Argumentation-Based Inquiry Practices from the Perspective of Teachers Receiving and Implementing Argumentation Training

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Abstract

The purpose of this study was to identify the Argumentation-based Inquiry (ABI) process from the perspective of teachers implementing the approach and determine the impacts of the process on both teachers and students. The researchers conducted the study via qualitative research methods. To this end, three science teachers teaching in three different secondary schools in the province of Kastamonu took part in the study. First, the researchers provided an eight-week ABI training to the teachers. Following this training, they asked the teachers to implement the ABI practices on a science unit in the classroom. When the teachers completed these practices, the researchers conducted semi-structured interviews with the teachers. The interview questions were specified with the aim of determining the views of the teachers on the ABI process, as well as its impact on teachers and students. The interviews were recorded and then analyzed. A descriptive analysis was carried out on the data. According to the findings, the teachers stressed the importance of planning the teaching process and being prepared for the subject for the effectiveness of the ABI process. Furthermore, the teachers stated that the questions asked by both teachers and students played a key role in the ABI process. Last but not least, the teachers reported that their knowledge of the field had increased and their skills of asking questions had developed owing to the process, while the knowledge obtained by the students had become permanent and the inquiry and communication skills of the students had developed in the process.

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INTRODUCTION

In learning environments where conceptual teaching is more dominant, including different learning outcomes and making students achieve these outcomes have become prominent in recent years. Instead of training students who only have knowledge, it is necessary to raise individuals with the ability to solve daily life problems. In this respect, we encounter a set of skills called the 21st century skills since it includes skills and competencies which are necessary for lifelong learning. This set of skills consists of life skills (agility, flexibility and adaptability), labour skills (cooperation, leadership attempt and responsibility), practical skills (access to information, analysis, effective communication and finding alternative solutions to problems), personal skills (curiosity, imagination, critical thinking and problem solving), interpersonal skills (cooperation and teamwork) and non-cognitive skills (managing emotions) (McComas, 2014). Therefore, it is noteworthy that students obtain conceptual information in science class and also gain and develop these skills called the 21st century skills as much as possible. Furthermore, the Next Generation Science Standards (NGSS, 2013) report stresses the importance of developing the scientific capacities of students. To this end, students are required to have the opportunity to actively conduct research on scientific incidents so that they can find solutions to problems. As one can see, it appears to be the common goal of every educational level to raise individuals with 21st century skills on a global scale. Teachers are required to update their teaching and qualification profiles to strengthen the 21st century skills of students (Caena & Redecker, 2019).

It is possible to argue that conveying the course content to students is a frequent opinion related to teaching since teachers usually have concerns over increasing the conceptual knowledge of students (Loughran, Berry & Mulhall, 2012). Therefore, teachers plan their classroom activities in this direction. However, this results in rote learning instead of achieving an in-depth conceptual understanding. With appropriate educational environments, it is possible to develop different skills of students and increase their conceptual knowledge related to science topics at the same time. In order to achieve these goals, teachers are required to carry out different teaching activities in the classroom. Argumentation activities which are based on inquiry are among such activities that can be carried out in the classroom with the aim of increasing conceptual knowledge and developing skills.

Argumentation is a basic science practice, inherently full of moments of uncertainty; however, schools do not usually teach science as a process of managing uncertainty (Chen, Benus & Hernandes, 2019). Science is usually accepted as a repository of indisputable knowledge that deals with facts, theories and scientific laws and it is taught in the same way in schools (Anne, 2021). It is possible to see the emphasis on teaching concepts in science classes as a mirror reflecting this situation. In fact, argumentation activities based on inquiry particularly stress uncertainty situations in the formation of scientific knowledge. When students have the opportunity to practice managing uncertainty, they develop skills that are necessary to participate in each other's words and use collaborative epistemic resources while developing acceptable knowledge with their peers (Chen & Qiao, 2020). Experiencing these moments in science lessons includes activities that can be used in the classroom to increase conceptual knowledge and develop a variety of skills.

Osborne, Erduran and Simon (2004) reported that argumentation activities created with pedagogical strategies and appropriate activities are crucial in helping students develop a conceptual understanding of science and achieve their epistemic, cognitive and social goals. Scientific research and science teaching stress the importance of claim and evidence-based debates (Duschl & Osborne, 2002). This requires the participation of students in scientific debates to learn scientific concepts and develop a proper scientific understanding (Osborne, 2002). In this respect, we know that argumentation practices to be carried out during classroom activities will contribute to the multilateral development of students such as high levels of skills and communication (Hand, Shelley, Fostvedt, & Therrien, 2018; Kabataş Memiş, 2011). Science teachers are required to improve their knowledge of argumentation to plan and implement the argumentation process and assess student arguments (Şengül, Enderle, & Schwartz, 2020). In addition, it is crucial for teachers to see the moments of uncertainty in the process as an epistemic source of knowledge (Chen & Qiao, 2020). It is possible to

argue that different strategies like argumentation are not used in the classroom environment mainly because teachers lack adequate content and pedagogical knowledge. Teachers are not ready for inquiry-based science teaching since they are not trained for adequate and in-depth content knowledge and thus, generally resort to less effective teaching strategies in the classroom environment (Worch, Duran & Duran, 2016).

Literature Framework

Argumentation-based Inquiry

The Argumentation-based Inquiry (ABI) approach is used in scientific discussions related to the content of science class and in the instruction of concepts. The ABI is a tool both for students and teachers to think in a more detailed manner and structure the information by inquiry (Hand, 2008). The ABI is an approach based on inquiry and is used to ensure that a student actively fulfils conceptual learning by doing research (Kabataş Memiş, 2014). Students support their claims with evidences, obtain data through experiments and develop ideas and concepts. They build new knowledge on their prelearnings (Burke, Brain, Poock, & Greenbowe, 2005). With discussions conducted in the classroom within the scope of the ABI approach, students increase their conceptual knowledge and also have the chance to test their own explanations and observations by taking the opposite ideas into consideration (Hand, Norton-Meier, Gunel & Akkus, 2016).

In experimental studies, individuals develop their inference skills by designing experiments, seeking evidences, evaluating and interpreting the data obtained from the experiment (Kuhn & Pearsall, 2000). Students create concepts and ideas by supporting their assertions with evidences acquired from experiments and build new knowledge on their preliminary learning (Burke, et al., 2005). The ABI approach provides guidelines both for teachers and students to have further thought and structure the knowledge by questioning. Hand and Keys (1999) offer teachers and students two templates to use the ABI approach effectively throughout laboratory activities. Table 1 demonstrates these templates.

Table 1. The ABI teacher and student template (Hand & Keys 1999, p. 28)

The ABI Part I: A template for teacher-designed activities to promote laboratory understanding	The ABI Part II: A template for students
1. Exploration of pre-instructional understanding through individual or group concept-mapping.	1. Beginning ideas: What are my questions?
2. Pre-laboratory activities, including informal writing, making observations, brainstorming and asking questions.	2. Tests: What did I do?
3. Participation in scientific activities.	3. Observations: What did I see?
4. Negotiation phase I: writing personal accounts of scientific activity (e.g. writing journals).	4. Claims: What can I claim?
5. Negotiation phase II: sharing and comparing data interpretations in small groups (e.g. making a group chart).	5. Evidence: How do I know? Why am I making these claims?
6. Negotiation phase III: comparing scientific ideas to textbooks or other printed resources (e.g. writing group notes in response to focus questions).	6. Reading: How do I compare my ideas with those of others?
7. Negotiation phase IV: individual reflection and writing (e.g. presentation to a larger audience).	7. Reflection: How have my ideas changed?
8. Exploration of post-instructional understanding through concept-mapping.	

The purpose in the ABI is to include students in the learning process in an active manner and enable them to structure the knowledge with their teachers and peers. Designing an activity, implementing the activities and ensuring that the concepts are understood are the main responsibilities assigned to teachers in this process (Hohenshell & Hand, 2006). In the ABI, teacher learns along with students instead of being at the centre and offering the information (Hand, 2008). Therefore, it is possible to argue that the ABI approach is of paramount importance for the development of both students and teachers. The literature has studies reporting that teachers applying argumentation in the

class have effective pedagogical education and thus may create effective educational environments. We can observe the results of teachers' achievements in students (impacts on students) as the number of practices grows (Omar, 2004; Osborne, Erduran & Simon, 2004). Choi, Seung, and Kim (2019) examined the teachers' views on arguments in scientific inquiry and argumentation-based science teaching and concluded that argumentation-based science teaching is noteworthy because it enables students to experience the formation of scientific knowledge and enrich their thoughts. Considering the multilateral contributions of the process to both students and teachers, it is necessary to encourage teachers to plan and implement the ABI activities in the classroom environment. Furthermore, encouraging teachers to gain awareness about themselves and review their teaching activities might as well increase the quality of the overall teaching. The present study was inspired within this framework. The purpose of the study was to examine the ABI process of teachers implementing these activities in the classroom, how the roles of teachers and students were defined during the process and the impacts of the process on teachers and students from the perspective of teachers. Moreover, the study may draw specific conclusions related to the implementation of activities based on the ABI approach in the classroom in science teaching. Within this framework, the study addressed the following questions:

1. How do science teachers receiving the ABI training and implementing the ABI approach define the ABI approach?

2. How do science teachers receiving the ABI training and implementing the ABI approach define the impacts of the ABI approach on students and teachers?

Research Methodology

Research Design

Phenomenology is a qualitative research method which enables individuals to express their understanding, emotions, perspectives and perceptions concerning a specific phenomenon or concept and it defines how they experience this phenomenon (Rose, Beeby & Parker, 1995). The main purpose of phenomenology is to define the experiences of individuals concerning a phenomenon (van Manen, 1990, p. 177). In phenomenology, the researcher collects data from individuals experiencing the phenomenon and develops an integrated definition concerning what individuals experience and how they experience it (Moustakas, 1994). Therefore, in a phenomenological study, it is crucial that individuals have experience of the phenomenon (Creswell, 2016, p. 265). Within this framework, the researchers conducted the current study to determine the definitions and experiences of science teachers concerning the ABI process using a phenomenological design.

Participants

The researchers conducted the study with three science teachers teaching in different secondary schools located in the city center of Kastamonu province during the 2018-2019 academic year. In addition, the study included a total of three science teachers. In phenomenological studies, it is recommended that participants who have relevant experience and may share this experience be chosen (Yıldırım & Şimşek, 2016). Therefore, when determining the participants in the study, the researchers chose teachers with experience of the ABI process. Although experienced teachers are preferred, these experiences are not the same for all teachers. It is also thought that through these experiences, teachers will experience a more efficient implementation process and the effects of the trainings will be more evident. Accordingly, when choosing the participants, the researchers used the criterion sampling method which is among purposeful sampling methods. They reached the teachers who met this criterion and had been specified previously according to this method and included them in the study (Merriam, 2015). The researchers used the homogeneous sampling method to reach the teachers. They chose purposeful sampling because it had the opportunity to obtain rich data for the study (Patton, 2014). In purposeful sampling, participants are determined according to the most appropriate characteristics for the study.

Teacher Training Process

Teacher Training Practices: The teachers who took part in the study primarily received an eight-week training on the ABI and discussions were conducted with the teachers for assessing this training process. An educator who is currently employed as a faculty member at the faculty of education in a university, has a doctoral thesis on argumentation, has current research in this field and conducts numerous argumentation applications with different working groups gave the training. In addition, the teacher educators give courses on this subject at postgraduate level. Table 1 demonstrates weekly topics of the training.

Table 1. Tables and figures are to be valuable, relevant and visually attractive

Practice Week	Practice Topics	Practice Durations
Week 1	Preparatory activity	2-3 hours
Week 2	Density	2-3 hours
Week 3	Force and force of friction	2-3 hours
Week 4	Inclined plane	2-3 hours
Week 5	Air and water resistance	2-3 hours
Week 6	Discussion activities	2-3 hours
Week 7	Discussion activities	2-3 hours
Week 8	Discussion activities	2-3 hours

The training aimed to ensure that the teachers recognize the ABI process by experiencing it in person, understand the importance of the skill of asking questions and make sense of the concepts of question, claim, evidence, reasoning and rebuttal, which are the components of argumentation, as well as their relationships with each other. With a joint decision, the teachers and researchers specified the topic of the training to be "Mechanics". During the first week of the training, a preparation activity was conducted with the teachers. The activity aimed to enable the teachers to make sense of the concepts of claim, evidence, reasoning and rebuttal as the elements of argumentation, as well as their interrelations and experience an effective ABI process. During the following weeks, the ABI practices were conducted on the topics of "Density, Force and Force of Friction, Inclined Plane, Air and Water Resistance". The teachers were asked to prepare two questions about the subject to be addressed prior to coming to the class each week. During the activity, each teacher primarily explained the initial questions and discussed the researchability of the questions. Each teacher personally designed and implemented their experiments. While the teachers were conducting their experiments, one researcher managed the process as a guide. During the process, the researcher directed questions to the teachers to make them think more intensely on the subject and support the deliberation process (for instance, what were the differences between the two materials that you used? Why did you do it that way? What do you think about the cause of the differing results? How did our actions affect the result? What can be used instead of this?). The teachers developed their claims on the basis of observations and data obtained from the experiments and shared them. The deliberation process continued on the claims of each teacher under the guidance of the researcher. Afterwards, the researcher developed a general framework with respect to the activity conducted and evaluated the process at the end of each practice.

After completing the five-week ABI applications, the researchers conducted discussion activities with the teachers for three weeks. They carried out these discussion activities within the scope of what were experienced during the ABI process, structure of the dialogues between the trainer and the teachers, and structure and quality of the questions addressed. In addition, they exchanged opinions regarding the nature of the ABI approach, place of questioning and discussion in this process, role of questions in directing the process and roles to take as teachers. The researchers exchanged opinions regarding how the teachers who were to practise in their own classes would conduct the process. They stressed the importance of teachers' questions in encouraging students to question, have a high level of thinking and attend the classes actively. When doing this, the researchers asked them to consider and analyze the trainings they had received for five weeks. After completing the whole training process, the teachers performed the ABI applications in their classes.

The ABI Process: Following the ABI trainings, the science unit on which the practices were to be conducted was determined together with the teachers (the unit titled "Force and Energy" of seventh grade) and the practices to be implemented in the classrooms were planned. All teachers conducted the ABI applications in grade seven classes. Prior to the applications, the teachers separated the students into smaller groups of 4-5. Afterwards, the preparation activity was carried out to enable the students, who were not familiar with the ABI process, to understand the process, identify the elements (claim, evidence, reasoning and rebuttal) of an argument and adapt to the process. At the end of this activity, the characteristics of claims and evidences were determined and the students were informed that they were to conduct their lessons in this way. As part of the ABI student template, the students first prepared the research questions they wondered, designed experiments in small groups, created claims, completed the process of supporting their claims with the evidences they had obtained from the experiments with their peers under the guidance of the teacher and then shared their claims and experiments with the whole class in large group discussions. The teachers, on the other hand, directed both small and large group discussions like a guide. For instance, they shaped large group discussions with the following questions to maintain student-student dialogue: Why do you think so? What is the difference between these two concepts (mass and weight)? Why did you do the experiment with these materials or in this way? Why do you agree or disagree with your friend? What do you think about the claims and evidences of your friends? Thanks to these discussions, students had the chance to structure the information together with their peers and teachers. After the completion of large group discussions, the students completed the ABI experiment reports.

Data Collection Procedure

After completing the teacher training and in-class activities, they conducted semi-structured interviews with each teacher. The researchers gathered and created interview questions. Two faculty members, a teacher who did doctorate and a doctoral student prepared the questions. The questions were submitted to three people employed in these fields to obtain expert opinion and the questions took their final form in line with the opinions received. The semi-structured interview questions consisted of two subscales with the aim of determining the views of the teachers on the ABI process and teacher-student changes. Different questions were created for each subscale. 13 questions were asked about the ABI process within the framework of "preparation for lessons, asking questions during activities, student-teacher and student-student interaction in the ABI, managing the ABI process". In the teacher-student change subscale, 10 questions were used concerning "students' participation in the process, the role of the teacher during the activities, changes in the students, reasons of recommending it to colleagues, changes in the teacher and students". In addition, during the interviews, follow-up and drilling questions were asked depending on the answers from the teachers. A researcher who was included in the study and had an interview experience conducted the interviews. The researchers recorded the interviews on a voice recorder with the permissions of the teachers. The interview records of the teachers were about 40 to 45 minutes. For instance, regarding the introduction of the ABI process, the following questions were addressed to the teachers: "Considering the whole class, when should a teacher ask questions? What did you pay attention to when asking questions? What are the characteristics of a good question? Did the students ask questions? To whom did they address the questions? What would you pay attention to if you carried out the activity in another classroom? Do you recommend it to other teachers? Why?" In addition, the semi-structured interview questions included questions about teacher and student changes. In this subscale, the questions related to teacher changes were "How do you assess yourself compared to the beginning? Were your responsibilities as a teacher same in the classes?", while the questions related to student changes were "Did your students adapt to the process right away? What were the changes you observed in your students?"

Data Analysis

The researchers analyzed the data of the study via an interpretive phenomenological analysis method to generalize on subjective experiences of the participants. In line with this method, they focused on having an interpretive relationship with the interview texts, as is expressed by Smith and

Osborn (2003), instead of measuring the frequencies of the inferences. During this process, they analyzed the data via description, systematic analysis and interpretation by following the steps specified by Wolcott (1994). They directly quoted from the participants using the descriptive approach. They supported these quotations with cause and effect connections and explanations based on the systematic analysis approach. In addition to these, the researchers reflected their own interpretations via an interpretive approach.

Then the researchers transcribed the recordings and put them in writing. In order to obtain profound information from the interview texts, they tried to define all aspects of the content via open coding. Then they grouped and tagged them as sub-categories and categories with similar concepts and incidents (Polit & Beck 2004). The researchers tried to attain the ultimate themes using a comparative method technic to determine how the categories accorded with the themes in terms of similar, different and intersecting properties (Strauss & Corbin, 1998). After creating the themes, the findings were reported by establishing a relationship between the teacher expressions and themes. Names and surnames of the teachers were not disclosed during the analyses and the teachers were coded as T1, T2 and T3.

Reliability of the Study

Reliability is a way for researchers to convince that their research findings are remarkable (Lincoln & Guba, 1985). Applications aimed at ensuring validity in qualitative research are defined as follows; spending a long time in the field and with participants to collect data, detailed description of the research environment, participants and themes and supervision of the research process by both a participant and a non-research person (Creswell & Miller, 2000). Therefore, it is possible to evaluate the validity of qualitative research through the eyes of the researcher, views of the participants, readers and referees who have reviewed the research (Creswell, 2017). Within the scope of the study, adequate time was spent both in the working environment and with the teachers. The researchers gathered to create semi-structured interview questions, obtained expert opinion and discussed the points to be taken into account during the data collection process. Studies were conducted on the significance and integrity of the findings obtained from the interviews. The steps followed during the analysis of the data were explained in detail. Consistency between the themes, categories and codes or with other themes was evaluated and it was examined whether it formed a meaningful whole. Detailed and rich definitions were made for the readers and direct quotations from the participants were included.

RESULTS

As a result of analyzing the data, the researchers attained two themes as 'Describing the ABI Process' and 'Determining the Impacts of the ABI Process'. They completed the process by creating appropriate codes for the themes throughout the analysis. Table 2 demonstrates the findings obtained from the analysis of the data. The findings concerning these themes are presented in detail under different topics with teacher statements, as follows.

Table 2. Findings on descriptive analysis

Themes	Categories	Codes	Teachers
Describing the The ABI Process	Prior to the class in the ABI	Preparation	T1, T3
		Lesson planned	T1, T2
	Asking questions during the ABI	Directed	T1, T2, T3
		Purposeful	T1, T3
		Think	T2, T3
		Question	T1
		Leading to the truth	T1
		Paved the way for discussions	T2
		Providing reasoning	T2

	Communication during the ABI	Inquiry peers	T1, T2, T3
		Revealing the claim-evidence relations	T1, T3
		Obtaining information	T2, T3
	The difficulties encountered during the ABI	Unfamiliarity of students with the process	T1, T2, T3
		Inconvenience of the classroom arrangement	T1, T2
		A lack of time	T2
Determining the Impacts of the ABI Process	Impact on students	Increasing success	T1, T2, T3
		Positive attitude	T1, T3
		Communication skills	T2
		Scientific process skills	T2
		Questioning the information	T3
		Adaptation to school	T3
	Impact on teacher	Mentioning eliminating misconceptions	T1
		Preparing high quality questions	T2
		Establishing a democratic classroom environment	T2
		Starting inquiry	T3
		Effective process planning	T3
	Justification for recommending to colleagues	Increased student participation	T1, T2, T3
		Directing to research-inquiry	T1
		Making students think	T1
		Providing the teacher with convenience	T2
		Making classes entertaining	T3
		Rendering knowledge permanent	T3
	Self-assessment	Well-planning of the lesson	T1, T2, T3
		Increasing the quality of questions	T2
		Receiving different ideas	T2
		Including passive students	T2
		Increasing field knowledge	T3

Teacher Views on Describing the The ABI Process

During the interviews, specific questions were addressed to the teachers concerning what they had experienced before and during the performance of the ABI activities. The teachers stressed that a proper preparation was required prior to the class and the whole process was required to be well-planned from the beginning to the end for an efficient ABI process. Some of the related statements were as follows: T1 *'I had difficulty at the beginning of the class due to a lack of preparation. For efficiency of the process, a good preparation is required and the process is to be well-planned. The beginning of the class is to be interesting…'*; T2 *'Prior to the class, the process is to be well-planned…'* and T3 *'A better preparation is required. For the following phases of the process, the introduction section of the class is crucial and the preparedness of the students affects the situation in a positive manner…'*. The teachers also stated that asking questions were crucial during the ABI activities and they mainly asked questions that were directing, were purposeful, made students think and question, led them to the truth and paved the way for discussions. The teachers explained the importance of questions during the process as follows: T1 *'Asking questions is crucial during the process. Questions should make students think, lead them to the truth and direct them toward inquiry. They should direct the students toward thinking and inquiry…'*; T2 *'Asking questions is the first step of thinking and explaining what you have learned…'* and T3 *'I think that the trick of the activity is to be able to ask the right question, asking a question which has a specific purpose… Questions that are purposeful, target scientific outcomes and thinking and mentally motivate and direct students…'*. T1 stated that he asked purposeful questions that motivated students, as follows: *'Actually I was trying to ensure that the topic was to bring the targeted outcome. We tried to keep the topic around what we intended. Otherwise, the kids could take the topic to very different points. In addition, we had outcomes, targets and we tried to address the topic accordingly…'* T2 stated that he asked questions that were to direct the students and help them justify the information and gave examples to the questions. T2 defined the characteristics of the questions as follows: *'…questions that have no single answer, are open to discussion, may be addressed from different perspectives and allow for reasoning*

and interpreting. For instance, instead of a yes/no question like "Is mass the fixed amount of matter?", in the simplest terms, a question should be like "Compare mass to a weight"... I asked leading questions... The main questions were why, how or why do you think so. I also wanted them to justify their answers. Not only the idea that came to the mind at that moment...' Stating that the questions motivating the students to think were the correct questions, T3 expressed that the teachers were required to have substantial field knowledge for asking the correct questions. T3 explained this view with the following statement: *'... First, you need to have command over the topic to ask the correct question. You have to have command over the field. You need to get prepared. We have made a great deal of preparation with you... Asking the right question will motivate the students to think and it will canalize them...'.* Furthermore, T3 compared the questions he had asked during the previous classes and those directed during the ABI process and stated that he had asked a higher level of questions during the latter. The statement of T3 was as follows: *'...For example, we used to ask "What is atom?" Several students would raise hands. Then you would answer the question. Usually, we would ask questions that were simple, aimed at measuring the knowledge and would ensure the participation of several students. However, during this process, the levels of questions are higher. Interpreting is particularly noteworthy for children. They present claims and evidences, try to prove them and think. Students indicate the points that they find inappropriate. These increase the quality of questions. As a matter of fact, this is one of the most important points of this practice...'.*

Additionally, the teachers stated that, in addition to the questions they asked, the students asked questions to them and their peers, as well. They stated that the students asked questions in small group discussions mainly with the aim of inquiring their peers, while in large group discussions they aimed to reveal the claim-evidence relations of groups and obtain further information from the teachers. For instance, a relevant statement of T1 was as follows *"...Within the groups, questions were like 'what was your purpose in doing this, why do we do this... The students were asking to see whether their friends knew what they had already known... If they could answer, we could assume that their claims were strong... In cases where the experiment was not related to the claims or variables were not determined fully, the students asked questions to each other...".* This statement demonstrated that the students tried to question each other and assess what they did in small group discussions while they asked questions to measure the claim of the group presenting the claim in large group discussions. T2 stated that when peers did not ask proper questions to each other during small group discussions, they had difficulty justifying their claims and developing strong claims. Accordingly, T2 stated *'...Questions are like "why did you do this, let's do this in this way"... If they had not asked questions adequately to each other in small groups, their deficiencies might have become more apparent in large group discussions. Actually, small group discussions provide an infrastructure for justification. If they do not , unexpected questions may come in large group discussions. For instance, one group conducted an activity with their planes. It was expected that the one with a sharper nose would go farther, but the exact opposite happened. They had difficulty explaining such things. Questions like "Are the planes identical, did you make them from the same paper, did you consider these" could be addressed. Then they had difficulty explaining..."* T2 also stated that during the ABI process, the students directed questions to him/her, as well, as follows: *'...There were questions from the students, as well. They would address questions to their friends and also to me... About the activity, they would ask "What would happen if we did this or can we do this". I would say "let's try and see or what about the other one". By this way, I try to make them test different situations or test their ideas in different situations. When they directly asked for information with questions like "What affects kinetic energy", I would not answer the question directly. If I had to, I would try to answer through examples and metaphors or I try to make them predict the variables. I certainly would not make any direct explanations in this process...'.* Likewise, T3 stated that the students addressed questions to him/her as follows: *'...At the beginning, they were asking too many questions. What is this, how will this happen, etc.? Instead of directly answering them, I would respond "What do you think, how about this, etc." Sometimes I would give information as it might go beyond your control... Sometimes I would provide more information to correct the explanations made by the students. I would make explanations to correct their explanations instead of answering their questions...'.* According to these statements, the teachers did not give answers including direct information to the

questions of the students. They gave clues on the basis of the explanations of the students and allowed them to discover the answer themselves by pointing out different aspects of the issue.

The teachers reported that they had specific difficulties conducting the ABI activities. Unfamiliarity of the students with the process, inconvenience of the classroom arrangement and a lack of time were among the problems they had experienced during the process. In this respect, T1 stated *'...The kids first thought that it would be like a preparation activity and did not associate it with the class at all. When we adapted it to the class, they faltered a little bit. At the beginning, we had difficulty writing and expressing claims and evidences. At first, they could not create them. During the following phases, they associated them with the class. They studied the subjects and started to explain them (claims and evidences) in the form of a class. Towards the end of the process, they were able to create them to some extent...'.* Furthermore, T3 made the following explanation: *'...We had a great deal of difficulty at the beginning... The students did not know what to do. Maybe it was for the first time that they encountered such a method. This created a great deal of difficulty for them...'.* Such statements of teachers demonstrated that the students had difficulty adapting to the process since they were not familiar with it and establishing a relationship between claims and evidences, in particular. T2 referred to the inconvenience of the classroom arrangement and a lack of time to be the problems experienced as follows: *'...I made explanations more about the process. For example, this would be the following step, etc. I reminded the next step to make them faster. Time is paramount. We had this problem. Since our classroom did not have any laboratory arrangement, we had to change the arrangement, etc. Otherwise we might have saved more time in that respect...'.*

Teacher Views on the Determining the Impacts of the ABI Process

Impacts of the ABI Process on Students

Specific questions were addressed to the teachers during the interviews conducted for determining the impact of the ABI process on students and teachers. All three teachers stated that the process had increased the success of the students. Furthermore, the teachers reported that positive attitudes, communication and scientific process skills of the students had developed, they had started to question the information and even the process had facilitated their adaptation to school. Regarding the changes observed in the students at the end of the process, the following statements of T1 demonstrated that the process had increased the success of the students and helped them develop positive attitudes towards the class: *'...Students with normally lower levels of interest in the class became eager for the continuation of activities and this reflected on their grades...'* and *'...Several students of mine particularly grabbed my attention. They were students who had lower levels of interest in the class. For instance, one day we had a class in the evening after the activity. He was asking if we were to continue the class. He came to the class, sat on the front row and was still sitting there. After the activity, we had a test about it. It was better and reflected on the grades, as well...'* Similarly, T3 pointed out to the increased success and also stated that the students had started to question the information as follows: *'...The process allowed for inquiring the right and the wrong and resulted in increased success and active participation in the class...'.* T2 reported that increase in success was more apparent in the students with lower or moderate levels of success by stating *'...Maybe success remains the same in students who are already successful. But I think that success increases in those having moderate and lower levels of success...'.* On the other hand, the following statement of T2 demonstrated that the students experiencing the ABI process had particularly become more successful in conceptual questions and their communication and scientific process skills had developed: *'...We saw that they were making more explanations and descriptions in conceptual questions... Their communication skills with peers had developed. Their scientific process skills such as determining the variables and testing them had developed. The process also supported them in terms of measurement skills and the use of measurement tools...'.* T3 exemplified how these activities facilitated the adaptation of the students to school as follows: *'... We had this student. He was pretty quiet in the class prior to the activity. He started to come to school only several weeks before the start of the activity. Therefore, I thought that the student would have a great deal of difficulty. It was an adaptation process. Even that student surprised me. His adaptation was so fast. He was feeling happy*

and was asking good questions…'. Based on the statements of the teachers, it is clear that the ABI approach contributes to the multilateral development of students.

Impacts of the ABI Process on Teachers

Concerning the changes in themselves, the teachers mainly mentioned eliminating misconceptions, preparing high quality questions, establishing a democratic classroom environment, starting inquiry and effective process planning. T1 pointed out the eight-week training process and explained how the change started at the beginning of the training as follows: *'…The change started as early as the ABI training process. I realized that there were misconceptions and there was not much emphasis on the details…'*. The teacher stated that he had become aware of misconceptions and deficiencies in the field knowledge owing to the process. T2 stated that the process had contributed to him/her in terms of asking high quality questions and creating a democratic classroom environment by saying, *'…I think that this process has contributed to me a lot in terms of asking questions. It has also increased the quality of my questions. Moreover, this method enables teachers to create a democratic classroom environment…'* The following statement of T3 *'…At the end of the process, I started to question more, as well…'* demonstrated that the process motivated the teachers to question. Furthermore, T3 made a comparison between previous teaching practices and those carried out within the scope of the study. In this respect, the statement of T3 was as follows: *'…Of course, another crucial point exists for teachers. You need to come to the class prepared. I understand this once more… Under normal conditions, you prepare for the class but it is not as comprehensive and detailed as this one. I have understood its importance. Previously, I would check the subject, what I would tell and the outcomes. I would focus on such things. However, frankly, I would not make such detailed preparations to make the students think and question. I have learned this. It has really been a precious process for me…'*. It is possible to argue that the development aspects that the teachers mentioned had indirectly made significant contributions to the field and pedagogical knowledge of the teachers.

Teacher Views on the Justification for Recommending to Colleagues

During the interviews, the teachers were asked to explain whether they would recommend the ABI approach to their colleagues and justify their answers. All three teachers recommended the ABI approach to their colleagues. To justify their answers, they all stated that the approach had increased student participation. Moreover, they mentioned other advantages such as directing to research-inquiry, making students think, providing the teacher with convenience, making classes entertaining and making the knowledge permanent. T1 explained the reasons of recommending as follows: *'…It ensures student participation. It motivates students to research-inquiry and thinking. Since the level of student participation is higher, I think that the research, inquiries or thinking might be more permanent. I recommend it; however, it requires a good preparation…'*. This statement points out the phase of preparation once again and stresses the necessity of a good preparation for an efficient activity. T2 answered this question as follows: *'…I recommend it because it ensures a higher level of participation than a normal class… It is very good that the teacher deliberates over questions. Maybe it alleviates burden compared to a normal class…'*. According to this statement, the teacher recommended the approach to his colleagues because it required the teacher to be well-prepared for the class and alleviated the burden of the teacher. Finally, T3 expressed his/her views with the following statement: *'…I definitely recommend it… To begin with, the class becomes more enjoyable for both parties - students and teachers alike. Under normal circumstances, you sometimes think how those 40 minutes will pass in the classroom. But now, it is as if 40 minutes are not adequate. We never know when the class starts and when it ends… Student participation is paramount…'*. Moreover, T3 stated that he recommended the approach to his/her colleagues because the students could obtain permanent knowledge by taking part in the learning process as follows: *'…I think it is important for permanence, as well. Kids actively take part in the process. They question and find answers. They see what is correct and what is wrong. They experience a mental process. This is highly valuable for me…'*. The teachers apparently recommended the ABI approach because it ensured a higher level of student participation than other classes.

Teacher Views on Self-assessment

During the interviews, the teachers were asked *"What would you keep in mind if you conducted an ABI activity anew?"*. All three teachers pointed out the necessity of well-planning of the class. They stated that they would pay attention to increasing the quality of questions in the class, receiving different ideas including passive students and increasing field knowledge. In this respect, T1 pointed out that a good planning would affect the continuation of the class as follows: *'...First of all, activities should be highly interesting at the beginning since how you start the class determines its continuation for children...'*. The statement of T2 was as follows: *'...I would certainly make a plan... I would think about the questions... Maybe I might focus a bit more on the discussion process since questions are shaped in that process... I would try to increase the quality of questions even further. For example, I can obtain opinions from my colleagues. What kind of questions can I ask in such an activity, etc.? I would try to include passive students in discussions more often...'*. The teacher stressed the planning of the class, increasing the quality of questions, obtaining different opinions and including passive students in the class. T3 explained his/her views as follows: *'...I would be better prepared. This activity requires a better preparation. I would be more prepared for the introduction, because the initial parts are crucial...'*. In general, the teachers laid emphasis on the necessity for a good preparation, making a strong introduction, including passive students in the class and obtaining opinions from colleagues.

DISCUSSION

According to the findings of the study, all three teachers stressed that asking questions was of prime importance for the efficiency of the ABI process. In addition, they stated that, in addition to the questions they asked, the students addressed questions to their teachers and peers. They pointed out that the teachers' questions were crucial in the achievement of the goals in the discussion process and the comprehension of the subject. The peers sometimes gave wrong answers to the questions addressed by the students. Two of the teachers stated that they interfered and corrected the wrong answers so as not to get off the point while the other teacher stated that he/she did not interfere in wrong answers so that the students could adopt the discussion culture. The teachers stressed that class introductions were to be interesting, a good preparation was to be made prior to the class and the process was to be well-planned from the beginning to the end for an efficient ABI process. They recommended the ABI approach to other teachers because it included students in the learning process, helped them question themselves and their peers and made the class more enjoyable than other classes. The teachers also reported that the students taking part in the ABI process had higher marks in written exams, their scientific process skills such as determining and testing variables had developed and they were able to establish better communication with their peers. The teachers stressed that the process motivated them to question and it enhanced their abilities to ask questions, as well as conceptual developments. Furthermore, they stated that the ABI approach contributed to teacher satisfaction by allowing for the creation of a democratic classroom environment and the development of conceptual skill and a variety of other skills (thinking skills, scientific process skills) of students.

Since the 2013 science curriculum, there has been an apparent emphasis on inquiry and the importance of students searching and inquiring information with peers (MNE, 2013; 2018). Discussions based on scientific inquiry are at the center of science teaching (National Research Council [NRC], 2013). To shape the teaching culture in science classes in this direction, teachers are to be informed of the activities based on inquiry. Teachers who are usually accustomed to traditional teaching and verification-type laboratory activities will have difficulty planning and implementing argumentation-based scientific activities (Choi, Seung & Kim, 2019). In the study, the teachers stated that they had difficulty planning the class and making an introduction to the class.

In the structuring of the knowledge, teachers have responsibilities as the guides of students. The ABI has two main elements: the teacher template and the student template. During this process, students think about the concepts while teachers design and implement an activity first and then help students comprehend the concepts (Hohenshell & Hand, 2006). In the study, the teachers stressed that

a good preparation was required prior to the class and the process was to be well-planned from the beginning to the end for an efficient process. A well-planned ABI activity will result in more intense peer communication and more efficient discussions based on scientific information. Therefore, small and large group discussions conducted within these activities will help students understand and make sense of science concepts on the basis of the arguments created (Kabataş Memiş, 2014). According to the statements of the teachers, the students established better communication with their peers and teachers and the conceptual development of students had increased owing to the process they experienced in the classroom. The science curriculum states that while students search for information during the learning process, they will communicate and cooperate effectively with their peers, as well (MNE, 2013; 2018).

It is beyond doubt that one of the most important mechanisms of the ABI process is discussion. As discussion activities keep students mentally active and curious throughout the class, students are required to learn how to take part in a scientific dialogue. In science classes, "well-chosen teacher questions" is a valid way of triggering scientific discussions in the classroom (Darling-Hammond, Flook, Cook-Harvey, Barron, & Osher, 2020). As students develop answers and explanations for their research; teachers are required to talk less and use higher-order questions to justify their reasoning (Hand, Chen, Suh, 2021). During the interviews conducted within the scope of the study, the science teachers stressed the importance of teacher questions during the process. They stated that asking questions was crucial in science classes to lead students to the right, include them in the discussion, make them think and make them gain inquiry skills, in particular. In order to develop deep conceptual understanding in students, it is noteworthy to contribute to the professional development of teachers in asking correct questions and using student answers (Khoza & Msimanga, 2021).

In accordance with the aforementioned statements, the necessity of creating environments that allow for discussions in science classes comes into prominence. The most significant task of a teacher in the creation of these environments is to ask effective questions initiating and leading discussions. Osborne, Erduran, Simon and Monk (2001) reported that teachers may initiate or lead a discussion process by choosing appropriate questions out of a series of questions. The researchers specified questions such as "Why do you think so? What do you think is the reason of this? Can you think of another argument? Can you think of a counter-claim? How do you know? What is your evidence? Is there any other argument in your belief? The questions aim to urge students to think, have no exact answers and result in a discussion environment where different views are expressed. Students take part in the discussions created by the teacher along with their peers. After a certain point in the discussion, the need for the questions of the teacher is minimised and students produce their own questions. For effectiveness of the process, inquiry is not adequate for students. They are also required to find answers to their questions (Kuhn, 2009).

As a consequence, an efficient ABI process will not require a good preparation and planning. The quality of questions to be addressed by teachers in the class during the ABI applications is of particular importance. Purposeful questions which make students think, question and reason are noteworthy in this process. Peer questioning and claim-evidence relationship are the noteworthy activities of the ABI process. Alienation of students to the ABI applications, grade and a lack of time are among the factors complicating the process. Teachers indicated that the ABI process contributes to the multilateral development of both teachers and students.

Implications

We know that an expectation exists for inquiry-based science teaching in the science curriculum and the literature, in particular. Therefore, studies that compare the curriculum and classroom activities determine the obstacles during the full implementation of the curriculum and ensure that teachers realize how they teach is of paramount importance. Moreover, what prevents teachers from using different teaching activities in the classroom is to be determined. It is beyond doubt that the quality of education will be increased only by increasing the training of teachers who

provide the education. In this respect, it is noteworthy that various training activities be conducted both for preservice teachers and teachers.

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