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| Research Article / Araştırma Makalesi |

The Effect of Argumentation-Based Inquiry Approach Supported by Metacognitive Activities on Science Achievement of Preservice Teachers

Üst Bilişsel Aktivite İle Desteklenmiş Argümantasyon Tabanlı Bilim Öğrenme Yaklaşımının Öğretmen Adaylarının Fen Başarısına Etkisi

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Keywords

1. Argument Based Inquiry (ABI)
2.Metacognition
3.Science achievement

Anahtar Kelimeler

1.Argümantasyon Tabanlı Bilim Öğrenme (ATBÖ)
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Abstract

Purpose: This study was conducted with students in their third year at the Department of Science Teaching at Kastamonu University in the 2015-2016 academic year. The study's objective is to investigate the effect of the argumentation-based and argumentation-based inquiry approaches supported by metacognition activities on students' science achievement.

Design/Methodology/Approach: The study was carried out in 10 weeks with the participation of 69 students divided into three groups, namely, the ABI group, the ABI + metacognitive activity group and the group in which the traditional method was applied. An achievement test consisting of 25 questions and semi-structured interviews were used as data collection tools. In the data analysis, pre-post test evaluations and descriptive statistics were used.

Findings: The data obtained showed that there was a significant difference between the groups, which was in favour of groups where the ABI approach was applied, and that there was a slightly significant difference between groups of ABI and the ABI supported by metacognition activities, which was in favour of the ABI group supported by metacognition activities. The interviews with students revealed many significant and positive outcomes; they stated that they were satisfied with the ABI applications, that they would prefer ABI in their professional lives, and that the applications facilitated scientific thinking.

Highlights: Metacognition has an important place in scientific literacy and knowledge structuring. Because it provides metacognition to be aware of the individual's learning and learning process, it can be said that language practices such as discussion and writing, especially in the ABI process, activate cognitive and metacognitive mechanisms.

Öz

Çalışmanın amacı: Bu çalışma, 2015-2016 eğitim öğretim yılında Kastamonu Üniversitesi İlköğretim Fen Bilgisi Öğretmenliğinde öğrenim gören 3.sınıf öğrencileriyle gerçekleştirilmiştir. Çalışmanın amacı argümantasyon tabanlı bilim öğrenme yaklaşımının ve üst bilişsel aktiviteyle desteklenmiş argümantasyon tabanlı bilim öğrenme yaklaşımın öğrencilerin fen başarısına etkisini araştırmaktır.

Materyal ve Yöntem: Çalışma 69 öğrencinin katılımıyla; ATBÖ grubu, ATBÖ+üst bilişsel aktivite grubu ve geleneksel yöntemin uygulandığı grup şeklinde 10 haftada gerçekleştirilmiştir. Veri toplama aracı olarak 25 sorudan oluşan başarı testi ve yarı yapılandırılmış görüşmeler kullanılmıştır. Elde edilen verilerin analizinde ön-son test değerlendirmeler ve tanımlayıcı istatistik kullanılmıştır.

Bulgular: Elde edilen verilere göre, gruplar arasında anlamlı bir farkın olduğu, bu farkın ATBÖ yaklaşımının uygulandığı sınıflar lehine olduğu, ATBÖ ve üst bilişsel aktivite ile desteklenmiş ATBÖ grupları arasında ise çok az anlamlı bir farkın üst bilişsel aktivite ile desteklenmiş ATBÖ grubu lehine olduğu sonucuna ulaşılmıştır. Öğrencilerle yapılan görüşmeler sonucunda öğrencilerin ATBÖ uygulamalarından memnun olduklarını, ATBÖ'yü meslek hayatlarında tercih edeceklerini, uygulamaların bilimsel düşünme sürecini sağladığı gibi birçok önemli ve olumlu sonucuna ulaşılmıştır.

Önemli Vurgular: Bilimsel okuryazarlık ve bilginin yapılandırılmasında üst bilişin önemli bir yer bulmaktadır. Çünkü üst biliş bireyin kendi öğrenmeleri ve öğrenme sürecinin farkında olmasını sağlamakatadır. Özellikle ATBÖ sürecinde yer alan tartışma ve yazma gibi dil pratiklerinin bilişsel ve üst bilişsel mekanizmaları harekete geçirdiği söylenebilir.

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INTRODUCTION

Due to the developments in rapidly advancing information and communication technologies both in Turkey and in the world, the accumulation and sharing of information in many areas happen very quickly. However, circumstances where individuals approach subjects from a critical point of view and question the information they obtain, rather than accepting it as it is, are appreciated more in the education system. The aim is to raise individuals with strong social and communication skills who choose, question, and interpret information rather than those who will do whatever they are told (Aslan, 2014). Our students, who have the potential to become the leaders or decision-makers of society in the future, should be able to think about alternative explanations with an open-minded, sceptical and questioning approach when they make decisions regarding any issues they might encounter; they should be able to make informed decisions by critically evaluating the claims, justifications, and arguments brought forward in discussions (Tümay & Köseoğlu, 2011).

While determining the essential goals of science education and the tools that can be used to reach those goals, American National Science Education Standards (NRC, 1996) emphasized that inquiry is the heart of science education. In the Science Course Curriculum, which was prepared with an inquiry-based learning approach, an integrated perspective was adopted in regards to learning-teaching theories and practices; a learning strategy based on inquiry and the transfer of knowledge where students are responsible for their learning, and actively participate in the learning process was embraced in general (MNE, 2018 p.10). Students who research, inquire, construct the information in their minds, and explain and discuss their findings are at the centre of the learning process. Creating environments where students can actively participate in learning is related to selecting the appropriate teaching methods and techniques (Aydede & Matyar, 2009). Therefore, in formal and non-formal educational environments, different learning and teaching methods should be used (Günel, Uzoğlu, and Büyükkasap, 2009). Science classes, where inquiry-based activities are performed, are environments where students actively participate in the course (Günel, Kabataş Memiş and Büyükkasap, 2010). This was clearly stated in the science curriculum "The process of research and inquiry is considered to consist not only of 'discovery and experiment' but also as a process of creating an 'explanation and argument.' Inquiry-based learning is a student-centred learning approach where students have the desire to explore all that is around them, develop strong arguments by explaining the natural and physical world around them with strong justification, grow up as individuals who are enthusiastic about science and recognize its value, and in short, construct information in their minds by acting-living-thinking like scientists," (MNE, 2013 p.3).

Scientists emphasize the scientific discussion approach to understand nature through discussion, evidence, and ideas (Ford, 2012). The concepts of scientific discussion and discussion do not have the same meaning. The Turkish Language Association dictionary defines discussion as defending opposing ideas by different parties. In contrast to discussions with winners and losers, a scientific discussion is a process by which individuals exchange ideas with one another by introducing evidence (Küçük & Aycan, 2014). A scientific discussion aims to attain the correct result mutually (Kaya & Kılıç, 2008). The scientific discussion approach is an argument-based method (Uluay, 2012). The argument, a component of scientific discussion, which essentially consists of logical inferences based on specific information, is at the core of the philosophy of science (Newton, Driver and Osborne, 1999). According to Newton et al. (1999), the discussion is a logical process. From the days of Aristotle, the scientific discussion has been the principal activity of scientific meetings held to introduce ideas and discuss their admissibility, beginning with asking questions. Individuals who participate in scientific discussions by putting forward their arguments initiate the process by sharing their views about events and situations. For all the views presented or the discussions carried out to be considered scientific, the arguments put forward must be formed correctly (Küçük & Aycan, 2014).

The activities that support and facilitate scientific discussion in the classroom environment aim to improve students' inquiry, discussion, and evaluation skills (Aydın & Kaptan, 2014). In the course of scientific discussions in the classroom, students openly explain the reasons that support their views by using their prior knowledge and trying to prove the accuracy of those views. Students act as scientists throughout this process and develop and construct their arguments (Özkara, 2011). Students learn the rules of discussion with activities centred around scientific discussions and can achieve permanent learning due to these practices (Kaya & Kılıç, 2008). When people comprehend the nature of the scientific discussion and learn how to utilize effective means of discussing a scientific subject matter at an early age, they can participate more in scientific discussions and make informed decisions. Competence and experience in this area constitute an essential part of life in contemporary societies (Kaya, 2013).

Argumentation is a process centred around collaborative group discussions to develop and explain arguments. Questions are asked, evidence is collected, claims are explained, and alternative claims are evaluated and discussed throughout the activity (Chin & Obsorne, 2010). It is referred to as scientific discussion (Demirel, 2015). Argumentation is an effective teaching method that supports science literacy and improves thinking skills, which are essential to acquire in science education (Köseoğlu, Tümay and Budak, 2008). Argumentation, essential in commenting and developing models, and theories, contributes significantly to implementing the discussion-oriented teaching approach (Türkoğuz & Cin, 2013). Thanks to argumentation practices, students do not see science and scientific knowledge as absolute and immutable facts, and they can develop a more realistic understanding of the nature of science (Driver, Newton and Osborne, 2000). Argumentation enables students to develop scientific process skills and high-order scientific process skills such as analysis, synthesis and creating new hypotheses with the method of discussion by basing subject matters on scientific knowledge (Kabataş Memiş & Ezberci Çevik, 2017). The inclusion of students in the argumentation process in science classes, which is of paramount importance in terms of the production, progression, and evaluation of scientific knowledge, enables them to understand better both the scientific structure of ideas and the social aspect of scientific ideas (Bell & Linn, 2000). Because argumentation is an approach that has the student at its centre, where students interact and utilize their mental skills (Türkoğuz & Cin, 2013). The teacher determines the details the students fail to grasp and guides them so they may arrive at the truth through their own experience.

Argumentation, addressed for the first time by Toulmin (1958), was determined to be a model (Aydın & Kaptan, 2014). According to Toulmin (1958), argumentation is a tool that can be used to test supported claims and ideas. In Toulmin's model, data, claim, warrant and backing are the basis of argumentation, and qualifier and rebuttal are the other elements of a more complex argument (Erduran, Simon and Osborne, 2004; Osborne, 2005). Argumentation, which can be dealt with within the context of the scientist's habits of mind, can be defined as the process of supporting arguments with data and having them approved after providing the necessary explanations (Tümay & Köseoğlu, 2011). The Toulmin method of argumentation consists of the claim, the evidence that supports the claim, the warrants that demonstrate the relationship between the claim and the evidence, the insufficient knowledge (backing) that reinforces the warrants, the qualifiers, and the rebuttal which recognizes that the claim is not always valid (Erduran et al., 2004). For students to understand and interpret science, they must improve their language skills, such as learning scientific concepts, expressing what they learn, doing alternative writing activities, and establishing a connection between daily language and the language of science (Demirbağ & Günel, 2014). Language practices such as oral expression and writing conducted in the classroom are essential elements of research and inquiry (Hand, Wallace & Yang, 2004; Hand, 2008). As an essential element of science education (NRC, 1996), writing must make sense of events and activities and record them (Kabataş Memiş & Seven, 2015).

Argumentation-Based Inquiry (ABI) (Kabataş Memiş, 2016) is one of the inquiry-based approaches that are used to help students learn scientific concepts, and it includes a series of objectives such as critical thinking (Sönmez, Kabataş Memiş, & Yerlikaya, 2019; Çakan Akkaş, 2017; Öz, 2020), discussing information, developing communication and linguistic skills, gaining scientific process skills.

Argumentation-Based Inquiry (ABI)

ABI is an approach that facilitates the production of scientific information through argumentation in research-inquiry environments and it also prompts cognitive and metacognition mechanisms with language practices (Günel, et al., 2010). This approach includes theoretical foundations related to the learning and teaching process such as constructivist learning, understanding the nature of science, scientific argumentation (Aydın, 2013). ABI consists of a series of activities that guide both teachers and students in regard to thinking and writing (Hand, Wallace, and Yang, 2004). These activities are given in Table 1.

Tablo 1. Student and teacher template

Student Template	Teacher Template
1. Beginning Ideas –What are my questions?	1. Exploration of pre-instruction understanding through individual or group concept mapping.
2. Tests – What did I do?	2.Pre-laboratory activities, including informal writing, making observations, brainstorming, and posing questions.
3. Observations– What did I see?	3. Participation in laboratory activity.
4. Claims – What can I claim?	4. Negatiation phase I- writing personal meanings for laboratory activity (For example, Journaling).
5. Evidence – How do I know? Why am I making these claims?	5. Negatiation phase II- sharing and comparing data interpretations in small groups (For example, making a group chart).
6. Readind – How do my ideas compare with other ideas?	6. Negatiation phase III- comparing science ideas to textbooks or other printed resources (For exampe, writing group notes in response to focus questions).
7. Reflection – How have my ideas changed?	7. Negatiation phase IV- individual reflection and writing (For exampe, writing a report or textbook explanation).
	8. Explanation of post instruction understanding through concept mapping.

ABI is a process that starts with students preparing the questions they want to research and continues as they design activities that will enable them to find the answers to the research questions, develop their claims that are part of the scientific process according to the findings they obtain as a result of the experiment, support their claims with evidence and defend their findings in small and large group discussions (Keys et al., 1999). The ABI approach introduces a new form of writing where the students prepare the initial questions; it guides the views, writing, and discussions of students about the conclusions they reach through data, claims, and evidence and how it relates to their prior knowledge (Hand & Keys, 1999). It is an inquiry-based method that uses language practices such as reading, writing, and speaking, which facilitate the production of scientific information through argumentation (Hand, 2008).

Because ABI contains rich language practices and uses science teaching as a base through research and inquiry, it is used in educational environments. In ABI practices, ideas are introduced through research and inquiry; questions create arguments, claims, evidence, and reconciliation and negotiation procedures are carried out (Akkuş, Günel and Hand, 2007). Students investigate their questions themselves and make sense of scientific concepts through large and small group discussions on explanations, tests, claims, and evidence employing argumentation (Hand & Keys, 1999). Students reconstruct scientific concepts by discussing them throughout the ABI process. They do this through oral discussions and by creating written content where they convey their ideas and re-read the said content (Keys et al., 1999).

Compared to the traditional method, ABI has a bigger effect on student achievement (Yıldırım and Nakibolu, 2014; Yeşildağ Hasançebi and Günel, 2013; Ceylan, 2010; Kabataş Memiş, 2011; Newton et al., 1999; Hand and Yang, 2004; Hand and Keys, 1999; Chen et al., 2011). The scientific argumentation method emphasises an explicit reflective approach, improves scientific literacy (Jimenez Aleixandre, 2007) and encourages individuals to actively participate in the social structuring of scientific knowledge (Köseoğlu et al., 2008). Students actively participate in ABI practices; therefore, the learning becomes more meaningful and permanent (Uluçınar, Doğan and Kaya, 2008). ABI facilitates learning, improves self-confidence, and provides individuals with a sense of responsibility (Kabataş Memiş, 2014; Kabataş Memiş & Seven, 2015). It ensures that students learn science more meaningfully and effectively (Kabataş Memiş & Ezberci Çevik, 2017). ABI improves the problem-solving and data analysis skills of students and advances their interpretation and self-evaluation abilities (Tüysüz, Demirel and Yıldırım, 2014). This method helps students to grow up to be individuals who can solve problems, make decisions and think scientifically (Üstünkaya & Savran Gencer, 2012). In addition, ABI enables students to express themselves more comfortably and think critically (Kabataş Memiş, 2016; Sönmez, Kabataş Memiş and Yerlikaya, 2019). The relationship between metacognition and ABI was investigated to make inferences about the kind of effect ABI, which contains many learning outcomes, might have when supported by a metacognition activity.

Metacognition and ABI

Concepts such as "self-learning," "learning to learn", and "effective learning" has become more critical in recent years. The concept of metacognition came to the forefront with the thought that it helps the individual gain "self-learning" competence (Akpunar, 2011). Metacognition, which underlies thinking and encompasses all thinking skills, covers abilities such as determining the steps to take while acting, planning about an action or a subject matter, constantly reviewing the said plan, and feeling the need to correct the incomplete or faulty parts (Demir & Özmen, 2011). According to Flavell (1979), metacognition is the individual's knowledge of the cognitive process and its outcomes regarding a given situation. It can also be defined as using high-order mental processes for learning, such as when an individual plan to learn something, develops the necessary strategies and skills to solve a problem, makes predictions on a subject, and determines the limits of learning (Dunlosky & Thiede, 1998). Metacognition awareness means that the individual is aware of what s/he knows and does not know, takes responsibility for his/her learning, evaluates, plans, monitors his/her learning, as well as controls his/her mental processes (Bağçeci, Döş and Sarıca, 2011).

Educational writing activities (Yıldız & Büyükkasap, 2011) are considered to be some of the most important activities that improve high-order mental process skills in science classes and stimulate rich cognitive growth in learning science concepts (Günel et al., 2010). According to Klein (2000), writing is a process that helps students think critically and acquire new knowledge. Writing activities that include learning methods based on constructivism, which enable students to establish meaningful cognitive and affective connections among concepts through their expressions (İnaltekin, Başak Özyurt and Akçay, 2012), make it easier for students to comprehend more profound concepts (Prain & Hand, 1999). Writing increases students' awareness, enables more thinking, learning more effectively and deeply, and facilitates the transfer of information through intimate feelings and thoughts. All these characteristics make it an extraordinary, unique way of learning (Emig, 1977). Therefore the activity of writing positively supports metacognition. For these reasons, students were tasked with journaling as writing activity to support metacognition activity.

During the ABI process, students actively use writing practices; they revise the information and make sense of it before using it. While writing practices incorporating traditional approaches ensure that the existing knowledge is repeated and transferred to the paper as it is, writing practices using contemporary approaches help the information be seen from different perspectives. The literature review showed that many studies were carried out on the ABI approach. Based on the results of those studies, ABI increases the metacognition and logical skills of individuals (Kabataş Memiş & Ezberci Çevik, 2017); improve conceptual learning in students (Hand & Norton Meier, 2011), brings possible misconceptions into light (Kıngır, 2011) and enables students to achieve more permanent learning (Arlı, 2014; Kabataş Memiş, 2011).

Within this scope, this study aims to investigate whether supporting Argumentation-Based Inquiry, a method that activates metacognition skills with an additional metacognition activity, affects students' science achievement.

METHOD

The Research Method

"Argumentation-Based Inquiry," "Argumentation-Based Inquiry + Journaling Activity," and "traditional" methods were employed with 3rd-grade preservice science teachers on several physics subjects that are in the syllabus of the Science Teaching Laboratory Practices-I course. The subjects include density, horizontal force, inclined plane, horizontal velocity, motions, and free-fall. The results were examined to determine whether there is a significant difference in science achievement among these groups. A quasi-experimental research method was used as a quantitative research design in this study. Non-experimental descriptive analysis was used in the analysis of qualitative data used to support quantitative data. The groups were randomly selected as control and experimental groups, and the data were collected with pretests and posttests. While one of the experimental groups carried out laboratory work with ABI practices, in the other group, journaling activity, which activates metacognition, was used in addition to the ABI practices. The traditional method was used in the control group, and the course was conducted with experiments based on the same subjects, selected from the Science Teaching Laboratory Practices-I coursebook (Kesmez, 2010). The students conducted the experiments selected from the book by the teacher in accordance with the theme of each week, completed the test reports and handed them in during class. The Science Achievement Test was conducted as a pretest at the beginning of the process and as a posttest, after the practices were completed.

Sampling

The sample for this study consists of a total of 69 students, 47 of whom are female and 22 are male, in their third year at the Department of Science Teaching at Kastamonu University, in the fall semester of the 2015-2016 academic year. The students come from socioeconomically middle-class families and enrolled at the university between 2013 and 2017 with scores ranging from 199 to 260. Three different groups, as two experimental groups and one control group, were included in the study carried out within the scope of the Science Teaching Laboratory Practices-I course. For the experimental and control groups, groups of 3 or 4, as determined by the students, were formed without the intervention of the researcher. The students worked in these groups that they formed during the whole semester. The practices of the experimental groups and the control group were carried out by the same researcher.

The Research Period

The research carried out in groups of 3 or 4 people determined by the students at the beginning of the semester continued for 10 weeks. The Science Achievement pretest was conducted in the first week to determine the science achievement levels of the students. A preparatory activity was carried out for the students in the experimental groups to inform them about the argumentation process and help them understand it. The activity aimed to encourage the students to judge and discuss the concepts of claim and evidence. In the following weeks, the selected physics subjects (density, horizontal force, inclined plane, horizontal velocity, motions, and free-fall) were taught by the argumentation process, and discussions were shaped with the same approach. Two hours of class each week were dedicated to small group discussions, and two hours were dedicated to extensive group discussions. The students wrote their reports after classes using the ABI report template. In the experimental group where the ABI and journaling activity was adopted, the students wrote journaling in addition to writing reports. The journaling instructions prepared by the researcher each week were e-mailed to students after class.

Experiments from the Science Teaching Laboratory Practices-I course book were carried out with the students in the control group. The students in the control group attended classes in a learning environment employing the traditional method. In educational environments using the traditional method (Bayram, Patlı, and Savcı, 1998), where a teacher authoritatively instructs students, the student is in the listener position, and the teacher is the instructor who directly communicates information. In this scope, experiments selected from the book were conducted on each week's theme. The students in the experimental group carried out their writing activities by the homework instructions given to them. For the class duration, the researcher took on the role of a guide who answered students' questions when needed, participated in table discussions, or provided technical support. The students wrote reports on the experiments they conducted in that period and handed them in during class. The reports included the title and the purpose of the experiment, the data collected during the experiment, and the result of the experiment.

Data Collection

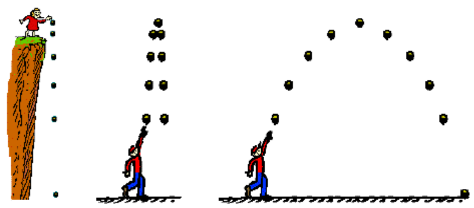
The Science Achievement test conducted at the beginning and the end of the study and semi-structured interviews conducted with selected students at the end of the study were used as the data collection tool. In line with the objective of the study, students were asked to write diaries to examine the development of their metacognition skills. The journaling were not subjected to any rating or evaluation by the researcher.

The Science Achievement Test

The science achievement test was developed by Kabataş Memiş, Günel and Büyükkasap (2009). The test, which includes 13 multiple choice and 12 open-ended concept questions, was conducted both as a pretest and posttest. Cronbach's alpha reliability coefficient of the Science Achievement Test was determined as .70. Students were given 50 minutes for the test. Since the Science Achievement Test consists of two types of questions, multiple-choice and open-ended questions, the questions were scored differently. For the multiple-choice questions, unanswered questions and wrong answers were given 0 points and correct answers were given 3 points; one of the open-ended questions was given 6 points and the others were given 5 points, and the test was evaluated over 100 points. The key to the open-ended questions was prepared by the researcher and all open-ended questions were scored. Examples of the questions of the Science Achievement Test given to students are given below.

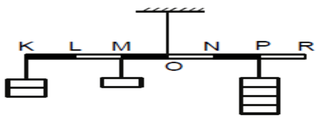
OEQ1 : While you were traveling with your younger sibling, they asked you "why you moved forward when the car's brakes were applied." How would you explain that to your sibling?

OEQ2 : A publishing house, which believes that your knowledge in physics is very reliable, sends you a physics book for you to edit. In this book, the picture below is included with the following statement: "The forces acting on the balls are different in all three pictures. But these different forces can move these balls." How would you interpret this statement by looking at the picture? Support your interpretation with vectorial expressions.



OEQ10 : 1 kg of cotton and 3 kg of iron balls with the same external volume are released from the h height at the same time. What would you say about the falling time of the objects?

MCQ1



7 identical objects are tied to the K, M, P points of an equal-split bar of insignificant weight hanging from the O point, as can bee seen in the figure.

Which of the following actions done before releasing it will keep the horizontal bar in a horizontal position?

A) Shifting the objects in K to L
B) Shifting the object in M to L
C) Shifting the object in M to N
D) Shifting the objects in P to N
E) Shifting the objects in P to R

MCQ4 : The masses of K, L liquids, each of which has a volume of V, are m and 2m, respectively. By mixing these liquids, a homogeneous mixture with a volume of 2V is created.

If the core mass of the mixture is d, what is the core mass of the K liquid?

A) 1/2 B) 2/3 C) 3/4 D) 4/3 E) 3/2

MCQ5 : If the speed of an object thrown in projectile motion is increased from Vo to 2Vo provided that the motion angle remains the same, how many times does the X distance it falls increases?

A)1 B)2 C) 3 D)4 E)5

Semi-structured Interviews

Semi-structured interviews were conducted by the researcher in order to reveal students' opinions about ABI, metacognition activity and traditional approach. Interview questions were prepared by the researcher and after consulting expert opinions, interviews were conducted with the final version of the questions. 6 students were selected from each group on a volunteer basis and a total of 18 students were interviewed.. Students with high, moderate, and low academic success were selected to create a homogeneous sampling and semi-structured interviews were held with the students. The interviews were recorded using a voice recorder and they lasted for 15 to 50 minutes. The students were asked questions about comparing the ABI approach and the traditional method, determining the roles of students and teachers in this process and metacognition activity (Journaling).

Data Analysis

To measure the academic science achievement of the students, pretest and posttest scores of students were taken into consideration. SPSS software package was used to analyze the pretest and posttest scores of the students. One-way ANOVA and descriptive statistics were used on the data to compare the scores of the groups. The effect size was calculated using Cohen's d to determine the difference between group averages. To ensure the internal validity of the study, the groups were formed neutrally, and the data was collected in the same environment.

Descriptive analysis was used to interpret the qualitative data. At the end of the study, 6 students were selected from each of the experimental and control groups and semi-structured interviews were conducted with a total of 18 students. The names of the students who participated in the interviews were not shared in light of ethical considerations. Students were assigned codes names such as S_1, S_2, and S_3 and all the data were shared using these code names. The interviews conducted with the students were recorded with a voice recorder and were later transcribed and examined. Main themes such as "roles of the teacher," "roles of the student," "ABI-traditional method comparison" were taken into consideration in the examination of the ABI group, which was one of the experimental groups. In addition to these themes, the "journaling" theme was taken into consideration in the examination of the ABI + Journaling group. The activities students attended during the study, how they conducted group activities, the tasks the teachers undertook in the process, and how much they reflected the change that the process brought about in them were all analyzed.

FINDINGS

Science Achievement Pre-post test Analysis

At the beginning of the study, one-way ANOVA was applied to the data to determine whether or not there was a difference between the groups in terms of science achievement. The total score of the multiple-choice questions, the total score of the open-ended questions, the averages and standard deviations of the scores in the total test score are given in Table 2.

Table 2. Findings related to the science achievement pretest of the students

Pretest	Study Groups	n	X	SD
TSMCQ	ABI	19	8.1	3.3
	ABI + Journal	26	7.8	3.9
	Control	25	7.2	4.3
TSOEQ	ABI	19	5.8	4.8
	ABI + Journal	26	5.0	4.4
	Control	25	4.3	3.3
TTS	ABI	19	13.9	6.8
	ABI + Journal	26	12.7	4.8
	Control	25	11.5	6.3

TSMCQ: Total Score of Multiple-Choice Questions
TSOEQ: Total Score of Open-Ended Questions
TTS: Test Total Score

One-way ANOVA was used to determine whether there was a significant difference between the groups. The findings related to the ANOVA test are given in Table 3. According to the results obtained from the data; no statistically significant difference was found between the total score of science achievement test (F(2, 69) = .909, p=.408, n^2=.026), total sore of open-ended questions ($F_{(2, 69)}$=.753, p=.475, n^2=.022) and total score of multiple-choice questions ($F_{(2, 69)}$=.292, p=.748, n^2=.009) of the groups at $p < 0.05$ significance level.

Table 3. Findings related to the One-Way ANOVA of the science achievement pretest

		Total Sum of Squares	Degrees of Freedom	Mean Squares	F	p	η_p^2
TSMCQ	Intergroup	9.111	2	4.555	.292	.748	.009
	Intragroup	1046.332	67	15.617			
	Total	1055.443	69				
TSOEQ	Intergroup	26.344	2	13.172	.753	.475	.022
	Intragroup	1172.528	67	17.500			
	Total	1198.871	69				
TTS	Intergroup	64.275	2	32.137	.909	.408	.026
	Intragroup	2368.068	67	35.344			
	Total	2432.343	69				

The averages and standard deviations of the posttest scores of each group regarding the Science Achievement Test are given in Table 3. One-way ANOVA was used to determine whether there was a significant difference between the groups. The findings related to the one-way ANOVA are given in Table 4.

Table 4. Findings related to the science achievement posttest of the students

Pretest	Study Groups	N	X	SD
TSMCQ	ABI	19	8.7	4.2
	ABI + Journal	26	10.1	4.6
	Control	25	8.6	4.6
TSOEQ	ABI	19	30.8	8.6
	ABI + Journal	26	33.7	8.6
	Control	25	16.9	5.7
TTS	ABI	19	39.5	10.7
	ABI + Journal	26	43.8	9.8
	Control	25	25.5	7.7

Table 5. Findings related to the One-Way ANOVA of the science achievement posttest

		Total Sum of Squares	Degrees of Freedom	Mean Squares	F	p	η_p^2
TSMCQ	Intergroup	31.116	2	15.558	.760	.471	.022
	Intragroup	1370.827	67	20.460			
	Total	1401.943	69				
TSOEQ	Intergroup	3625.022	2	1812.551	30.868	.000	.487
	Intragroup	3816.725	67	58.719			
	Total	7441.746	69				
TTS	Intergroup	4402.242	2	2201.121	25.128	.000	.436
	Intragroup	5693.710	65	87.596			
	Total	10095.952	67				

One-way ANOVA results revealed a significant difference among the posttest total scores of open-ended questions ($F(2, 69)=30.868$, $p<.01$) and test total scores ($F(2, 69)= 25.128$, $p<.01$) of the experiment groups and the control group. Post-Hoc Tests (LSD) were used to determine between which groups this difference occurred. The results of this test revealed a significant difference between the "ABI" group (M=39.50, SD=10.7) and the control group (M=25.50, SD=7.7) in favor of the "ABI" group, and a significant difference between the "ABI+ Journaling" group (M=43.80, SD=9.8) and the control group (M=25.50, SD=7.7) in favor of the "ABI+ Journaling" group.

Cohen's d was calculated to determine the effect size of the group independent variable on the dependent variables. The calculated Cohen's d values are interpreted according to Cohen's (1992) "d" index. Cohen (1992) identified certain breakpoints for the interpretation of d. The effect sizes between d= 0.2 and 0.5 are categorized as "small," as "medium" if they are between d= 0.5 and 0.8, and as "large" if they are d= 0.8 and above. If the effect size value has a minus sign it only determines the direction. In Table 6 below, the effect sizes among the total score of multiple-choice questions, the total score of open-ended questions, and the test total scores were determined.

Table 6. Comparison of the effect sizes of the groups

Test	Group	Group	d	Size
TSMCQ	ABI	Control	-0.07	Negative
	ABI + Journal	ABI	1.07	Large
	Control	ABI + Journal	0	Negative
TSOEQ	ABI	Control	3	Large
	ABI + Journaling	ABI	0	Negative
	Control	ABI + Journal	3.7	Large
TTS	ABI	Control	2.6	Large
	ABI	ABI + Journal	-1.4	Large
	Control	ABI + Journal	4.3	Large

Table 6 shows that the large effect between the "ABI + Journal group" and the ABI group in the total score of multiple-choice questions in the Science Achievement Test posttest is in favor of the "ABI + Journal group." In the total score of open-ended questions, the large effect between the ABI group and the control group is in favor of the ABI group. Similarly, the large effect between the "ABI + Journal group" and the control group is in favor of the "ABI + Journal group." A review of the test total scores of the test shows that there is a large effect between ABI and the control group. This effect is in favor of the ABI group. It can be concluded that the effect between the "ABI + Journal group" and the ABI group is large and this effect is in favor of the "ABI + Journal group." Similarly, there is a large effect between the control group and the "ABI + Journal group" and this effect is in favor of the "ABI + Journal group."

Semi-Structured Interviews

Interviews with the Experimental Groups

Various themes were created following an examination of the data obtained from the interviews. These themes are: Comparing the ABI approach and the traditional method, change in the student, journaling, teacher and student roles. Findings for each theme are given under separate headings. The themes, codes and frequencies resulting from the examination of the interviews are given in Table 7.

Table 7. Themes, Codes and frequencies resulting from the examination of the views of students on the practice of ABI and the journaling activity

Theme	Code	Frequency (%)
Comparing the ABI Approach and the Traditional Approach	A process that supports learning	5 (42%)
	Student activity	6 (50%)
	Ensuring permanent learning	6 (50%)
	Learning more than one information	3 (25%)
	Enabling discussion	7 (59%)
	Possibility of presentation	4 (34%)
	Preparing questions on their own	6 (50%)
	Approach preference	12 (100%)
Change in the Student	Being more attentive	3 (25%)
	Improved communication skills	6 (50%)
	Ability express themselves	3 (25%)
	Learning how to transfer information	4 (34%)
	Gaining critical perspective	5 (42%)
	Increasing self-confidence	6 (50%)
	Ability to interpret	5 (42%)
	Creativity	1 (9%)
	Inquiring	5 (42%)
	Better learning	12 (100%)
	Gaining the habit of writing	1 (9%)
	Gaining different perspectives	2 (17%)
	Taking responsibility	1 (9%)
Journaling	Transfer of information	3 (50%)
	Creating awareness	1 (17%)
	Ensuring learning	6 (100%)
	Ensuring permanence	3 (50%)
	Reinforcing knowledge	1 (17%)
	Inducing thought	1 (17%)
	Including sincerity/emotions and thoughts	5 (84%)
	Ability to interpret	2 (34%)
Teacher Roles	Questions	11 (92%)
	Transfers knowledge when needed	10 (83%)
	Summarizes at the end	1 (9%)
	Guides the discussion with questions	5 (42%)
	Critical	5 (42%)
	Supportive	3 (25%)
	Gives time to think	8 (67%)
	Listens	4 (34%)
	Supervisor	2 (17%)
Student Roles	Preparation before class	9 (75%)
	Active in class	4 (34%)
	Critical	2 (17%)
	Studies	3 (25%)
	Researches	5 (42%)
	Self-improving	2 (17%)
	Presenter	5 (42%)
	Discusses	4 (34%)

When the students compared the Science Teaching Laboratory class to the ABI approach and the traditional one, the topics they emphasized the most in the interviews were the discussions. They stated that in the previous years, they conducted experiments by following the steps laid out in the guides called "experiment sheets," that they reported the data without being sure if it was correct or not, and that they could not receive any feedback about it. The students said that this semester, they researched the subjects they were curious about, designed their experiments and conducted them in the laboratory, presented their experiments to other groups and discussed the subject matters. The Student with code S1 expressed the importance of the discussion in the ABI process with the following sentences: "*…We used to receive sheets titled "Experiment 1," "Experiment 2" We would only follow the directions on them. And then, we would make comments according to the results of the experiments. However, now we have discussions, talk to each other, and everyone participates in the dialogue. We learn many things instead of just one thing. Everyone conducts an experiment they are curious about and explains it in discussions. I think this approach is more informative. Also, we did not use to inquire into things in laboratory classes, but now, if we do not understand something, we can ask our questions during discussions. That way, information becomes more permanent."* Student coded S5 offered a similar statement and explained that the discussion opportunity ensured the information's permanence and improved their self-confidence.: *"…There was no discussion opportunity in the previous semesters. There were only individual groups. However, now we have large groups where we present our ideas. These groups ensure the permanence of information. Also, my self-confidence has improved, and I can now express my ideas more comfortably. I was not such an active person before.*" Student coded S6 mentioned that they learned by discussing the information during class and adopted this approach in their daily lives: *"...I have learned about the scientific discussion. I have learned how to handle a topic discussed outside of class when I go into a different setting. Conducting classes with this approach has taught me how to discuss if nothing else.*" These statements show that the discussion process positively affects students and improves their reasoning skills.

Students stated that they had learned the information better with the ABI approach and thought it had become more permanent. Student coded S4 described the process that shaped the information as it passed through various stages: *"… First, we research the subject. Then we determine questions according to our research. Then we look into those questions, and we do experiments. Then we discuss what we did with the groups and with you. Finally, we recall all the stages and report on them*.". Student coded S1 said that these practices made the knowledge they acquired more permanent: *"...In this way, information is more permanent, more memorable. It is a very instructive method…*"

In the semi-structured interviews, the students described the changes they had experienced in themselves as; being more attentive, improved communication skills, expressing themselves comfortably, learning how to transfer information, gaining a critical perspective, improved self-confidence, gaining the ability to interpret the ability of inquiry, adopting the habit of Writing, learning better, gaining different perspectives and taking responsibility. The students stated that this process increased their self-confidence and that they learned how to give criticism. The Student coded S5 stated these improvements: *"...I can now criticize all the groups. I do not know what the other party thinks about my idea; they might like it or not. That does not make me uncomfortable*." Students coded S12 stated that they gained a critical perspective and learned how to be more open to criticism in this process: *"...I have become a little more open to criticism. Because I was not open to criticism, I can now appropriately respond to criticism and properly criticize others.*" Student coded S6 gave a similar statement and summarized the changes in themselves: *"… I started noticing the things that I did not before in daily life. I used to think rather simply, but now I have a broader point of view. This process had great advantages for me in terms of expressing myself*." Another student, coded S3, said: "*… In the first week, I could not even articulate the things I knew during my presentation, but in recent weeks I have become so comfortable speaking that I can almost convince the class of anything I want. My self-confidence has improved... I have learned how to speak in front of a crowd*" stating that the process improved their self-confidence and communication skills.

Students coded S1 stated that they could view ordinary events from a scientific perspective and that they had become more attentive, describing the changes that the process has created in them with the following sentences: *"…I have become more attentive. My point of view has changed. I no longer say, ' The leaf is swimming in the water,' but I articulate, ' Because it has less density than water, it floats.' Also, I used to have no idea how to convey this information to my future students, but now I have learned how to do that, and I know the method of transferring information.*"

The students expressed the changes they had experienced as learning how to transfer information, increased awareness, better learning, the permanence of information, reinforced knowledge, thinking more, conveying sincere emotions and thoughts and gaining interpretation skills. Students coded S6 stated that they learned more quickly through Writing and that writing information down repeatedly while journaling was beneficial in terms of permanence of the information: *"... Writing helps me learn. I repeat everything as I write, and then I read it all. I check to see if the person reading it will understand it. I keep repeating those as I read. This repetition helps me to learn better.*" The same Student also said that journaling facilitated the transfer of information because it had room for emotions and thoughts and provided an intimate atmosphere. "*...I improvise as I write as if there is someone in front of me. I convey the information I have more comfortably in a conversational mood.*" The Student coded S4 made a similar statement: *"...I do not think journaling should be formal. I wrote comfortably and sincerely in light of my feelings and thoughts. That helped me learn.*" They added that they had found a way to transfer information while journaling by saying, *"...I have learned how to teach a subject to my students in a way that they can understand when I start teaching in the future. I came up with examples; I wrote stories. It has helped me improve.*" These comments show that the Student coded S4 was satisfied with this activity.

In light of the answers given by the students, the researcher examined the position of the teacher in the class in two categories passive and active. The teacher who gives students time to think to answer questions, listens to their presentations and observes them is passive in the classroom with these roles. The teacher who asks questions transfers information when needed, criticizes, guides the discussion with questions, supports the students during the discussion, summarizes the subject at the end of the class, and is active in the classroom with these roles.

Student coded S3 stated that the teacher visited the groups during small group discussions and gave the students time to think before answering questions posed: *"...You asked us questions, but did not want an immediate answer. You gave us around 10 minutes to think. Moreover, we tried to find the answers to your questions*." Another student coded S4 stated, *"...The teacher was like a supervisor. S/he corrected us whenever necessary. S/he also criticized us when necessary and asked us questions about our experiment set-ups. S/he never directly pointed it out if something was wrong*." The same Student also stated that the teacher gave directions that would make the students more active in the process.

"*I think it was completely a student-focused study. For example, when we created our set-ups incorrectly, s/he did not directly reject them. S/he made the students see it for themselves. S/he was thinking, 'Do it yourselves so you can learn.*" A similar statement was provided by the Student coded S2: *"...You criticized our questions, asking whether they were meaningful or not. You visited the groups and asked questions about the subjects and the experiments. I think that encouragement stimulated our prior knowledge. You gave us time to think about the questions you asked. Moreover, when we asked you a question, you would reply, 'I do not know; you can demonstrate that for us.' So, the goal was to keep us active throughout the process*."

Student coded S11 said, "*The teacher was an observer. S/he was trying to determine 'What are the students doing, how are they doing it, what are the misconceptions they have?' and trying to correct them by guiding us with questions. If s/he did not get an immediate response, s/he has the students some time to think. Moreover, they summarized the subject at the end of the class*" and emphasized that the teacher did not provide the information directly. However, that s/he tried to eliminate the students' misconceptions by asking them questions. Another student coded S6 said: *"… The teacher never told us we were wrong, even when we made mistakes. The teacher did not give us fish, s/he taught us how to fish*," emphasizing that the Student was at the centre the whole time and that the teacher was trying to teach them how to learn.

After the questions posed to the students by the researcher regarding their roles in the process, the students were found to have roles such as preparing before the class, actively participating in the class, studying, criticizing, inquiring, constantly improving themselves and participating in discussions. The sample statements of the students on this subject are as follows: S1: "*We read the theoretical information before the class, which probably will not be recalled the next day. However, we see and prove this information during the class, so it becomes more permanent.*" S4: "*The students do research before class. They do scientific research. Moreover, they conduct and present their experiments during class. So, they are presenters."* S6: "*Students improve themselves. They come to the class prepared. Moreover, they present their experiments*." S9: "...*We prepare before class to better grasp the theoretical subjects. We present what we did during the experiment to the class and try to reach the truth by discussing the points that draw criticism*." The students' statements showed that coming to class prepared is the most critical role the students have in the argumentation process. The Student coded S3 emphasized the importance of coming to class prepared by saying, "*One can always tell which Student is unprepared for the class. If the Student wants to learn something, s/he should study and be prepared for the class*." Similarly, the Student coded S7 said, "*If the Student comes to the class without having done any research, s/he cannot do anything during or after the class. S/he can learn a couple of things during discussions at the most. There is no point in coming to class if you have not done any research beforehand*" and underlined the importance of coming prepared for the class.

Interviews with the Control Group

Examinations of the data obtained from the interviews with the control group students revealed different themes. These themes are the course process and the roles of the teachers and the students. Findings related to each theme were examined under separate headings. The themes, codes and frequencies resulting from the examination of the interviews are given in Table 8.

Table 8. Themes, codes and frequencies resulting from the examination of the interviews with the students in the control group

Theme	Code	Frequency (%)
Course process	Using experiment sheets	6 (100%)
	Not providing permanent learning	6 (100%)
	Memorization	6 (100%)
	Easy experiments	3 (50%)
Teacher Roles	Supervisor	6 (100%)
Student Roles	Not preparing before class	5 (66%)
	Writing the report in class	6 (100%)

As a result of the interviews conducted with the control group students, they stated that the activities they performed using the traditional method were not really efficient and that achieving an obvious result did not facilitate learning more. The statement of the student coded S_{14} can be given as an example. *"…"We just do the experiment, we state everything that happened and move on.. But in the end, it does not give us anything else. It only provides us with verbal information."* Another student, coded S_{15} similarly stated that they would quickly forget what they learned: *"Since I study only for the exam, I forget the information once it is over."* The student coded S_{15} stated that the students did not come to class prepared most of the time, and the fact that the coursebook had all the steps that they needed to follow for the experiment made things easier for them. *"We were told a week in advance what experiments we were going to do. And the materials that we needed to use for the set-ups were all listed in the* *coursebook. We just bought them, set them up, and did the experiments. The result was already known, so we kept the experiment going until we reached that."* revealing that they conducted experiments based on memorization and results.

The students stated that the role of the teacher in the classroom in the traditional method, was more passive and that they needed the guidance of the teacher. *"I would like the teacher to go up to the board and explain things, to be honest. I would like to have some theoretical knowledge about the exam, the course of the experiments, and the application methods,"* said the student coded S_{16}, and added that they needed the teacher's knowledge and that learning from the teacher is the best way. *"That's the way it has always been. I expected the teacher to teach things."*

The control group students were briefly informed by the researcher about the ABI approach and asked whether they wanted the class to be conducted in this way. Student coded S_{14} stated that they would indeed prefer this method, saying, *"I would like to try that approach. Because I think it will help me learn more. I will do everything myself as if I am starting from scratch. I will learn by experience, without obsessing about whether it is right or wrong. I will enjoy that more."* The student coded S_{16} supported that statement and said that the efficiency of a discussion environment was the main reason for preferring the ABI approach. They said *"Mistakes can be detected more easily in a discussion environment. And that ensures better learning."*

DISCUSSION and CONCLUSION

The research was carried out to investigate whether there was a significant difference in the science achievement of groups of students in subjects taught with the ABI approach supported by a metacognition activity, taught by using the ABI practices alone, and the groups taught with the traditional approach. The results of the studies carried out with this purpose showed that the science achievement of students in a learning environment where the ABI approach was supported with a metacognition activity was higher than that of students in learning environments using a traditional approach and ABI practices. This difference between students was detected in line with the Science Achievement Test and student interviews.

Examination of the pretest findings revealed that the experimental and control group students had similar success levels at the beginning of the study. When the Science Achievement Test posttest findings were examined, it was concluded that there was a significant difference between the experimental and control groups' total scores on the open-ended questions and the total test score. The students in the experimental groups were found to be more successful than the control group students. This result is consistent with the opinions and studies of Keys et al. (1999), who stated that the ABI approach increased the concept learning levels of students at different grade levels.

ABI requires students to think, establish relationships between data, interpret data, and explain results by making connections between claims and evidence, which improves their high-order thinking skills (Kabataş Memiş, 2011). Since ABI, which can have all the effects mentioned earlier when used on its own, is considered to produce better results when supported by metacognition activities, journaling activity was added to ABI practices in the study. Many studies show that ABI practices create significant differences in the posttest scores of students (Akkus et al., 2007; Hand and Keys, 1999; Hohenshell & Hand, 2006). The results of those studies can be said to be consistent with the results of our study.

There was no statistically significant difference in science achievement between the experimental group where argumentation practices were supported with metacognition activity and the experimental group where argumentation practices were done independently. However, in terms of group averages, it was concluded that the average science achievement of the experimental group, where journaling activity was used, was higher than the science achievement of the group where only argumentation practices were performed, and that metacognitive activity had a positive effect.

There is a connection between learning, a mental activity, and writing (Emig, 1977). Writing has always been essential for individuals to convey their ideas about science. Writing practices can serve as a means of learning for both the writer and reader (Klein, 2000). While writing practices incorporating traditional approaches ensure that the existing information is repeated and transferred to the paper, those using contemporary approaches enable the information to be handled from different perspectives. During the ABI process, where students actively use writing practices, they can revise the information and make sense of it before using it. Expressing opinions and thoughts in writing requires being mentally active. Expressing things in writing facilitates the definition of problems, mental interpretations, reasoning, making inferences and expressing oneself better (Doğanay & Ünal, 2006). Writing helps students improve their high-order cognitive skills, better understand their learning methods and develop their metacognition awareness regarding learning strategies (Prain & Hand, 1999). This ABI process, supported by metacognition activity, will considerably increase learning efficiency. The argumentation process is an application that activates the cognitive and metacognition mechanisms with language practices (Günel et al., 2010). Therefore, supported by writing activities, the ABI approach will increase the success rate even more.

In the interviews, the students emphasized that they were constantly interacting with their peers throughout the ABI process, that they learned what they did not know from each other, they had the opportunity to think more about the subjects by doing experiments on them, and that they tried to find answers to their questions through discussions inside and among the groups. Students gained the ability to inquire more because they were constantly experiencing a reasoning process during ABI practices. Students go through an inquiry-based discussion process and actively learn science concepts with the claim-evidence construct. During the interviews, the students stated that they were looking for answers to their questions and were active in the process. In the traditional approach, the students stated that they carried out the experiments assigned to them by rote, following the exact order of the necessary steps, that they were aware that they would reach an already-known result, and that it did not make the lesson attractive to them. The students also stated that the information they learned with the experiments they carried out by following the book was not very permanent and that they could not learn very well. These statements showed that those activities included in the traditional approach were inadequate in learning the information and that the permanence of the information learned was lower.

Students experience a scientific discourse during the ABI process. Discourse, which has an important place in the creation of scientific information, includes the interpretation made by students regarding alternative explanations, their reasoning about which of these explanations they prefer and why they prefer them. Throughout the discourse, students achieve a more precise conceptual understanding by challenging their peers, expressing their doubts, offering alternatives, and evaluating options (Driver et al., 2000). In this study, students actively participated in learning and structured the concepts with their peers. In addition, dialogues that the students participate in as part of the discourse activities are a powerful tool for developing high-order thinking skills (Erduran et al., 2007). The ABI process provides students with the opportunity to construct rich field knowledge and help them gain scientific literacy skills, which are frequently emphasized by national and international standards (Hand et al., 2004). This approach also provides access to cognitive processes, aims to develop students' critical thinking and communication skills, improves scientific literacy, encourages students to speak and write, creates a scientific culture, and enables students to socialize and develop their inquiry skills (Newton et al., 1999).

Experimental group students stated that they experienced specific changes at the end of the process, which was in the desired direction. The students who have stated that they have experienced positive changes in speaking in front of a crowd, expressing themselves, and defending an idea in line with certain principles, which show that they have gained self-confidence, a sense of responsibility, and a critical point of view. We can also conclude that the students in the ABI group who also did journaling activity are better able to express their feelings and thoughts thanks to journaling. Because putting information down on paper while revising helps them see how they can explain a subject more efficiently and increases their sense of responsibility. In addition to the ABI process and the student's writing and speaking, journaling activities enable them to express information differently, ensuring deep conceptual learning (Hand et al., 2004).

Since the students went through a continuous reasoning process, we can conclude that they have gained the ability to inquire. Awareness of the changes in themselves enabled the students to use their metacognition skills. Journaling, a metacognitive activity, is essential in enabling students to think more deeply about a subject and how they can convey it better. When students try to convey scientific concepts related to a subject, they have to mould it into a form that the reader can understand, which is the daily language used in everyday life. This effort stimulates metacognitive thinking (Wallace & Hand, 2004). Students revise information through writing. They can also find the opportunity to evaluate themselves within the process through self-evaluation. During the interviews, the students stated that self-evaluation helped them realize their deficiencies and positively move the process and their learning.

In conclusion, using the ABI approach in learning environments facilitates conceptual learning and the development of higher-order thinking skills. The benefits provided by the ABI approach should be used more in educational environments, and students should be able to experience this process frequently. Using the ABI approach in science classes improves students' positive attitude towards science, helps them achieve more meaningful and permanent learning, and teaches them to respect and care about other ideas. ABI activities improve problem-solving, decision making and critical thinking skills and encourage high-order thinking (Hand, 2008). With the help of ABI activities, individuals achieve significant outcomes academically and for use in daily life. Metacognition, essential for science learning, is an important dimension of scientific literacy (Ulu & Bayram, 2014). Reading and writing activities that facilitate information structuring depend on metacognition, one of the most critical components of scientific literacy. Günel et al. (2010) stated that ABI is an approach that activates cognitive and metacognition mechanisms with language practices in inquiry-based learning environments. It can be concluded that laboratory work supported by metacognition activities is more successful than performing it with classical approaches and methods. In light of these results, we can say that popularizing the ABI approach and the ABI supported by. Metacognition activities are critical in raising individuals who are self-confident, self-improving, actively learning and able to use language more competently.

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Statements of publication ethics

We hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

Researchers' contribution rate

The study was conducted and reported with equal collaboration of the researchers.

Ethics Committee Approval Information

Ethics Committee Approval is not required since the data of the our article is before 2020.

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