the teacher, questioning (teacher and student questioning), classroom interaction, classroom management, and accessing resources and equipment.

Introduction

Along with the rapid development of science and technology, many countries have made substantial changes in their curricula. The current science curriculum movements view scientific literacy as their central goal. Curricula that are designed with respect to the today's science education reform movement enable individuals cope with the changes in science, technology and society. Science curriculum is designed by asking what students should know, do and value as a citizen to achieve scientific literacy for all students (Hurd, 1998).

Turkey is one of the countries in which a new science curriculum has just developed. Some international indicators like Trends in International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA) and the feedback from the previous science curriculum forced the educational system to undergo a major curricular change at science curriculum to meet the goal of scientific literacy. Characteristics of a scientifically literate individual was described as follows: understanding the scientific nature of knowledge; understanding the basic science concepts, principles, theories and laws, and utilizing them appropriately; utilizing science process skills during problem-solving and decision-making; understanding the interaction among science, technology, society and environment; developing scientific and technical psychomotor skills (Ministry of National Education [MNE], 2004).

With the revision of science curriculum, there has been a growing interest in using the argument-

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based interventions in Turkish science education context (e.g., Erduran, Ardaç & Yakmacı-Güzel, 2006; Gümrah & Kabapınar, 2010; Kaya & Kılıç, 2008). Current studies reveal that engagement in argumentation process develops students' conceptual understanding, reasoning abilities and cognitive, metacognitive, communication, and critical thinking skills, which further cultivates scientific literacy (Jimenez-Aleixandre & Erduran, 2007; Cavagnetto, 2010). Reviewing a number of studies, Cavagnetto (2010) demonstrated a variation in the nature of the argument-based interventions based on three orientations: a) immersion in science for learning scientific argument, b) understanding the structure to learn scientific argument, and c) understanding the interaction of science and society to learn scientific argument. He concluded that although all three orientations promoted scientific literacy at some level, immersion-oriented interventions were the most promising one for motivating scientific literacy. This conclusion supports Hurd's (1998) assertion that science literacy characteristics should be embedded in a lived curriculum instead of teaching them directly. There are some instructional approaches that blend inquiry and argumentation in science teaching, e.g., argument-driven inquiry (Sampson & Gleim, 2009), personally seeded discussions (Clark & Sampson, 2007), and the Science Writing Heuristic (Keys, Hand, Prain & Collins, 1999).

Over the last decade, Science Writing Heuristic (SWH) has been used extensively as an argument-based inquiry approach (ABI) in many countries including USA, Korea and Turkey. The SWH was originally developed by (Keys et al., 1999) to integrate argument-based inquiry activities, collaborative group work and writing-to-learn strategies. Argumentation and inquiry are two main underlying elements of the SWH. In the current research agenda, ongoing scholars in this field focused on the argumentation processes embedded within the context of doing inquiry and referred to SWH approach as an argument-based inquiry approach (e.g., Cavagnetto, 2010; Hand, Norton-Meier, Staker, & Bintz, 2009; Yoon, Bennett, Mendez, & Hand, 2010). SWH proposes two flexible templates to guide teachers and students (Table 1). Teacher template can be used in designing the learning environment considering the exploration of prior learning, engagement in activities, small group and whole class negotiations, individual negotiations through writing-to-learn, and discussion of the concepts under consideration. Student template may act for students as a tool for writing-to-learn or a guide for engaging in activities. The guiding questions provided in SWH student template promote students' participation in argumentation process. Similarly, guiding questions provided in SWH teacher template encourage teachers to create an argument-based inquiry learning environment.

Table 1: SWH template for teacher and student

Teacher template	*Student template*
Pre-instructional activities such as exploration of students' prior understandings, brainstorming and questioning.	What are my questions?
Participation in activities	What did I do?
Negotiation phase I – writing personal meanings for investigations	What can I claim?
Negotiation phase II – sharing and comparing data understandings with peers	Why am I making these claims?
Negotiation phase III – comparing science ideas to textbooks or other resources	How do my ideas compared with others?
Negotiation phase IV – individual reflection and writing Exploration of post-instructional understandings	How have my ideas changed?

Studies (e.g., Akkus, Gunel, & Hand, 2007; Burke, Hand, Poock, & Greenbowe, 2005; Cavagnetto, Norton-Meier, & Hand, 2006; Poock, Burke, Greenbowe, & Hand, 2007; Nam, Choi, & Hand, 2010; Omar & Hand, 2004) revealed that students' conceptual understanding in science becomes deeper when the degree of the teachers', instructors', or teaching assistants' implementation level increases. Teacher level of implementation was analyzed through the observations, video analyses, and field notes. Teachers' implementation level was categorized into low, medium and high considering teachers' ability to define the big ideas of the unit, engage students in dialogical interactions, and asking open-ended questions. As teachers define the big ideas properly, engage the students in dialogical interactions, and ask open-ended questions; their implementation level increases and thereby their students' conceptual understanding and development of scientific arguments enhances (Omar & Hand, 2004). The students who had an opportunity of greater voice in the classroom also had an opportunity to negotiate the meaning of the science concepts, which resulted in greater performance in science (Cavagnetto, et al., 2006). Moreover, Akkus et al. (2007) demonstrated that high-quality implementation of the SWH approach closed the achievement gap within science classrooms, and implementation of the SWH approach was useful for low-achieving students. As the implementation of SWH became higher, the benefit of low-achieving students gradually increased.

The implementation level of SWH could be improved by enhancing the quality of questioning, dialogical interaction, and argument structures. Martin and Hand (2009) designed a longitudinal single case study to analyze an experienced fifth grade teacher's implementation of SWH approach. The teacher participated in a professional development project and her class sessions were videotaped for further analyses. The videotapes were analyzed based on the Reformed Teacher Observation Protocol (RTOP). The results showed that the teacher moved from a traditional approach to a more student-centered approach through shifting her questioning patterns. The teacher's typical questioning was following an initiate-respond-evaluate (IRE) pattern where she evaluated student response immediately. She changed her questioning pattern into initiate-respond-feedback (IRF) where she gave feedback after student response without evaluating. She changed the type of questions from close-ended into more open-ended in the study. This study demonstrated a parallel shift between teacher's questioning and student voice. With more student voice, teacher voice decreased and the teacher acted as a listener and a resource person, and students' use of elements of argument such as claim, evidence and rebuttal increased.

Some problems in ABI classrooms were detected in low- or medium-level implementations, which were generally originating from the teacher or students. For example, Günel, Kıngır and Geban (2012) demonstrated some problems in three different Turkish argument-based inquiry classrooms using the SWH approach related with questioning and negotiation of ideas. The main problems detected in this study were as follows: 1) Teachers were asking many more questions than students, 2) Teachers were generally asking low-level questions, 3) Little teacher promotion for student talk, 4) Following Initiation-Response-Evaluation (IRE) pattern in which the teacher initiates a question, the student responds, and the teacher evaluates the response to end the interaction, 5) Teacher role as a director, 6) A difficulty in adopting non-traditional, student-centered, approaches in science class, and 7) Difficulty in classroom management for effective talking and listening. These problems were originating from both teachers and students. The authors focused on the role of the teacher for an effective implementation of the ABI approach. They asserted that teacher actions were the key determinants for student actions. If teachers exerted much effort in their classes, their students were likely to ask more questions and to talk more.

Taken as a whole, science courses should aim at training students who are scientifically thinking, critically analyzing, solving problems encountered in daily life, and integrating knowledge, technology, society and environment. The studies up to now consistently revealed that effectively implemented ABI approach supports the acquisition of those skills (e.g., Martin & Hand, 2009). In addition, effective implementation of the ABI also means effective implementation of the latest science curriculum. There is a limited study in Turkish context touching upon the problems in the ABI classrooms (e.g., Günel et al., 2012). There is a need for the identification of problems that hinder effective implementation of the ABI and propose solutions for those problems to enhance student benefit from the implementation of the ABI in Turkish context. Therefore, this study aimed at investigating the possible problems confronted in implementing ABI approach. In addition, the ways to deal with those problems were further investigated in this study.

Method

Methodology

In order to explore teacher's problems and solutions for these problems and teacher's suggestions, this study utilized a case study methodology. In this study, the case was a teacher's eighth–grade science classroom using the ABI approach. A case study is an in-depth analysis of an entity and it examines a bounded system, or a case, over time in depth, employing multiple sources of data found in the setting (McMillan & Schumacher, 2010). The case may be a program, an event, an activity, or a set of individuals bounded in time and place. In this study, semi-structured interviews and videotape recordings were used as sources of data.

Participant

The participant is a teacher at a primary school located in the eastern part of Turkey. He is a science teacher at the elementary level with four years of teaching experience. He utilized the ABI approach for science classroom for two years. He attended two professional development programs about ABI approach in science education. In this study, the teacher used ABI approach for the four learning topics in a science unit within one month period. The unit was force and motion unit (density, lift, pressure in solids, liquids and gases). In his classroom, there were 21 students participated in the study.

Data collection

Data was collected from two sources: classroom videotape recordings and semi-structured interviews. Teacher was observed by videotape during the study. Video recordings were collected over four topics of unit. Thus, four video recordings were collected. The videotape data was transcribed and written documents were obtained. Semi-structured interviews were conducted with the teacher at the end of the study. For its validity, interview questions were examined by an expert in science education. Teacher was asked to answer questions about problems that he had experienced in ABI process in his science classroom and suggestions for those problems. Sample questions included in the semi-structured interviews were given as follows:

- What were the problems that you encountered in the implementation of the ABI classroom?
- What were your solutions to the problem that it is inadequate for interaction among students?
- What was the nature of student-teacher interaction in your ABI classroom?
- What are your suggestions for solutions of problems?

Data analysis

All video recordings and teacher interview were transcribed and the transcripts were used to develop the coding schemes and to code the data. Two researchers identified broad codes/themes independent from each other through analyzing the classroom video and teacher interview transcripts. Then codes were compared and differences were discussed by researchers until being reached an agreement of 90%.

Results

The result section was organized around research questions. The findings were discussed under three headings: teacher's problems, solutions and suggestions for these problems. Under each heading, qualitative data from both videotapes and semi-structured interview were presented.

1. Teacher's problems encountered in the implementation of the ABI classroom

Teacher's problems in his ABI classroom can be classified as: difficulty in grasping the ABI, asking question (teacher and students questions) and promoting classroom interaction. When video recordings were analyzed, classroom management and insufficient resources /equipment were determined as teacher's problems, too.

1.1. Difficulty in grasping the ABI

In the semi-structured interview; teacher expressed that there were problems in grasping the ABI process, but students understood the ABI approach over time and began to get familiar with the ABI process.

> ***Teacher:*** *One of the problems was that my students couldn't get used to the ABI process. When students got used to the process, they were aware of what they should do.*

When video recordings were analyzed, it was detected that students experienced difficulties related to ABI process. Especially, teacher's alerts were outstanding at the beginning of the courses (ABI activities).

> ***Teacher:*** *Why is everybody asking the same question to investigate?*
>
> ***Teacher:*** *You must write your beginning ideas after you write your question*
>
> ***Students:*** *Ok*
>
> ***Teacher:*** *Is this your claim?*
>
> ***Students:*** *Yes, it is*
>
> ***Teacher:*** *Otherwise, this is your result of experiment. You are writing your result. Firstly, you must discuss your results and evidences. And your claims should be general.*
>
> ***Students:*** *Ok.*

1.1. The problems of asking question

This part can be classified as: teacher's questions and students' questions.

Teacher's questions: The teacher expressed that he wanted to ask questions that are thought-provoking and directing to investigate, but it was a problem at the beginning of the process.

> ***Teacher:*** *I was asking short-answer questions at the beginning. But I think that open ended questions are better than short-answer questions for students' thinking. Questions should be intelligible, thought-provoking and directing to investigate. For example, good questions can influence the creation of interaction among the students, and the ways of thinking and investigating.*

Students' questions: The problem in this part was questions that students wanted to investigate. Generally, questions were not associated with the topic, and they were not suitable for experimentation and investigation in the classroom, and students had already known the answer of question that was to be investigated. Students were in a difficulty in asking good questions. Teacher expressed that students needed to think for a good question. Thus, they could begin to ask a good question after a while.

Teacher: *The problem is that these students' questions aren't associated with the topic. The students need to think for asking question. Thus, they can begin to ask a good question after a while. If students ask good questions, this process works better.*

Interviewer: *What is a good question or bad question?*

Teacher: *The bad question isn't associated with the subject or the main idea of unit.*

1.2. Classroom interaction

Teacher- student interaction: The teacher emphasized that there was teacher-student interaction rather than student-student interaction in his classroom. When video recordings were investigated, it was determined that students wanted to speak with the teacher in discussions and they waited confirmation from him. After a while, an increase in student-student interaction was observed. Teacher emphasized that at the end of this process, unsociable students began to speak in lesson.

Teacher: *Teacher-student interaction is more common in the other classroom. It is same in my ABI classroom at the beginning, too. There are dialogues among students in this classroom, but it isn't adequate. There is an opinion that teacher guides students for everything in this classroom. My students always want to speak with me. They wait confirmation from me for the accuracy of their questions, experiments and claims. When students start to speak, they say teacher! Teacher…..*

Interviewer: *Why do your students say that "my teacher" as the first word of their sentences?*

Teacher*: This is a habit from the past. Students are accustomed to teacher-centered instruction. Students think that teacher knows the truth of everything.*

Another point was the participation of unsociable students in classroom interaction. Teacher believed that ABI activities elicited unsociable students' speaking. But there were problems in this situation, too. He said that the reason for these problems was related to students' unwillingness and unconcern to learn.

Teacher: *The unsociable students began to speak about the topic in the classroom through ABI activities. But this rate is only %50. Despite everything, some students aren't still speaking in lesson. I think that they may not want to learn and they may not be interested in lessons.*

Interviewer: *Is there any effect of teacher role on students' talking?*

Teacher: *Yes. If the teacher does not respond in a negative way when students state their ideas, students can speak in lesson. Also, if students see that their friends are pleased when they are thinking, speaking about lesson and learning something, they will want to speak. For example, when I spoke with a teacher in my school, he told that Ayşe was not speaking in the classroom. I was surprised to hear that. I said him that he should refer to someone else, because she speaks in my lesson. Afterwards, I observed that student and I noticed that she speaks in other lessons, too.*

Student-student interaction: The problem was limited interaction among students. The teacher thought that dialogues among students should be increased in class discussions and student-student interaction was important for students' learning.

> ***Teacher:*** *I have problems in promoting student–student dialogues. Students should learn how they should listen to each other, how they should rebut others' claims, and they should learn to respect each other's ideas. When a group build an argument, other students should find what they can learn from their friends' argument. But students' social life influence group communication. Some students wanted to change their groups.*
>
> ***Interviewer:*** *What are your students doing in the class discussions? Are they speaking with each other or with you?*
>
> ***Teacher:*** *Students' first word is "teacher". I say that you should explain to your friend. But it takes time to change this habit. This is a problem for me. I try to increase student-student interaction.*

1.3. Insufficient resources and equipment

When video recordings were analyzed, problems were detected about resources and equipment needed for the investigations. When students could not access to the required tools, they could not do experiment or they had to change questions that they wanted to investigate. So, they spend a lot of time to provide their tools.

> ***3.48. Teacher:*** *Do you have tools for your experiment?*
>
> ***3.49. Students:*** *No*
>
> ***3.50. Teacher:*** *How are you going to conduct your experiment?*
>
> ***3.51. Students:*** *I don't know. But, I think, we can't do that.*
>
> ***3.52. Teacher:*** *So, you can change your question.*

Interview data also revealed a teacher problem as inadequacy of experimental tools and the learning environment.

> ***Teacher:*** *A good learning environment is an environment that students can find materials and tools to test their investigation questions. Sometimes, there is not anything for students to use in their investigations. I have not a laboratory in my school and there aren't any experimental tools. If there are not any experimental tools for students to use, they can't do their experiment and they can become unhappy. For this reason, they are required to change their research questions sometimes.*
>
> ***Teacher:*** *Laboratory is import for ABI implementations. If students want to do an experiment with liquid, everywhere gets wet and carrying water becomes a problem. Moreover, I think that the laboratory motivates students and teacher. Students can concentrate on their works in laboratory. I have not a laboratory and I instruct students in a classroom. My classroom is small. So my students are in a difficulty of in moving in the classroom and doing experiment.*

1.4. Classroom Management

The video analysis showed that teacher sometimes had problem about classroom management. In this situation, teacher warned students to listen to him and their friends during the

ABI activities. For example; he said that “do not speak”, “sit down”, “listen to me”. When these warnings were made, it was observed in video recordings that students were following those rules. It was observed that student continued doing experiment or group discussion and students were writing their investigation reports or they were speaking with each other at that time.

2. Teacher's solutions to problems in ABI process

2.1. Teacher's solutions to difficulty in grasping the ABI

When teachers' ABI activities were analyzed by video recordings, it was determined that teacher informed and reminded about ABI process for solution of problem. For example:

> ***1.1. Teacher****: Firstly, we are preparing our questions, are not we? Questions should be about subject that we are investigating today. Then, we are doing experiment and making observations about our questions. Afterwards, we are justifying our claims with evidence, are not we? For example, Mendel experimented with peas in the previous unit. Can we do an experiment like this in our classroom?*
>
> ***1.2. Students:*** *No, no*
>
> ***1.3. Teacher:*** *So, we can do our experiment in here, can't we? Other important point is questions must be intelligible. A validity should be in experiment. For instance; my claim is boys are playing basketball very well from girls. But boys in the experiment are taller than girls. There are two variables: gender and height. It isn't a correct test, is it? Do you understand?*
>
> ***1.4. Students:*** *Yes, we understand.*
>
> Another example;
>
> ***Teacher:*** *It is result of your experiment. It isn't a claim. Claim is a general statement.*

2.2. Teacher's solutions to asking question

Asking question was analyzed as: Teacher's questions and students' questions.

Teacher's questions: In the interview, the teacher expressed that he began to ask open-ended questions to encourage students' thinking. Also, this data showed that he wanted students' to search for an answer for the questions

> ***Teacher:*** *I am asking question allowing for students' thinking and investigation. For example: I am asking “why is space dark” in spite of “Is the space dark?” So, this question allows them to think about this subject.*
>
> ***Teacher:*** *I am asking a question and I don't say answer. I want them to investigate and find the answer. But students are not used to find answer on themselves. They are asking to me the answer of question after the lesson. I am saying them when you find the answer; you should say it to your friends. It is important for students' learning.*

Students' questions: In the video recordings, it was determined that teacher assessed students' question before activities and gave feedback to students.

> ***2.2. Teacher:*** *Listen to me. After you write your question on the blackboard, we can look over your questions. Is your question ready?*

2.3. Student A: *Yes*

2.4. Teacher: *What is your question?*

2.5. Student: *What is the position of an object in a liquid?*

2.6. Teacher: *Can your friends try this experiment in the classroom?*

2.7. Students: *Yes, they can.*

2.8. Teacher: *The question is clear and intelligible, is not it?*

2.9. Students: *Yes, it is.*

2.10. Student B: *It is also related to our subject.*

Another example:

2.30. Teacher: *What is your question?*

2.31. Student C: *What is the relationship among the weight of the object, the upward force exerted by a fluid and the weight of the displaced fluid?*

2.30. Teacher*: It is good question. It is clear, intelligible and related to subject.*

Other example

4.46. Teacher: *Now, we look over questions*

4.47. Student D: *Our question is that can the liquids be compressed?*

4.46. Teacher*: But you have already learned the answer of this question. You learned it two years ago. This question is not acceptable. You should change your question.*

2.3. Teacher's solutions to classroom interaction

Teacher- student interaction: In the teacher's ABI implementations, it was observed that when students were speaking, teacher gained students' attention to communicate about question, claim and evidence. In addition, when students asked him questions, he answered with questions about daily life to students' question. Moreover, he encouraged students to participate in discussion to increase student-student interaction. Teacher mentioned about the same things in the interview, too.

Teacher: *I attempt to promote interaction between the students by saying "I am no longer in the classroom. You speak with your friends and it is useful for your learning. You should ask question to your friends and you should try to rebut your peers' claims. I want them to study all together as a group, listen to each other. I also want them to share things that they learned with their friends.*

Interviewer: *Is there any problem among students? How?*

Teacher: *Yes, there is a problem in the group. Some students wanted to change their groups. This is a problem for students. It sometimes occurs.*

Interviewer: *You said that some students wanted to change their groups. What are you doing in this situation?*

Teacher: *I am trying to persuade them not to change their groups. I tell them to get behind their words. In addition, I remind them that they are a group, they should think that their social life is different from the school life and they should learn to study together.*

Here are examples for the teacher's attitude related to student-student interaction:

2.177. Teacher: *You are writing only. You should have a discussion and debate with your friends.*

2.178. Student A: *Are we debating about experiment?*

2.179. Teacher: *You should deal with results of your experiment.*

2.180. Student A: *Dear friends! Let's debate!*

Other example;

2.63. Student A: *We are exerting a force and compressing the air. The piston is pushed by our hands.*

2.64. Student: *Does the gas pressure depend on its density?*

2.65. Teacher: *Your friends asked a good question. He asked if the gas pressure depends on its density.*

2.64. Student: *Yes, it depends on its density.*

2.65. Teacher: *You said yes. Why do you think that?*

2.64. Student C: *Because, when a gas is compressed, its mass does not change but its density increases.*

Student - student interaction: The video recording data showed that the teacher tried to increase the student-student interaction but rarely he could utilize the opportunities. For instance, two groups found different outcomes. In this case, he could begin to generate a discussion and provide student-student interaction about the content. But he confirmed one of the student idea. So, the discussion could not begin. Moreover, it was revealed that the teacher encouraged students to engage in a discussion, contact with other groups, and listen to their friends. Here is an example:

3.22. Teacher: *You should discuss about your experiment in your group. You should think about the procedure that you are going to follow for your experiment.*

2.332. Teacher: *If you want to do it, you can talk with Group A. Because they just learned how to do it. They did it a short time ago.*

4.157. Teacher: *You should discuss and write results of your experiment. What did you find? What did you do?*

Other example;

4.316. Student A: *Teacher! The reason of it is the air pressure, is not it?*

4.317. Teacher: *I do not know. Your friends did this experiment. You should ask them.*

4.318. Student A: *The reason of it is the air pressure, is not it?*

4.318. Student B*: Yes, because the air pressure dropped.*

Video recordings showed that student-student interaction increased after a while, especially in the last activities. Teacher mentioned about this improvement in the interview, too.

> ***Teacher:*** *Student-student interaction increased in my class after a while. I think that if interaction increases in the classroom, both teacher and students begin to enjoy from this process. You feel better. How can they reach an agreement if they don't talk with each other?*

An example from the last lesson;

> ***4.325. Student A:*** *Our claim is that the liquid pressure depends on its density and the depth of liquid.*
>
> ***4.326. Student B:*** *Does the pressure change if we change the shape of container?*
>
> ***4.327. Student A:*** *No, it doesn't change.*
>
> ***4.328. Student C:*** *Does the pressure change if we increase the shape of liquid?*
>
> ***4.329. Student A****: No, it does not change.*
>
> ***4.330. Students B:*** *I think if you use a thin and tall container, its pressure can change.*
>
> ***4.331. Student D:*** *I think it doesn't change*
>
> ***4.332. Students B:*** *We did it. We used square and rectangle containers. We made a hole in the same depth of containers. Water gushed 45 centimeters away from both containers. It is about the depth. The shape of container changed. But if depth is the same, pressure doesn't change. Surely it is for the same liquid.*

2.4. Teacher's solutions to insufficient resources and equipment

In video recordings, it was observed that teacher and students brought many tools to the classroom from outside. So they tried to solve this problem. The teacher said the same things in the interview, too.

> ***Teacher:*** *Before the lesson, I determined tools that students need for their experiment. I wanted them to bring basic tools that they would use for their experiment. (e.g, sand, stone, salt.)*

2.5. Teacher's solutions to classroom management

The interview data showed that the teacher sometimes faced with problems about the classroom management. But he thought that it was normal.

> ***Teacher:*** *When I am or a student is speaking, some students are not listening to me or their friends. They are doing something else or they are speaking with each other. So I warn them to listen to me/their friends.*
>
> ***Interviewer:*** *What are you thinking about when there is a noise in your* ***classroom?***
>
> ***Teacher:*** *It is a useful noise because they are speaking for their learning.*
>
> For example from lesson:
>
> ***2.189. Teacher:*** *Fadime listen to Ahmet. What is Ahmet's group idea?*

> ***2.59. Teacher:*** *How you find the object's weight? Listen to me. Be quite! How?*
>
> ***1.137. Teacher:*** *Ayşe, listen to him carefully. Yusuf, repeat it again please. Everybody, listen to Yusuf!*

Also, it was appeared in the video recordings that the teacher was interested in each group, and he attempted to control students' experiments and their prior knowledge.

3. Teacher's suggestions

Here are teacher's suggestions:

Effective learning environment: Teacher emphasized that school conditions should be adequate (e.g., laboratory, experimental tools, library) and the support of other teachers and school principals were important.

> ***Teacher:*** *The school conditions are important for ABI practices. Teacher should create an effective learning environment that can meet the students' needs. Students want to do experiment for their questions about the subject. When I can't give experimental tools, there is a problem in the lesson and students have to change their questions that they want to investigate. So teachers and school principals should cooperate to solve problems. School laboratory and library should meet students' needs. Because I have not a laboratory, there is a problem for my ABI practices. Also, teacher can plan tools that students want to experiment. Thus, they are prepared for students' needs.*

Asking good question: The interview data revealed that teacher considered asking good question and focused on thought-provoking and directing questions on ABI activities.

> ***Teacher:*** *Teacher should ask thought-provoking and directing questions. Teacher needs to ask good questions. The best questions are the questions that are orienting students to think and do the research. So, I try to ask open ended questions now. Because open ended questions are important to meet this aim. However, I am sometimes in a difficulty in asking good questions. Thus, teachers should be supported for asking good questions via in-service teacher training programs.*

Improving classroom interaction: The teacher thought that classroom interaction was important for students' learning. So, the teacher should provide an opportunity for students' talking. He suggested that teacher should improve classroom interaction.

> ***Teacher:*** *Teacher should support student-student interactions. I think students' ability to talk and to express them can develop over time. We want students to think and investigate about scientific subjects. Students are not accustomed to talk with their peers about scientific subjects in our education system. Because they generally have not opportunity for debate on science with friends and for discovery or research together. It is a process that will develop in time. So, teacher should create a learning environment in which students can talk, research and decide about a topic. The teacher should provide opportunities for students to talk with each other and also should be patient.*

Discussion

Results from this study highlight the problems that an experienced teacher faced in implementing the ABI approach. The problems encountered in ABI classes were mainly originating from tendency to traditional teaching methods and perception toward learning and teaching. It was not easy for students to grasp the learning setting dynamics of the ABI approach and for the teacher to change his pedagogical practices. For example, the teacher exerted much effort to change his questioning style from close-ended into open-ended, to promote student-student interaction, and to manage the classroom discussions. Insufficiency of resources and equipment was another problem that the teacher faced. In addition, the actions undertaken by the teacher against the problems were also analyzed in this study. The teacher tried to ask more open-ended and thought-provoking questions, value students' ideas without any judgment, and give feedback rather than confirming student responses. The teacher also exerted effort in promoting dialogue among the students through some talk moves (e.g., Any different idea? Do you agree with your peer?) and probing questions. The teacher was very careful in student use of elements of argument (question-claim-evidence) properly. The teacher was dealing with insufficiency of resources and equipment through guiding students change their questions if it was impossible to supply them. Moreover, he suggested that teachers need to be supported in designing an effective learning environment with sufficient resources and equipment and in asking good questions. The teacher also focused on the improvement of students' talking and listening skills beginning from elementary years because problems in those skills act as a barrier for effective classroom interaction.

Although the teacher was experienced in implementing the ABI approach, he struggled with several pedagogical problems. This finding implies that the shift in pedagogical practices is not easy, requires trial and error and takes a long time (e.g., Martin & Hand, 2009). Turkish students and teachers are not familiar with ABI approaches aligned with student-centered approaches because of the tendency toward traditional teacher-centered science learning environment. Although the recent science curriculum emphasizes student-centered approaches (MNE, 2004), there are numerious problems in transition from teacher-centeredness into student-centeredness (Acat, Anilan, & Anagun, 2010). Nationwide examinations might be a reason for adopting a teacher-centered approach because students' performances are not assessed via this test and therefore students and teachers feel redundant having a student-centered approach. Another reason of those problems might be teachers' inefficiency in designing learner-centered environment. This reason might arise from the problems in current teacher education programs in Turkey: The teaching approach practiced in many universities is still very traditional; therefore, pre-service teachers' training generally lags behind the needs of student-centered approaches. In faculties of education, preservice science teachers need to be given opportunities to see inquiry-based interventions modeled and then practice and see the effectiveness of those methods on students' learning (Czerniak & Lumpe, 1996).

Like Turkey, many countries (e.g., China) are struggling with adopting inquiry-based teaching practices to meet the goals of scientific literacy (e.g., Zhang et al., 2003). The barriers to inquiry-based approaches are generally arising from administration and curricula, teacher preparation, students' expectations, evaluation of students, the teaching environment and available resources. Teachers are not well prepared to change from traditional approaches of teaching science into inquiry-based teaching. Even if teachers attempt to implement inquiry-based methods, they face with the resistance of students who are successful in traditional classrooms. Those students are afraid of losing their advantage in inquiry based learning environment because national college entrance exams are favoring traditional methods of teaching science. Large class size, non-flexible arrangement of classroom, and limited resources constrain inquiry-based practices.

Previous studies examining the impacts of the ABI approach with respect to implementation level (e.g., Burke et al., 2005; Poock et al., 2007) suggested that students' construction of scientific conceptions can be enhanced when teachers implement the ABI approach properly. In high implementation ABI classes, students pose their own questions, design their own experimentation, construct claims and evidences, and reflect on their thoughts. Effective pedagogical practices are necessary for implementing the ABI approach successfully (e.g., Omar & Hand, 2004). Promoting student argumentation in science classrooms requires teachers to develop appropriate pedagogical strategies (Omar, Gunel & Hand, 2003; Omar & Hand, 2004; Yoon et al., 2010). Results of our study also suggested that effective implementation of ABI approach required teacher's pedagogical practices such as asking thought-proving and probing questions, using talk moves, and giving feedback without evaluating student ideas. These pedagogical practices would further result in improvement of students' argumentation skills and conceptual understanding (e.g., Günel et al., 2012; Martin & Hand, 2009; Yoon et al., 2010).

This study also showed the benefits of teacher engagement in professional development programs. Although the teacher participated in those programs for two years and supported by the science educators, the teacher was not considered as a high-level implementer of the ABI. This finding is compatible with the previous research (e.g., Boyle, Lamprianou, & Boyle, 2005) indicating that teachers who participated in longer term professional development changed one or more aspects of their teaching practice because teacher change requires time and energy (Zhang et al., 2003).

In Turkey, in-service teacher training programs are generally organized in the form of lectures giving information about a specific topic ranging from one to three weeks with no follow-up. Such short-term traditional staff development programs generally results in limited teacher change in pedagogical practices (Bağcı & Şimşek, 2010). Teacher professional development programs needs to be aligned with the purpose of meeting the requirements of science curriculum (MNE, 2004) designed to achieve scientific literacy. Therefore, in-service teacher training should be long term, with adequate support and follow up (Richardson, 1998) in order to develop teachers' pedagogical strategies and practices and accordingly student outcomes such as conceptual understanding and argumentation skills (e.g., Martin & Hand, 2009; Omar & Hand, 2004).

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