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The Effect of an Argumentation-Based Inquiry Approach on Students' Academic Achievement and Analytical Thinking Skills

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Abstract

This study aimed to investigate the effects of the argumentation-based inquiry (ABI) approach on the analytical thinking skills and academic achievement of seventh-grade students using a mixed method. It was conducted in a secondary school in the Western Black Sea region of Turkey with seventh-grade students from two classes during the fall semester of the 2021–2022 academic year. Unit-based achievement tests, analytical thinking scenarios, and semi-structured interviews were used as data collection tools. The findings show that the application of the ABI approach in science classes is effective in improving the academic achievement of students. According to the analytical thinking test findings, a significant difference was found in favor of the experimental group in the post-test. The evaluation of the quantitative and qualitative findings revealed that the ABI approach used in science lessons had improved the analytical thinking skills of the experimental group students.

Keywords: ABI, Argumentation, Analytical thinking skills, Inquiry, Science education

Introduction

Today, interest in 21st-century skills is increasing. These high-level skills, which make it possible to adapt to the era we live in, are also very important for our lives. High-level thinking includes detailing any given material, making inferences, discovering the statements behind the given, making meaningful representations, analyzing existing relationships, and establishing relationships between parts (Resnick, 1987). In short, the thinking skills that an individual uses when deciding what to believe and do are defined as higher-order thinking skills (Ennis, 1985).

Higher-order thinking skills include many cognitive activities such as reasoning, reaching a judgment, struggling with uncertainty, flexible thinking, and being open-minded (Çakır, 2013). The individual uses higher-order thinking skills while deciding what to do or what to believe (Ennis, 1985). Skills such as analytical thinking, critical thinking, problem solving, and decision-making are among the high-level thinking skills that are effective in gaining 21st century skills (Ezberci Çevik, 2021). Among these skills, analytical thinking has a very important place (Amer, 2005). Analytical thinking is a life skill that is very important to develop considering the learning process (Ramdiah, Mayasari, Husamah, & Fauzi, 2018).

Analytical thinking is generally defined as being able to examine an object, story, event, or situation from different aspects, breaking it down into meaningful parts, identifying the relationships between these parts, classifying them, and determining cause-and-effect relationships (Bloom, 1956). Looking at the expressions in the basic definitions in the literature, analytical thinking means being able to separate a whole into its parts or elements, to be able to determine the relations between parts, to deal with the whole in different aspects, to classify the given or obtained information according to various criteria, to distinguish the relevant or important among the given or obtained information, to organize the information within a certain logic, to be able to compare and contrast two or more things, to evaluate the characteristics of something, criticize, generalize and customize, determine the main view on which the existing claim is based, identify the side ideas that support the main idea and evaluate its accuracy, assumptions, their bias, an unspecified point of view, being able to identify bias or intent, inference, making sense, to make a judgment, being able to choose the right one for solving a

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problem, being able to make an effective evaluation is defined as being able to evaluate the reasoning (Akkuş & Senemoğlu, 2021).

Analytical thinking skills have a very important place in education. Education aims to enable individuals to access correct information by using scientific processes correctly and to use this information effectively. The scientific process can simply be defined as individuals' observing, defining, and testing the events they describe (Carey, 2011). Analytical thinking is a necessary way of thinking so that individuals can make relevant observations, reveal the relationships between the parts, and understand the role of each part in the whole (Sartika, 2018). Providing students with analytical thinking skills in the educational environment contributes to students becoming good problem solvers, decision makers, and individuals with lifelong learning skills (Schwab & Samans, 2016).

The main way to increase analytical thinking skills in science classes is through the development of inquiry skills (Ocak & Akkaş Baysal, 2021). It enables individuals to develop explanations for these questions by being directed to questions that have a scientific focus in inquiry and to formulate these explanations after collecting evidence to defend their explanations (National Research Council (NRC), 2000, p. 19). Individuals who have gained research-inquiry skills effectively use some high-level skills such as analysis, synthesis, and evaluation in this process (Ocak & Akkaş Baysal, 2021). Therefore, analytical thinking skills are closely related to the concept of inquiry. In addition, in science classes where research and inquiry-based applications take place, students have the opportunity to discover new information like scientists by being included in the learning process (Hand, 2008). The purpose of inquiry in science education is to provide correct preliminary information and effective learning environments, enabling individuals to assimilate and construct information (Kabataş Memiş & Çakan Akkaş, 2016).

One of the research-inquiry-based applications is argumentation. Argumentation, which is based on inquiry, includes the process of making claims about a situation, supporting or refuting claims with evidence, and establishing logical relationships between events and ideas (Duschl & Osborne, 2002). Osborne, Henderson, MacPherson, Szu, Wild, and Yao (2016) stated that argumentation is a central feature of science.

While learning science, students should be given the opportunity to learn about science concepts as well as gain insight into the epistemology of science, its applications and methods, and its nature as a social practice through science studies (Newton et al., 2000). In this respect, argumentation applications and pedagogies that encourage argumentation, which are of central importance for both education and science, also form the basis of an effective education in science (Newton et al., 1999). Since the argumentation-based science learning approach, by its nature, involves students' thinking, creating reasons, and collecting evidence for these reasons, students' ability to identify the relationship between claims and justifications, evaluate justifications, and analyze by presenting evidence has the potential to develop analytical thinking skills. In this context, it is thought that students' analytical thinking skills will develop in science classes where the ABI approach is applied. Therefore, in this study, it is aimed at improving the academic achievement and analytical thinking skills of students by using the ABI (Argumentation-Based Science Learning) approach.

Theoretical Framework

Analytical Thinking

Analytical thinking is defined as handling any object or event with different aspects, separating it into parts, detecting relations between parts, classifying, determining cause-and-effect relationships, understanding the reason for established relationships, and associating with each other (Bloom, 1956). Analytical thinking is a powerful thinking tool that can be used to understand the parts of a situation (Amer, 2005). Elder and Paul (2019) stated the basic stages of analytical thinking as follows to guide individuals' effective analytical thinking: thinking about the purpose, defining or stating the question, collecting information, checking inferences, checking assumptions, explaining concepts, being aware of personal perspective, and thinking about results.

Analytical thinking skills have a very important place in science education. One of the most important courses in which analytical thinking skills can be developed is science. Through this course, individuals with analytical thinking skills should be involved in every sense of society, and this understanding should be adopted in all courses together with the science course (Bozkurt, 2022). In this context, analytical thinking as one of the life skills that should be taught to students in the science curriculum has taken its place in the science curriculum as of 2013 and has been clearly stated in the curriculum that entered into force in 2018 (MNE, 2013, 2018, p. 9). It is very important that students gain analytical thinking skills, which are seen to be more popular in our country with their inclusion in the curriculum (Bozkurt, 2022).

Argumentation-Based Science Learning (ABI) Approach

Hand and Keys (1999) developed the ABI (original name: Science Writing Heuristic) approach in order to define the structure of scientific arguments in education and to develop them in education. ABI guides teachers and students in thinking and writing while encouraging thinking, understanding, discussion, and writing on a series of activities done in the science laboratory (Hand et al., 2004).

The ABI approach is frequently used in science classes as an inquiry- and writing-based approach (Sönmez et al., 2021). ABI is an inquiry-based approach that enables students to actively engage in conceptual learning by conducting research in a laboratory environment (Hand, 2008). ABI is a tool for both teachers and students to think in more detail and to construct knowledge by questioning. To ensure the effective use of this tool in the classroom, Hand and Keys (1999) developed separate templates for teachers and students (see Table 1). The teacher template, which consists of some suggested activities that address students' meaningful thinking, writing, reading, and discussion skills, offers the teacher the opportunity to develop different activities in the process (Sönmez et al., 2021). The student template helps students systematize their explanations in the process of asking questions, linking claims with evidence (Hand & Keys, 1999).

Table 1. ABI teacher and student template (Hand and Keys, 1999)

ABI part I: a template for teacher-designed activities to promote laboratory Understanding	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 posing 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., a presentation to a larger audience)	7. Reflection: How have my ideas changed?
8. Exploration of post-instructional understanding through concept-mapping	

It is important that teachers create a learning environment suitable for the ABI approach in science lessons. Because unlike the traditional approach, in ABI, the student is at the center of the learning process. Thus, the role of the teacher in the lesson moves away from the center and changes into the learner position with the student in the process (Hand, 2008).

The aim of the ABI approach is to involve the student in the learning process as much as possible. Contrary to the traditional approach throughout the process, the student actively constructs knowledge (Çakan Akkaş, 2017). From this point of view, this study is aimed at improving the academic achievement and analytical thinking skills of students studying in science classes based on the ABI approach. The research questions are given below:

1. Is there a difference between the academic success of students studying in science courses based on the ABI approach and the academic success of students attending science courses based on the traditional approach?
2. Is there a difference between the analytical thinking skills of the students studying in science courses based on the ABI approach and the analytical thinking skills of students attending science courses based on the traditional approach?
3. What are the students' views on the application of the ABI approach in science classes?

4. Is there a correlation between the analytical thinking skills and academic success of the students studying in science courses based on the ABI approach?

Method

Design

In this study, a mixed-methods approach, which includes both qualitative and quantitative approaches, was used. Mixed methods research is a research approach in which the researcher's quantitative and qualitative data or techniques are combined or mixed in a single study or series of closely related studies (Christensen et al., 2020). The mixed-methods researcher chooses a pattern that reflects interaction, priority, timing, and incorporation at the decision stage (Creswell & Plano Clark, 2020). In this study, a nested mixed method design was used in terms of suitability for the purpose. The nested mixed pattern is a large pattern that allows data to be gathered together in qualitative and quantitative patterns (Mazlum et al., 2017). The quantitative aspect of this research is based on a quasi-experimental design with a pretest-posttest control group. The qualitative aspect is based on the case study, which includes semi-structured interviews with students at the beginning and end of the process.

Participants

The study was carried out in the fall semester of the 2021–2022 academic year with two different 7th graders studying with a teacher in a boarding primary school affiliated with the National Education System in the Western Black Sea Region. A total of 29 students (11 girls and 18 boys) participated in the study, including 17 students (5 girls and 12 boys) from the control group and 12 students (6 girls and 6 boys) from the experimental group. The environment of the school where the students study, and therefore the students, is at a low level of economic income. The majority of the students participating in the study come from the surrounding villages. One of the 7th graders constituting the participants was randomly determined as the control group and the other as the experimental group for the ABI application.

Procedure

The study was carried out within the scope of a science course at a boarding school in the Western Black Sea region in the fall semester of the 2021–2022 academic year. The study was carried out during a 6-week course in the units of force and energy. Two branches, an experimental and a control group, were determined for the study. Before the application, an academic achievement pre-test and an analytical thinking skills pre-test were applied to both the experimental group and the control group.

Students in the application group have done six ABI activities (I am interpreting the table; mass or weight; is it work or not; solving the mystery of Kinpot; designing a ship or airplane; where is air resistance) in their science lessons. For each activity, ABI students reported their activities individually using the template. During the application, the materials that were thought to be used by the students in their experiments were provided by the researcher.

The control group students expressed the traditional approach: they studied in an environment where the teacher is the narrator and gives the information directly, the student is the listener, the teacher answers questions from time to time, the subject is followed from the textbook, and the end-of-chapter questions are solved as an individual activity. The control group students did not do any activities individually or as a group.

Data Collection Tools and Data Analysis

A unit-based achievement test, scenarios prepared for analytical thinking skills, and semi-structured interviews with students were used as data collection tools.

Unit-based achievement test

The unit-based achievement test consists of a total of 24 questions: 20 multiple-choice and 4 open-ended questions prepared for the Force and Energy unit. Multiple-choice questions were prepared by the researcher by using the outcome assessment tests prepared by the Ministry of National Education and questions appropriate to the subject of the study from the question banks at the grade level. Open-ended questions were prepared to measure the concepts that students learned about the unit in depth. The prepared test was evaluated for internal

reliability and validity by four experts in the field. With this evaluation, it was taken into account that the questions in the test should be clear so that the students could understand and serve their purpose, that the visuals should be suitable for the knowledge in the subject area, and that they should be aimed at the targeted acquisitions in the 7th grade science curriculum. At the end of the examination, the changes requested by the experts were made. After the evaluations, a reliability analysis was performed, and a question that greatly reduced the reliability was removed from the test. The final Cronbach's alpha reliability coefficient was determined to be 0.724.

40 minutes for students to answer the test at the given time. There are two types of questions in the test: multiple-choice questions and open-ended questions. Separate scoring keys were used for multiple-choice questions and open-ended questions. The answer key for all questions was prepared by the researcher. In scoring the questions, a teacher was asked to evaluate the answers of three different students for the reliability of the scoring. At the end of the evaluation, it was determined that no errors were found. In order to determine whether there is a significant difference between the scores obtained before the study and the scores after the application, a pre-test-post-test application was carried out.

First of all, it was determined that the data obtained from the unit-based achievement test did not show a normal distribution in the normality tests. The non-parametric Mann-Whitney U test, which can be an alternative to the t-test for unrelated samples, is applied in cases where the data do not show a normal distribution, the number of data is low, and the data are not at least on the interval scale (Can, 2020). For this reason, the Mann Whitney U test was used to determine whether there was a difference between the students' academic achievement pre-test and post-test scores in terms of groups.

Analytical thinking skill scenarios

The development process of the analytical thinking skill test started with a literature review. Existing analytical thinking skills tests were examined, but a test that could be applied to secondary school students could not be determined. In this context, the scenarios developed by Çakır (2013) were used in the measurement of analytical thinking skills, and within the scope of this study, scenarios at the secondary school level were prepared. In these scenarios, students were asked to analyze information, comments, and/or inferences in a given text. Moreover, they were expected to discuss the extent to which the defended idea was logical and to express their own ideas by providing grounds rather than summarizing the information in the text.

After the scenarios were prepared, two faculty members working on the measurement of analytical thinking skills and experts in their fields were asked to evaluate them for reliability and validity. In line with the feedback from the experts, corrections (spelling errors and mistakes in sentence structures, correct reflection of possible alternative thoughts) were reviewed, and errors were corrected. In addition, the logical errors in the texts were revised in line with the expert opinion and revised twice by the experts. In the scenarios, the students were asked not to examine how the discussions in the given text were developed, the cause-and-effect relationships, the connections between the discussions, whether the given examples supported the discussion, or if there were any inconsistencies or logical errors. They were given 50 minutes to write an essay expressing their views. In order to measure analytical thinking skills, three scenarios have been developed that consider that lightning can strike the same place twice, bats are not blind, and when worms are divided into two, two new worms do not form. While choosing the topics selected in the scenarios, the topics that contain inconsistencies, logical errors, and people's knowledge and beliefs that are weak in terms of scientific basis were chosen. The reason for choosing such topics is to determine whether the student can correctly evaluate the discussion given in the text by using analytical thinking skills. A short excerpt from the analytical thinking scenarios is given below.

There are also different beliefs about lightning among the people. The most well-known of these is the idea that a lightning bolt will not strike the same place twice. Because people believe in this idea, they easily use areas that have been struck by lightning before. This is why people choose open and flat areas for picnics. A team of physicists at the international level collected and analyzed data on many lightning events and observed that lightning strikes in different ways according to their loads, leaving distinctive traces and even falling on the same place several times.

Then, the pilot application of the scenarios was carried out. For this application, two students were asked to explain what they understood from the scenarios, and whether the scenarios were understood correctly or not was evaluated with the help of the students. As a result of the reliability analysis performed to determine the reliability of the scale, the Cronbach alpha coefficient was determined to be 0.874. After the scenarios took their final form, they were applied before and after the implementation.

The Analytical Thinking Skill Rating Key prepared by Çakır (2013) was used in the analysis of the data obtained from the analytical thinking skill scenarios. It was taken into account how clearly the students expressed the main idea in the compositions they wrote, how they developed and organized their ideas, presented the supporting ideas, and whether they concluded the analysis by evaluating them effectively. The data were scored in accordance with the scoring key. The scoring keys are given below.

	3	2	1	0
Identifying the Main Idea	Expressed fully and completely	Partially expressed	Very expressed	poorly Misrepresented
Revealing relationships between main ideas and side ideas	Expressed fully and completely	Expressed fully and completely	Very expressed	poorly Misrepresented
Find principles for combining elements	Expressed fully and completely	Expressed fully and completely	Very expressed	poorly Misrepresented
Come to a conclusion	Expressed fully and completely	Expressed fully and completely	Very expressed	poorly Misrepresented

It was determined that the data obtained from the analytical thinking test did not exhibit a normal distribution in the normality tests. The non-parametric Mann-Whitney U test, which can be an alternative to the t-test for unrelated samples, is applied in cases where the data do not show a normal distribution, the number of data is low, and the data are not at least on the interval scale (Can, 2020). For this reason, the data obtained from the analytical thinking pre-test and post-test were analyzed with the Mann-Whitney U test.

Semi-structured Interviews

Within the scope of this research, semi-structured interviews were conducted with the 7th grade students in order to examine the students' perceptions of the science lesson and their analytical thinking skills. A total of two interviews were conducted, at the beginning and at the end of the study.

Questions were prepared for the purposes specified by the researcher. During the preparation process of the questions, the literature was searched, the interview questions about analytical thinking and the ABI process were examined, and care was taken to prepare questions that could reveal both situations and the relationship between them. After the interview questions were prepared, a pilot application was made to evaluate the clarity of the questions and their suitability for the purpose, and then the necessary corrections were made. After the pilot application, the questions that were difficult for the students to understand were simplified and made more understandable. At the beginning of the study, preliminary interviews were conducted in order to determine the perceptions of the students towards the science lesson and their analytical thinking skills before the applications. After the implementations, final interviews were held and audio recordings were made in order to get the opinions of both groups on the process and to reveal the effect of the process on their analytical thinking. At the end of the study, interviews were conducted with a total of six students: three from the experimental group and three from the control group.

Experimental group students were coded as SE1, SE2, and SE3, and control group students were coded as SC1, SC2, and SC3. The recorded interview data were transcribed by the researcher and converted into written documents. Then, the written data was read repeatedly, and a new code was created for each different situation encountered. After the researcher completed the coding process, the reliability and validity of the codes were evaluated by an expert. After the coding process, categories and themes were created based on these categories. Thematic analysis was used for data analysis. The analysis process has an inductive point of view.

Results and Discussion

Quantitative Findings

Findings from the unit-based achievement test

Pretest findings

According to the results of the Mann Whitney U test, which was conducted to determine whether there was a difference in the academic achievement pre-test scores of the students in terms of the groups, no significant difference was observed between the experimental group and the control group ($U=100.500$, $p>0.05$). That is, the groups are equivalent at the start of the application. The results of the analysis are given below.

Table 2. Unit-Based Achievement Pre-Test Analysis Results

Group	N	Rank Average	Sum of rank	U	p
Experiment	12	15,13	181,50	100,500	0,947
Control	17	14,91	253,50		

Post-test findings

According to the results of the Mann Whitney U test, which was conducted to reveal whether there was a difference in the academic achievement post-test scores of the students in terms of the groups, it was determined that there was a statistically significant difference ($U=33.500$, $p<0.05$) between the experimental group and the control group in favor of the experimental group. The results of the analysis are given below.

Table 3. Unit-Based Achievement Post-Test Analysis Results

Group	N	Rank Average	Sum of Rank	U	P
Experiment	12	20,71	248,50	33,500	0.002
Control	17	10,97	186,50		

*Findings from the analytical thinking skill test**Pretest findings*

The p value obtained from the Mann-Whitney U test, which was conducted to determine whether there was a significant difference between the pre-test scores of the experimental and control groups, was determined to be 0.162. There was no significant difference between the pre-test average of the experimental group and the analytical thinking skill test scores of the control group ($U=71$, $p>0.05$). The analysis results are given in the table below.

Table 4. Analytical Thinking Skill: Pre-Test Analysis Results

Group	N	Rank Average	Sum of Rank	U	P
Experiment	12	17,58	224,00	71	0,162
Control	17	13,18	211,00		

Post-test findings

As a result of the Mann-Whitney U test, posttest scores show that there are significant differences between the groups in favor of the experimental group in the posttest total scores ($U=45$, $p<0.05$).

Table 5. Analytical Thinking Skill: Post-Test Analyze Results

Group	N	Rank Average	Sum of Rank	U	P
Experiment	12	19,71	236,50	45	0,012
Control	17	11,68	198,50		

Findings on the Relationship between Analytical Thinking Skills and Academic Success

A correlation analysis was performed to determine whether there is a relationship between analytical thinking and achievement test scores. The simple linear correlation procedure performed to reveal whether there is a relationship between students' academic achievement and analytical thinking skills shows that there is a positive and significant relationship between academic success and analytical thinking ($r=0.542, p<0.01$).

The variance explained by the variables in relation to each other is 30%. In other words, 30% of the change in academic achievement may be due to analytical thinking skills.

Table 6. Analytical Thinking Skill-Academic Achievement Relationship Analysis Results

	Analytical Thinking	
Academic Achievement	Pearson r	,542**
	p	,002
	N	29

Qualitative Findings

Control group interview findings

Pre-interview findings

In the interviews with three randomly selected students from the control group, they stated that the students liked science subjects and experimentation, and they liked the science lesson because they learned through it.

The students defined the science lesson as a lesson environment in which the content is transferred and the question solution is made. They stated that while the teacher is in the role of conveying the content, the student is also in the role of listening, studying, and being aware of their responsibilities. Interviewed students stated that they like group work, doing homework, and doing research. While using the internet as the main source of information, they also benefit from peers, family, the internet, and books when deciding on the accuracy of this information.

For students in the decision-making process, it was determined that the students did not consider the options, although they thought about the situations in an orderly and solution-oriented manner. In addition, it has been determined that the students are based on specifying the feature of the criterion and determining the person suitable for the criterion while thinking analytically.

If evaluated in general, the control group students love science because it enables them to experiment and learn; the content of the science lesson is transferred; the question solution is done; the teacher is in the role of conveying the content; the student is in the role of listening to the lesson; the student is in the role of studying group work, homework, and researching; it has a profile that uses the internet as a source and makes use of peer and authority when deciding on the accuracy of information. Looking at this profile, it can be said that the students have a profile based on the traditional approach. Students do not consider the options while making a decision; they only aim to reach a solution by listing the situations. In the analytical thinking process, they tried to specify the feature of the criterion and determine the person suitable for the criterion.

Post-interview findings

When the data obtained from the post-interview interviews with three randomly selected students was analyzed, the students stated that the science lesson was structured so that the questions were written and the questions were solved. They stated that the teacher solves questions, makes explanations, and experiments during the lesson, and the student is in the position of writing and studying. In short, the reflections of the traditional approach are seen in the last interviews with the control group students, as well as in the preliminary interviews. For the decision-making process, reviewing and criticizing options has been effective. When the answers given for the analytical thinking skill were analyzed, it was determined that only one student was based on the features of evaluating the options and making validation. Contrary to the pre-interview, principles such as determining the feature of the criterion and evaluating compliance with the criterion were not encountered in the post-interview interviews. Analytical thinking themes and codes for the control group are given in Table 7 below.

Table 7. The analytical thinking theme and codes of the control group

Theme	Code
Analytical thinking	Criticizing the options
	Justifying or strengthening the claim
	Provability
	Verifiability
	Decision-making

The control group students made statements about the decision-making process in the interviews. Then comes the code of criticizing the options, strengthening or justifying the claim, and proving its provability and verifiability. One student could not answer the question for discussion. The students in the control group did not mention the arguments that make the discussion strong, and they did not fully understand and express the elements that make up the discussion and the ideology of the discussion. An example dialogue reflecting this situation is shared below:

Researcher : *When arguing with your friend on any subject, how do you determine who is right and who is wrong, or who is more correct?*

S_{C1} : *I first find out who is right and who is doing what. Ask each other what happened. By understanding their purpose. By understanding why they are fighting. If it was a lesson-related thing, I would look at the book and ask you. I'll see your ideas. I see who is right and who is wrong. I decide based on what I learn.*

Moreover, in addition to the fact that students do not understand the discussion process, it is seen that the reliability of the information is not based on scientific foundations and that there are associations with the sense of mutual trust mentioned in human relations, and this situation causes them to move away from the discussion process in their evaluations. An example of a dialogue reflecting this situation is given below. It has been determined that the students think authority-based in the decision-making process and that they cannot reach their decisions on their own. For example, a student made the following statement reflecting this situation: "*I will research it first. If I haven't come across it after searching, I'll ask my teacher.*"

Researcher : *When arguing with your friend on any subject, how do you determine who is right and who is wrong, or who is more correct?*

S_{C2} : *I trust whoever is more reliable. There is another thing. But he can use my trust.*

Research : *How do they ensure this reliability?*

S_{C2} : *They are telling me the truth. They're being honest.*

Findings of the Experimental Group

Pre-interview Findings

In the interviews, when the answers given by the students to the questions about determining their attitudes towards science were analyzed, three students stated that they liked the science lesson. Students stated that the reason for liking the science lesson is that it is fun and provides access to information.

In the interview, the students explained the structure of the science course. It has been determined that they consider it a lesson environment where content is transferred and question solutions are made. In addition, they expressed the role of the teacher in the science lesson as conveying the content, and the role of the student as listening to the lesson, not angering the teacher, and being aware of their responsibilities. In addition, all of the students stated that they like group work, doing homework, and doing research, and that they especially benefited from the internet and reading as sources of information in this process. It is seen that they state that they are sure of the accuracy of the information obtained by comparing it with the internet, reading, and any authority.

Regarding the decision-making process, in any situation, it is seen that the students list the situations in the decision-making process, follow a solution-oriented path, but cannot fully evaluate the options. As for the analytical thinking skill, it is seen that the students are based on determining the feature of the criterion to be selected and the suitability of the person to the criterion, and they make justifications in this process.

In general, the experimental group students love the science lesson as it provides fun and access to information before the application, interprets the science lesson as a lesson environment where the content is transferred and

question solutions are made, keeps the teacher in the position of giving the lesson and the student listening to the lesson, loves doing group work, homework, and research, has a profile that uses the internet as a source of information, reads heavily from these sources, and is sure of the accuracy of the information from these sources. This profile represents the student profile in classes based on the traditional approach. Students try to choose the person who is suitable for the criteria, who can list the situations but cannot evaluate the options while making a decision, and who determines the characteristics of the criteria in the analytical thinking process by giving reasons.

Recent interview findings

When the data obtained from the interviews made with the experimental group students after the application were analyzed, they expressed the structure of the science course as a classroom environment in which writing and experiments were conducted. Regarding the difference between the lessons taught for the ABI process and the lessons before the application, they stated that this process provides learning, understanding, and explanation, facilitates learning, and is different from other lessons in terms of group work and discussion. While two students stated that they had difficulty adapting to the ABI process, they added that they adapted to this process over time. In addition, the students positioned the teacher in a position that asked questions and made the students think about the ABI process. In their statements, they emphasized that the student is in a position to write a report, share information, and interpret or discuss this process.

In general, when the pre- and post-interviews are evaluated together, they state that the experimental group students moved away from the traditional approach in the pre-test; they used statements about the research-inquiry approach that was dominant in the ABI process; they took the accuracy of the information and its support with justifications as criteria in the process, especially when making claims; they could not always reach a common decision in small group discussions, but they could not always reach a common decision in the continuation of the process with discussions or questions. It is seen that they express that they have reached a common decision by developing a strategy. It was determined that, especially during the large group discussions, the students questioned the ideas of other groups, asked for justification when they were confronted with a group with a different claim in these inquiries, and emphasized that this process provided peer teaching. Moreover, with these applications, the students understood the concepts more easily, learning took place, and they developed a positive attitude towards science.

Regarding the decision-making process, it is seen that at the end of the process, the students criticize the options and take their demonstrability as a basis. For analytical thinking skills, they specified criteria such as criticizing options, seeking provability, and justifying the claim. This situation can be evaluated as a reflection of inquiry on students' analytical thinking skills. The analytical thinking themes and codes of the experimental group are given below.

Table 8. The analytical thinking theme and codes of the experiment group

Theme	Code
Analytical thinking	Evaluating evidence
	Criticizing the options
	Justifying or strengthening the claim
	Provability
	Verifiability
	Decision-making

At the end of the interviews with the experimental group, the students emphasized processes such as evaluating the evidence, justifying or reinforcing the claim, provability, and verifiability, as well as using expressions for criticizing the options and making decisions. In addition, students were asked to evaluate the elements that make a discussion powerful. This is SE2's statement, "*The opinion is true; anyone can prove it,*" and SE3's, "*We have to present a claim first. Then we need to have reasons to make this claim. For example, if I have presented a claim to you, I need to strengthen it with my justifications.*" In addition, the experimental group students especially expressed the importance of presenting evidence in any discussion and emphasized the importance of this evidence in the process of persuading the other party. Below is a sample dialogue that reflects this situation:

Researcher : *When arguing with your friend on any subject, how do you determine who is right and who is wrong, or who is more correct?*

SE2 : *I'll prove it. I'll say it's wrong. If he is like Samet. When Samet was offended by us, he did not agree with our opinion. We tried to persuade Samet first.*

Add results and findings here. Add results and findings here. Add results and findings here. Add results and findings here. Add results and findings here. Add results and findings here. Add results and findings here. Add results and findings here. Add results and findings here.

Discussion and Conclusion

The main purpose of this study is to examine whether the application of the ABI approach has an effect on the academic success and analytical thinking skills of 7th grade students. As a result of the study carried out for this purpose, it was determined that the 7th grade students to whom the ABI approach was applied differed significantly from the traditional method with the unit-based academic achievement test, analytical thinking test, and semi-structured interviews. It can be said that the ABI application is effective for the academic success of the students. Many studies in the literature in which ABI was applied have created significant differences in post-test scores (Akkuş et al., 2007; Hand & Keys, 1999; Hihenshell & Hand, 2006; Kabataş et al., 2008; Kabataş Memiş et al., 2009). The results of these studies and the results obtained in the present study show parallelism with each other.

During the ABI approach, students become more involved in the learning process cognitively and metacognitively. With the ABI process, students stated that they were willing to complete the activities, which are cognitive activities, but also realized that they needed to make connections between various elements (Hand et al., 2004). When the findings obtained from the scenarios measuring analytical thinking skills were examined, it was found that there was no significant difference between the application and control groups in the pre-test of analytical thinking skills. In this respect, it can be said that the analytical thinking skills of the experimental and control group students were similar at the beginning of the study.

When the findings of the analytical thinking post-test applied at the end of the study were examined, it was determined that there was a significant difference between the groups in terms of the analytical thinking skills of the students, and it was in favor of the application group. The use of the ABI approach in science lessons improved students' analytical thinking skills. 30% of academic heads explain analytical thinking skills.

When we look at the literature, there are results showing that the application of ABI positively affects many skills, such as critical thinking and problem solving skills (Çakan Akkaş & Kabataş Memiş, 2021; Öz, 2020). Individuals who have gained research-inquiry skills effectively use some high-level skills such as analysis, synthesis, and evaluation in the process (Ocak & Akkaş Baysal, 2021). It can be said that during the application process, students' ability to determine the relationship between claims and justifications, evaluate the justifications, and analyze by presenting evidence during the actions of thinking, creating reasons, and collecting evidence for these reasons improves their analytical thinking skills. The data obtained from the interviews with the students also points out the effect of the ABI application on the analytical thinking process. The difference between the answers to the analytical thinking questions before and after the ABI application supports this.

While the students in the experimental group emphasized factors such as basing a claim on evidence, justifying the argument, and being proven or verified, the control group students expressed that they were not familiar with the discussion process, that they had to get support from a certain authority in the decision-making process, and that they could not make adequate assessments about the discussion. summarizes. There is a high level of positive correlation between analytical thinking and other high-level skills and students' communication and cooperation skills (Tsai et al., 2012).

Recommendations

This study was carried out with 7th grade students in the "Force and Energy" and "Force and Motion" units. A similar study can be applied to different grade levels, different units, and larger samples. In addition, a similar study can be conducted in regions with different socioeconomic and sociocultural characteristics.

Other studies to develop analytical thinking skills by using the ABI approach can be researched at the primary, secondary, and higher education levels. Training can be given in order to enable teachers to practice ABI. Thanks to the training provided, teachers will be able to apply the ABI approach correctly and effectively. Then, the effectiveness of these trainings can be evaluated.

Author (s) Contribution Rate

The contribution rate of the authors in this study is half.

Ethical Approval (only for necessary papers)

Ethical permission (07.12.2021-UADAUC3) was obtained from Kastamonu University's Social and Human Sciences Research and Publication Ethics Committee institution for this research.

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