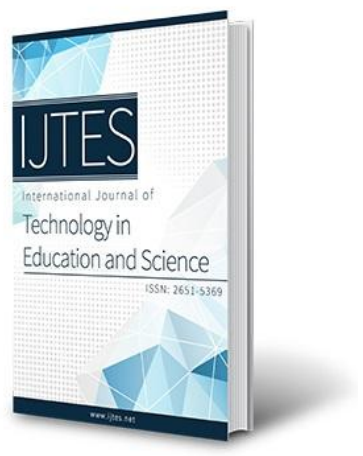

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To cite this article:

Sogut, S. & Genc, M. (2025). Determining students' argumentation levels towards space research through astronomy workshop activities. *International Journal of Technology in Education and Science (IJTES), 9*(1), 66- 86. https://doi.org/10.46328/ijtes.600

International Journal of Technology in Education and Science
2025, Vol. 9, No. 1, 66-86 https://doi.org/10.46328/ijtes.600

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Article Info

Article History

Received:

Accepted:

Keywords

Argumentation

Levels of argumentation

Space research

Socioscientific issues

Abstract

In today's world, where technology is advancing day by day and it is easier to access information, developments in science bring along a process that involves dilemmas regarding the ethical and moral values of individuals as well as providing basic scientific knowledge to society. Space exploration refers to a perspective that examines the social, cultural, economic and political effects of these studies as well as scientific studies aimed at exploring and understanding the universe. In this study, it is aimed to determine the effect of astronomy workshop activities on middle school students' argumentation levels towards space exploration. The study was conducted with 25 middle school students in a face-to-face astronomy workshop according to a 10-week plan. The activities in the implementation process were prepared and implemented by the researcher. The data obtained from the research were analyzed by content analysis. In determining the argumentation levels, argumentation tables prepared in accordance with Toulmin Argument Model were analyzed. The findings of the study indicated an augmentation in the diversity of student perspectives on space exploration, a socio-scientific issue that was addressed. The analysis revealed that the astronomy workshop activities designed to facilitate space exploration exhibited a significant impact on the students' argumentation levels.

Introduction

In today's world, where technology is advancing day by day and it is easier to access information, developments in science, in addition to providing basic scientific knowledge to society, bring along a process that involves dilemmas regarding the ethical and moral values of individuals. Throughout our lifetimes, we encounter numerous problems and dilemmas that require decision-making and choices. Socioscientific issues (SSI) are matters rooted in scientific concepts or problems, often contentious in nature, subjects of societal debate, and influenced by social factors (Sadler & Zeidler, 2005). Issues such as nuclear power plants, stem cell research, genetic replication, genetically modified foods (GMO), gene therapy, space exploration are on the agenda and their number is increasing day by day. Socioscientific issues include both scientific and social issues (Sadler, 2004). Socioscientific issues require personal or social decision-making as well as having a scientific aspect (Sadler, 2004; Zeidler, 2003). It is considered important to discuss socioscientific issues, to understand the scientific content of a socioscientific issue, to process the relevant information, and to evaluate it by considering moral and ethical values (Sadler et al., 2004). Issues such as gene therapy, nuclear power plants, stem cells, vaccines, genetically modified organisms, organ transplantation, surrogate motherhood, artificial intelligence affect both science and society (Genc, 2020). There are different opinions about these controversial issues based on scientific data. Accordingly, it has become a necessity for future generations to be composed of individuals who have the ability to make decisions about these controversial issues.

The fact that socioscientific topics consist of open-ended questions with unclear answers and dilemmas will contribute to students' decision-making skills, critical thinking skills, reasoning skills and scientific thinking habits (Genc, 2020). In this context, the socioscientific topics to be selected in the courses are expected to consist of informal questions. In science education, students are expected to understand the nature of science as well as its interaction with the environment and society, and to use their knowledge and skills in problem solving. One of the aims of the science curriculum is to develop students' scientific thinking habits by using socioscientific issues (Ministry of National Education [MoNE], 2013). Socioscientific issues in the science curriculum enable individuals to generate solutions to the problems they face and develop their scientific and moral reasoning skills (MoNE, 2013). In this direction, socioscientific issues have become more prominent in the curriculum and it is aimed to develop reasoning and decision-making skills as well as scientific thinking habits in students (MoNE, 2018). Within the scope of the objectives of the curriculum, it is emphasized that primary school students gain scientific thinking skills with the help of socioscientific issues and become aware that they have a role in solving social problems (MoNE, 2013). Today, with the inclusion of socioscientific issues in the science curriculum, it is seen that research on socioscientific issues has increased in Turkey and the importance of the subject has increased in the same direction.

Argumentation

While an argument includes each of the following components: claim (assertion), data (situations that justify the claim), justification (situations that relate the data and the claim), support (assurance of the justification), rebuttal (situations that refute the validity of the claim) (Toulmin, 2003), argumentation means combining all of these components, anticipating the thinking strategies of the individual himself or others, convincing them of his own argument, and presenting arguments against their arguments.

Banihashem et al. (2023) view argumentation not only as a means of conveying information, but also as an intellectual process that enables students to think more deeply, develop reasoning skills, and analyze opposing views. In this process, they emphasize that students should be able to make claims, defend those claims, evaluate opposing views, and construct structured arguments in discussions (Banihashem et al., 2023; Kerman et al., 2022; Bayat et al., 2022). This allows students to develop more advanced thinking skills. Argumentation is a powerful tool that promotes social science reasoning, critical thinking, problem solving, and collaborative learning (Latifi & Noroozi, 2021) while shaping students' intellectual processes. Argumentation has been demonstrated to facilitate the emergence of cognitive conflict in educational settings, thereby fostering students' acceptance of diverse perspectives (Kerman et al., 2022; Latifi & Noroozi, 2021). These cognitive conflicts have been shown to encourage students to question their own thought processes, thus leading to the development of more robust and grounded arguments.Argumentation enables students to organize their thoughts in a systematic manner, facilitating the analysis and evaluation of information and the development of new perspectives. This process encourages students to engage with information beyond mere acceptance, fostering a more robust internalization of ideas through discussion.In the context of argumentation, students are not only tasked with defending their own ideas, but also with critically examining and interrogating the ideas of their peers, and when necessary, formulating robust counterarguments (Bayat et al., 2022; Banihashem et al., 2023). Valero Haro et al. (2020) posit that argumentation-based learning fosters collaborative learning by enabling students to engage in discussions with their peers, exchange ideas, and engage in a more profound examination of opposing views.

Toulmin defined argumentation as a process of reasoning in which arguments are formed using components such as claim, data, and justification (Toulmin, 2003). Toulmin noted that individuals can form different arguments on any topic and developed the Toulmin Argument Model, which has contributed significantly to the development of the argumentation process. The use of argumentation in science education is based on Toulmin's (1958) studies. The Toulmin Argument Model is generally used in studies conducted in the field of science education (Demirci, 2008; Demircioglu & Uçar, 2014; Kardaş, 2013; Lazarou, 2010; Ogan Bekiroglu & Eskin 2012; Robertshaw & Campbell, 2013; Sadler, 2006; Untereiner, 2013).

A detailed description of the components of the Toulmin Argument Model (2003) is presented below:

Claim: An idea, conclusion or explanation put forward for a problem.

Data: Includes facts, examples or observations used to support the claim. However, different claims can be made with the same data; therefore, it should be made clear how the data used in argumentation supports the claim.

Justification: Reasons showing how the data support the claim.

Supporting: In some cases, in order to increase the acceptability of the reasoning, examples or other basic information accepted in the relevant field can be used. This information that supports the justification is referred to as support in the argument.

Rebuttal: Determines the conditions under which the claim would not be true or valid.

According to this argumentation model, the explanations put forward by the individual express claims, while the evidence that forms the basis of these claims constitutes data (Sampson & Clark, 2008). In a good argument, justifications are used to explain the connection between claims and data (Sampson & Clark, 2008). Statements used to strengthen the justification are called supports (Toulmin, 2003) and are defined as generalizations that increase the credibility of the claim (Erduran et al., 2004). Refutations are included in higher level arguments (Erduran et al., 2004) and refer to situations where the argument cannot be valid (Toulmin, 2003). The use of argumentation as a method in the field of education has increased after its components were defined and the relationship between the components was revealed.

Space Exploration and its Place in the Science Education Curriculum

Since space exploration is an issue closely related to both science and society, it is handled based on socioscientific issues that are complex, open-ended, dilemmatic, controversial and without a definitive answer (Durak, 2022). Therefore, space exploration is a subject that can be analyzed from economic, social, political, health and ethical perspectives as well as scientific aspects. When we evaluate space exploration in terms of its positive and negative aspects, two different perspectives emerge. The health problems experienced by astronauts who go to space for space exploration (Cohen, 2022; Yurgiden, 2023), space pollution caused by satellites that have completed their mission in space, the damage that these satellites can cause to astronauts and satellites that have not yet completed their mission, and the allocation of huge budgets for space exploration can be listed as the views of individuals who oppose space exploration (Genc & Toktas, 2023). On the other hand, the contributions provided to medical, military and commercial fields thanks to space exploration, and the fact that it helps development in areas such as national security, lifestyle and productivity can be listed as the views of individuals who support space exploration (Ekşi et al., 2019). Accordingly, space exploration reveals that space exploration is a socioscientific issue as it is a dilemma-creating issue such as whether space exploration should or should not be done (Durak, 2022). It is possible to express space exploration as a socioscientific issue since it is related to science from a technological point of view but contains contradictions from a social point of view (Genc & Toktas, 2023).

The space technologies and infrastructures provided by space exploration have increased human awareness and interest in space, led to a growing interest in space tourism, and enabled safe and accessible travel to space, thus making space tourism possible. This raises a number of dilemmas, such as the need to ensure the sustainability of space tourism while minimizing its environmental impact, the necessity to balance the economic viability of space tourism with environmental sustainability, the rapid technological advances and the establishment of regulatory frameworks to accommodate these advances, the balance between the environmental impacts of space tourism and the socio-economic benefits it provides, how to align societal motivations with economic realities, and how to integrate environmental motivations into the sustainable development of the space tourism sector (Paladini & Saha, 2023; Zhang & Wang, 2022; Frost & Frost, 2022).

Space exploration refers to scientific endeavors to explore and understand the universe, as well as the social, cultural, economic and political implications of these endeavors. Considered as a socioscientific issue, space exploration encompasses the impacts on society, social perceptions, cultural changes, economic consequences and political processes. In addition, it aims to understand the interactions and relationships between society and space exploration and technologies. It is inevitable that space exploration will generate debates in society on many issues such as how to use resources, space pollution, ethical issues and potential benefits. These debates also involve dilemmas as they reflect the limits of scientific and technological progress and humanity's aspirations for future discoveries. As a result, space exploration can be considered as a socioscientific issue since it can be handled not only from a scientific point of view but also from a social point of view and involves discussions (Genc & Toktas, 2023).

In this study, the topic of 'Space Exploration' in the 'Solar System and Beyond' unit of the 7th grade science course was discussed. In the science curriculum, it is aimed for 7th grade students to gain creative and innovative thinking skills in the subject of "Space Exploration" (MoNE, 2018). The achievements in the science curriculum on space exploration are given in Table 1.

Table 1. Achievements in Space Exploration

Gain No	Gains
F. 7. 1. 1. 1	Explains space technologies. a. Artificial satellites are mentioned. b. The satellites sent into space by Turkey and their missions are mentioned.
F. 7. 1. 1. 2	Expresses the causes of space pollution and predicts the possible consequences of this pollution.
F. 7. 1. 1. 3	Examines the relationship between technology and space exploration.
F. 1. 1. 1. 4	Explains the structure of the telescope and what it does. a. Telescope types are mentioned. b. Light pollution is mentioned.
F. 1. 1. 1. 5	Makes inferences about the importance of the telescope in the development of astronomy.
F. 1. 1. 1. 6	Prepares and presents a simple telescope model.

Looking at Table 1, it can be said that in the context of the study, it is aimed to have knowledge and skills about the contributions of space exploration and to discuss the causes of space pollution by considering the technology dimension in the curriculum. While space exploration is mostly considered as a technological dimension in education, it is emphasized that the dilemma dimension of this situation should also be addressed with the outcome "F.7.1.1.2. Expresses the causes of space pollution and predicts the possible consequences that this pollution may cause." in the science curriculum (MoNE, 2018). Thus, like other socioscientific issues, space exploration should also be examined by considering the dilemma dimension.

Socioscientific Issues and Argumentation

Socioscientific issues involving the relationship between science, technology and society become an important tool to help students grow as qualified individuals when argumentation and different techniques are included. Driver et al. (2000) contend that argumentation constitutes a vital element of science education, aiding students in making present and future decisions. It is crucial for students to possess the capability to assess the risks and benefits of various solutions, pose inquiries, evaluate arguments and counterarguments, and make informed decisions. Furthermore, they must be adept at engaging in oral debates and discussions concerning socioscientific issues. According to Erduran and Jiménez-Aleixandre (2008), argumentation serves as a means to facilitate the development and honing of decision-making skills among students. Through participation in argumentation, students acquire insights into the conventions of scientific debate and the construction of scientific knowledge. Actively engaging in discussions enables students to articulate their evolving scientific comprehension. Argumentation enables students to gain skills in reasoning, critical thinking, and presenting arguments both orally and in writing (Driver et al., 2000; Osborne et al., 2004). One outcome that should be emphasized in an argumentation-based teaching process is that students critique the weaknesses in their opponent's argument in order to strengthen their own argument (Kuhn & Udell, 2007). In this way, argumentation allows students to experience a dual perspective, that is, the process of critiquing arguments and counter-arguments; it also provides students with opportunities for critical thinking. Regardless of whether oral or written argumentation is preferred, it is necessary to create a discussion environment in the classroom on a scientific or socioscientific topic.

Socioscientific issues involve the intentional utilization of scientific topics that necessitate students' involvement in dialogue, discussion, and debate. These topics are often contentious but also require a degree of moral reasoning or consideration of ethical concerns in the decision-making process regarding their potential resolution. Crucially, socioscientific issues are personally relevant and captivating for students, necessitate evidence-based reasoning, and furnish a framework for comprehending scientific knowledge (Sadler, 2004; Zeidler, 2003). The integration of discussion and debate into science classrooms is an increasingly intriguing area of focus among science educators, paralleling the rise of social controversies in science alongside technological advancements. Nonetheless, employing discussion and debate serves as a valuable tool for cultivating critical thinking and reasoning skills and reflecting on discourse practices to advance scientific understanding (Chen et al., 2019).

Purpose of the Study

The aim of this study is to determine the effect of astronomy workshop activities on middle school students' argumentation levels towards space exploration. In this direction, an answer to the question "How do the argumentation levels of middle school students change with astronomy workshop activities prepared for space exploration?" was sought.

Method

Case study, one of the qualitative research methods, was utilized in the study. Case study is a research approach used to understand and explain a specific event, situation or behaviors in a group in depth (Büyüköztürk, 2012). In this study, the effect of space exploration activities on middle school students' argumentation levels was investigated in depth.

Working Group

The study group of the research consisted of 25 female students who were studying in a secondary school in Ankara in the 2022-2023 academic year and participated in the astronomy workshop. Since only female students were studying at the school where the study was conducted, the gender of the study group was limited to female students. The study group was formed according to the participation of the students at each grade level in the astronomy workshop. The participation of students in the astronomy workshop is voluntary and according to their interest in the activities carried out in the workshop. Within the framework of ethical rules in the research, the students in the study group were coded as S1, S2, S3, ..., S25. The distribution of the study group according to grade levels is 5th grade (5 students), 6th grade (5 students), 7th grade (5 students) and 8th grade (10 students).

Data Collection Tools

In the study, students were asked to create argumentation tables in line with the Toulmin Argument Model. The Toulmin Argument Model is a theoretical framework that enables the systematic analysis of students' argumentation processes and the paths they follow in these processes. The present study employed this model to examine students' argumentation processes in depth, identifying the arguments they developed in the discussions and the logical foundations supporting these arguments. The structural characteristics of the Toulmin Argument Model were utilized to identify gaps in students' argumentation. Additionally, the study evaluated the students' management of counterarguments and the attainment of discussion objectives. The model's components illuminate the arguments presented by students, the manner in which they substantiate these arguments, and their approach to counterarguments. Given the students' lack of prior experience with argumentation-based learning, the researcher found the Toulmin Argument Model to be particularly comprehensible and applicable. The Toulmin Argument Model enabled a thorough analysis of the structural components of the students' arguments, facilitating a more comprehensive evaluation of the discussions and the arguments employed. In the context of an educational environment, the examination of students' argument components yielded more concrete data on the development of their critical thinking and logical reasoning skills.

In order to determine the argumentation levels and the development in argumentation levels, two different applications were made to the students, first and last. The argumentation pretest was administered to the students in the 4th week. The reason for this is to ensure that the students have the skills to create an argumentation table. Immediately after the Week 3 and Week 4 activities with the students, a pretest of the students' individual argumentation tables was administered. Then, the post-test application regarding the students' individual argumentation tables was completed immediately after the debate activity in Week 9.

Implementation Process

The implementation was carried out face-to-face according to a 10-week plan within the scope of the studies conducted in the astronomy workshop. Expert opinion was taken while developing the implementation process. In face-to-face applications, students were divided into groups of five. In this way, it was ensured that all students fully performed the activities, repeated them, took an active role in each application and interacted. Table 2 shows the distribution of the training according to the weeks and Table 3 shows the detailed explanation.

Table 2. Training During the Implementation in Breakdown by Weeks

Week	**Training Conducted**
Week 1	Preliminary Information
Week 2	Information on Space Exploration
Week 3	Presentation and Practice on the Positive Aspects of Space Exploration
Week 4	Presentation and Practice on Negative Aspects of Space Exploration Argumentation Pre-Test Application
Week 5	Participation in Astronomy Center Tour and e-Conference
Week 6	Mars Colony Event
Week 7	Astronomy Camp
Week 8	Movie Impression
Week 9	Debate Event
Week 10	Argumentation Post-Test Application and Closing

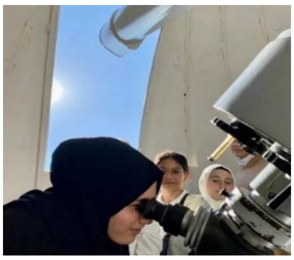
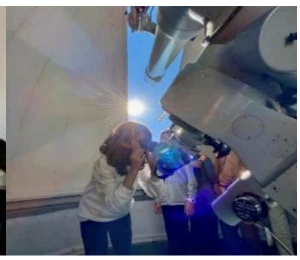
Astronomy Workshop

The work in the astronomy workshop was carried out outside of class time. Students who love and are interested in astronomy participate in this workshop as part of after-school courses. It consists of a total of two class hours per day, with one class hour lasting 45 minutes. Trainings in the astronomy workshop are held one day a week. However, in case of insufficient time depending on the planned trainings during the research, the duration of the course was increased or the course was continued for two days a week in order not to disrupt the research. For example, in the 3rd and 4th weeks, students were given additional time to prepare for the group discussion and to do research on the subject, and the training continued in the astronomy workshop the next day.

In the study, a research plan including the research model, study group, data collection tools and data analysis techniques appropriate to the purpose and objectives of the study was prepared. The activities were finalized by taking expert opinion before the implementation. In order to determine students' argumentation levels and their views on space exploration, activities were designed in which space exploration, a socioscientific subject, was integrated. The school administration, astronomy workshop students and parents were informed. Approval for out-of-school activities was obtained from the parents with a permission document. During the implementation, the researcher managed the data collection process and observed students' participation in the activities. After the implementation, the collected data were analyzed. The first researcher proposed and conducted the astronomy workshop activities herself. She interacted with and guided the students in the activities throughout the implementation. In the debate activity, the jury members were formed by other teachers in the school in order to prepare a more professional environment for the students. All activities were photographed by the first researcher.

Table 3. Detailed Descriptions of Trainings During Implementation

Week	Training Conducted	Education Content	Implementation
WEEK 1	**Preliminary Information**	Providing preliminary information. Giving detailed information about the work to be done.	 
WEEK 2	Information on Space Exploration	Space Space exploration Space technologies The relationship between technology and space exploration Space pollution Structure of the telescope The importance of the telescope in the development of astronomy	 

Week	Training Conducted	Education Content	Implementation
		Space law Space tourism	
WEEK 3	Presentation on the Positive Aspects of Space Exploration Argumentation Practice Group Discussion	Presentation on the positive and negative aspects of space exploration. Students are asked to prepare for the next day's group discussion. At the end of their research, they are asked to develop an individual written argument about their position on the topic. Students are brought together with their peers to discuss in small groups. Immediately after the group discussions, students are asked to write down their individual reflections on whether they found new arguments or changed their views after the discussion. Argumentation pre-test is applied. Individual written argumentation tables are collected from the students regarding their opinions.	 
WEEK 4	Presentation on the Negative Aspects of Space Exploration Argumentation Practice Group Discussion Argumentation Pre-Test Application		 
WEEK 5	Excursion to the Astronomy Center Participation in e-Conference (out-of-school learning environment)	Visiting Ankara University Kreiken Observatory and making observations. Participation in the e-conference on 'Robots on Mars and Space Tourism'. Mars is a source of great curiosity for humanity and many robotic missions have been carried out to satisfy this curiosity. Spacecraft sent to explore the surface of Mars have collected important data by examining the planet's	   

Week	Training Conducted	Education Content	Implementation
		geography, geology and atmosphere. They have provided important information about the past climate and geology of Mars, found evidence of the presence of water and searched for potential traces of life. With the success of robotic missions to Mars, human interest in the red planet has increased. Space agencies and private companies are working on various projects to take humans to Mars in the future. Space tourism has the potential to become a new industry that will enable people to travel beyond Earth. These space tourism projects will expand humanity's frontiers in space and open up new possibilities for the exploration of Mars.	 
WEEK 6	Mars Colony Event	The activity prepared with the 5E learning model is applied (given in Appendix 1). At each step, students are asked questions to help them reason. At the end of the activity, students are asked to design their own Mars colonies. Such activities can increase students' critical thinking skills, their ability to develop empathy, their ability to defend their own views, and their ability to work in teams. The Mars colony activity allows students to participate in the decision-	     

Week	Training Conducted	Education Content	Implementation
		making process. Students make their own decisions about whether or not to colonize Mars by creating and analyzing arguments. During the activity, they develop their ability to evaluate different arguments. Before making a decision, students need to consider various factors and evaluate the arguments logically. The Mars colony activity was carried out in groups. This allows students to develop their skills of collaboration and bringing different perspectives together.	  
WEEK 7	Astronomy Camp	A two-day camp was planned with the participation of students and students were able to reinforce their knowledge in an out-of-school learning environment. Sky observation was made with a telescope. Students will be able to explain the structure and function of a telescope. Students were informed about telescopes and telescope types, which are of great importance for space exploration.	   
WEEK 8	Movie Screening (First Man)	They are shown the movie First Man on the Moon, about astronaut Neil Armstrong's NASA-based mission to the moon. The movie, which includes the prices paid by Armstrong and the country, the sacrifices	

Week	Training Conducted	Education Content	Implementation
		made, and the pressure that NASA and the Apollo 11 team faced in the 1960s to win the space race against the USSR, was shown to the students so that they could see and reason.	 
WEEK 9	Debate	Students debate on whether space exploration should or should not be done. Students will be able to discuss the environmental, social, economic and political dimensions of space exploration through a debate activity.	   
WEEK 10	Argumentation Posttest Application Closing	Argumentation post-test is applied. Individual written argumentation tables are taken from the students regarding their opinions.	

"First Man" is a 2018 biographical drama film that tells the story of Neil Armstrong becoming the first man to set foot on the Moon during the Apollo 11 mission. By addressing the topic of space exploration, it emphasizes the scientific and social importance of space exploration and humanity's presence in space. It emphasizes the technological advances and scientific discoveries related to space exploration. The film shows the technical and engineering challenges and achievements of NASA's Moon landing program. It reflects the space race between the United States and the Soviet Union and the political and ideological context of the Cold War era. It also addresses the social and cultural impact of space exploration. This movie was shown to students as it is an important source for understanding the place of space exploration in human history and its social, cultural and scientific impacts.

The debate activity "To do space exploration or not to do space exploration?" involves different views, arguments and evidence and can be approached from a variety of angles. Some may emphasize the importance of space exploration, while others may argue that resources should be directed elsewhere. This type of debate can help participants develop their reasoning skills and empathize with different perspectives. It can also include topics such as the impact of space exploration on society, economic costs and benefits, so this type of debate can provide a rich and in-depth discussion.

Data Analysis

In this study, descriptive analysis, one of the qualitative analysis methods, was used to analyze the written argumentation tables created by the students. Descriptive analysis is an analysis approach that includes the steps of processing qualitative data based on a predetermined theoretical framework, defining the findings and interpreting the findings (Yıldırım and Şimşek, 2016). In determining the argumentation levels, the argumentation tables prepared in accordance with the Toulmin Argument Model were analyzed. According to Şahin (2014), the Toulmin Argument Model provides researchers with a qualitative evaluation opportunity to compare the characteristics of the components in the argument, as well as the opportunity to make quantitative evaluations by allowing researchers to determine the level according to whether it includes one or all of the components. In the study, the "Argumentation Assessment Rubric" developed by Erduran et al. (2004) was used to determine students' argumentation levels. The rubric is given in Table 4.

Table 4. Argumentation Evaluation Rubric (Erduran et al., 2004)

Level 1	Arguments consisting of a simple claim in response to a claim or counterclaim.
Level 2	The level at which a claim is accompanied by data, justification or support, but no rebuttal.
Level 3	It is the level at which arguments consist of a series of claims or counterclaims with data, justification or support and rarely weak rebuttals.
Level 4	This is the level where arguments consist of a series of claims or counterclaims with data, justification or support and a clear rebuttal.
Level 5	This is the level where arguments consist of a series of claims or counterclaims with data, justification or support and multiple rebuttals.

The lowest score to be obtained from the rubric is 1 and the highest score is 5. The levels were determined between "Levels 1-5" according to the presence of argument components (claim, data, justification, support and rebuttal) in the written arguments created by the students. After the argumentation level of each student was determined according to the pre-test and post-test applications, their frequencies were calculated, reported and presented graphically in the findings. In addition, examples of each argumentation level are included in the findings.

Findings

The findings regarding the argument levels formed by the students within the scope of the sub-problem of the research are given below**.**

Table 5. Pre-Test - Post-Test Argumentation Levels Distributions

Level	**Pre-Test**		**Post-Test**	
	frequency (f)	**percentage (%)**	**frequency (f)**	**percentage (%)**
Level 1	3	%12	-	-
Level 2	9	%36	-	-
Level 3	9	%36	3	%12
Level 4	4	%16	10	%40
Level 5	-	-	12	%48

When the findings of the first application were analyzed, it was determined that the majority of the students formed arguments at Level 2 (f=9, 36%) and Level 3 (f=9, 36%). 3 students (12%) formed arguments at Level 1, 9 students (36%) at Level 2, 9 students (36%) at Level 3, and 4 students (16%) at Level 4. It was observed that there were no students who formed arguments at Level 5. According to these findings, it was determined that 12% of the students could only make a claim but did not make any statements about the other components of argumentation; 36% of the students used data, justification and support in addition to their claims in the argument formation process.

When the findings of the post-application were analyzed, it was determined that the majority of the students formed arguments at Level 5 (f=12, 48%). 3 students (12%) formed arguments at Level 3, 10 students (40%) at Level 4, and 12 students (48%) at Level 5. It was observed that there were no students who formed arguments at Level 1 and Level 2. According to these findings, it is seen that there are no students who can only make a claim but do not make any statements about the other components of argumentation, and who use data, justification and support in addition to their claims in the argument formation process, and who form arguments at Level 1 and Level 2. Therefore, it is seen that students' argumentation levels have improved.

According to the classification in Erduran et al. (2004)'s rubric, in order to have Level 3 and higher argumentation skills, it is necessary to have a weak or clear definition and number of rebuttal in the arguments created in addition to claim, data, justification and support. Therefore, as a result of the analysis of the data obtained, it was determined that all of the students formed arguments at Level 3, 4 and 5.

Argumentation tables are given below as examples of the changes in the argumentation levels of the students according to the findings obtained as a result of the pre-test and post-test applications:

While the student coded S21 was at level 1 in the pre-test, it was determined that he reached level 3 in the post-test.

Pre-Test S21

Data: ________________

Claim: Space exploration must be done.

Justification: _______________

Support: __________________

Rebuttal: __________________

Post-Test S21

Data: Many of the products we use in daily life, medicine, etc. were obtained thanks to space exploration.

Claim: Space exploration must be done.

Justification: Products such as TV broadcasts, MRI devices, GPS technology, weather tracking systems and scratch-proof glass were developed thanks to space exploration.

Support: __________________

Rebuttal: Although space exploration contributes to the development of technology, it is very costly in economic terms.

While the student coded S2 was at the level 3 in the pre-test, it was determined that he reached the level 5 in the post-test.

Pre-Test S2

Data: TV broadcasts, MRI devices, GPS technologies, scratch-proof glass, baby food, elevators and escalators are the result of space exploration.

Claim: Space exploration must be done.

Justification: Space exploration has brought great benefits to daily life beyond the activities that take place outside the Earth.

Support: ____________________

Rebuttal: With so many problems in the world today, we need to address world problems and protect what we have.

Post-Test S2

Data: With the recent space exploration, the world has suffered great financial losses. For example, Elon Musk suffered million-dollar losses by crashing the starship he was working on with SpaceX. On May 8, 2021, the 18-ton rocket fragment that fell into the Indian Ocean on the Earth's surface is just one of the ocean massacres.

Claim: Space exploration should not take place.

Justification: Besides financial losses, pollution is also a negative impact of space exploration. Another reason why space exploration is supported is that it is a rebellion against the attempts to establish order in space that cannot be achieved on Earth.
Support: While there are hundreds of problems we have on Earth such as global warming, extinct species, inconsistency in seasonal transitions, I think that instead of looking for solutions to these problems, research that causes waste of energy, money and time should be suspended, and we should focus on our home Earth and Earth problems rather than a foreign concept such as space.
Rebuttal: Thanks to this research into space, we are becoming more scientifically knowledgeable and science is advancing. This leads to the development of technological tools and the emergence of new technologies. For example, GPS allows the distance between satellites and individuals or vehicles to be measured, so that a person's precise location on Earth can be determined, making it easier for safety. MRI helps detect disease or damage and monitor the effectiveness of a treatment. Many technologies such as these have been discovered thanks to space technologies.

While the student coded S4 was at level 2 in the pre-test, it was determined that he reached level 5 in the post-test.

Pre-Test S4
Data: Space exploration has led to the development of technologies we use today, such as GPS systems, aluminum foil and transparent braces.
Claim: Space exploration must be done.
Justification: ____________________
Support: ________________________
Rebuttal: _______________________

Post-Test S4
Data: To date, scientists have discovered about 4% of the visible universe. Thanks to these discoveries, research has led to the advancement of technology.
Claim: Space exploration must be done.
Justification: Technology transfers provide business opportunities for new providers of space technology and systems and strengthen industry, and we also become more scientifically informed.
Support: NASA's OSIRIS-REX, launched in 2016, is intended to collect samples from Bennu, an asteroid thought to be 4.5 billion years old. It is hoped that the pristine material that will soon come from Bennu will provide generations of scientists with a window into the time when the Sun and planets formed around 4.5 billion years ago. In another example, today we can use the internet while traveling by bus or train and watch live news on the television in buses. Again, space exploration has given us this opportunity with moving satellite antennas.
Rebuttal: It can be said that with every space mission that takes place, future missions are jeopardized. This is because every spacecraft that is launched and the increased work in space creates more and more uncontrolled debris that poses a threat to spacecraft in orbit. It creates space garbage in space. Space exploration is also very costly.

While the student coded S17 was at level 2 in the pre-test, it was determined that he reached level 5 in the post-test.

Pre-Test S17

Data: ________________________

Claim: Space exploration must be done.

Justification: People want to do everything easier and faster.

Support: Easier navigation with GPS systems and internet access thanks to space exploration.

Rebuttal: ____________________

Post-Test S17

Data: A satellite sent into space by the United States scans the temperature of forests in the country 24 hours a day, and when a sudden increase in temperature is detected in any forest, it notifies the nearest fire department to extinguish the fire. Thanks to this technology and space exploration, many fires are contained before they grow.

Claim: Space exploration must be done.

Justification: Many technologies have been developed thanks to space exploration.

Support: From TV broadcasts to MRI devices, from weather monitoring systems to scratch-proof glass, from baby food to elevator and escalator motors, from endoscopy devices to artificial heart pumps, there are countless technological innovations that are the product of space research.

Rebuttal: Astronauts who stay in spacecraft for a long time are negatively affected sociologically and psychologically. In addition, satellites that have completed their mission in space create space pollution.

It was determined that the increase in students' argumentation levels increased according to the post-test data applied after the debate. It can be said that the debate activity and the movie screening affected the argumentation levels. It is seen that the dilemmas faced in the movie that the students watched and the fact that they constantly presented opposing views that would refute the other side during the debate were effective in the students' comprehension of the argumentation process and in increasing their argumentation levels.

Discussion and Conclusion

When the findings of the pre-test application were analyzed, it was determined that the majority of the students formed arguments at Level 2 and Level 3. 3 students formed arguments at Level 1, 9 students at Level 2, 9 students at Level 3, and 4 students at Level 4. It was observed that no student formed arguments at Level 5. When the findings of the post-test application were analyzed, it was determined that the majority of the students formed arguments at Level 5. 3 students formed arguments at Level 3, 10 students at Level 4 and 12 students at Level 5. It was determined that there were no students who formed arguments at Level 1 and Level 2. Therefore, it was determined that the argumentation levels of the students were improved in this study.

Similar to this study, Reznitskaya et al. (2001) conducted a study with middle school students and Msimanga and Lelliott (2012) conducted a study with high school students and reported that oral discussions positively affected students' argument formation levels. Similarly, in their study, Zohar and Nemet (2002) divided ninth grade students into two groups as experimental and control groups, and in the experimental group, they continued the lesson process through argumentation-based and dilemma-based topics. At the end of the study, they saw that students' argument quality increased. Untereiner (2013) examined the level of oral arguments created by eighth grade students and found that students could not use all argument elements (claim, data, justification, support, rebuttal) at the beginning of the process, but at the end of the process, they produced more advanced arguments by using more argument elements. In his study, Karcılı (2022) determined that 7th grade students were able to write at least one rebuttal while creating an argument in the process and that they mostly wrote arguments at Level 4. In their studies, Gültepe (2011) and İşbilir (2010) stated that students' argumentation skills gradually increased with the use of argumentation in the teaching process. These results are similar to the results obtained from the current study.

In the 3rd and 4th weeks, students were included in the argumentation process with group discussion on space exploration. At the same time, the practices involving argumentation were diversified with the debate activity. Therefore, it can be said that the implementation process including argumentation practices had an effect on students' argumentation levels. The Week 9 debate activity on 'space exploration should be done, space exploration should not be done' had a positive effect on students' argumentation levels. It contributed to students' reasoning about space exploration. During the debate process, it was observed that students revealed their skills of researching, collecting and analyzing information to learn about space exploration and to support their arguments. While evaluating different arguments during the debate, students used their reasoning skills to refute the counterarguments. Therefore, it was seen that it increased students' oral communication skills and persuasiveness and positively affected their argumentation levels. As a result of the findings obtained from the research, it was determined that the activities carried out within the scope of space exploration, which is a socioscientific subject, had a positive effect on students' argumentation levels, that is, students were able to form better arguments in the process. In this direction, it can be concluded that the teaching process applied on the basis of socioscientific issues has a positive effect on the development of students' argumentation levels. It was determined that astronomy workshop activities prepared for the subject of space exploration affected students' argumentation levels. It can be said that the increase in students' argumentation levels is due to the fact that the activities were designed in an interactive and discussion-based manner. It was observed that students working in groups and discussing different views contributed to the development and defense of their own arguments against opposing views. This shows the importance of interactive and discussion-based learning methods for developing students' scientific thinking and argumentation skills.

When the literature was examined, no study was found in which the argumentation levels of space exploration as a socioscientific subject were examined. In this context, it is thought that the current study will contribute to the field.

Recommendations

Suggestions were made for the results obtained from the research.

• This study is limited to female students only. It may be recommended to researchers to conduct a similar study with a mixed group at the secondary school level.

• When the literature was examined, no study based on space exploration as a socioscientific issue was found. Since this topic is seen as missing in the literature, it can be suggested that researchers should conduct new studies on this topic.

• When the findings of the study are evaluated, it is recommended that space exploration on the basis of socioscientific issues should be given more space in school environments.

• As a result of the study, it was observed that astronomy workshop activities were an effective method in determining the argumentation levels of middle school students towards space exploration. Researchers are recommended to develop different activities for space exploration.

• In the study, it was found that student-centered activities positively affected students' argumentation levels towards space exploration. Therefore, other researchers can evaluate the effect of student-centered activities in science education in more detail and investigate how these activities can be improved.

• In the study, it was shown that different educational strategies and tools can be used to determine the argumentation levels of middle school students towards space exploration. These findings can guide the development and implementation of more effective strategies for space exploration.

References

Banihashem, S. K., Noroozi, O., Biemans, H. J. A., & Tassone, V. C. (2023). The intersection of epistemic beliefs and gender in argumentation performance. *Innovations in Education and Teaching International*, *61*(4), 716–734. https://doi.org/10.1080/14703297.2023.2198995

Bayat, M., Banihashem, S. K., & Noroozi, O. (2022). The effects of collaborative reasoning strategies on improving primary school students' argumentative decision-making skills. *The Journal of Educational Research*, *115*(6), 349–358. https://doi.org/10.1080/00220671.2022.2155602

Chen, Y. C., Benus, M. J., & Hernandez, J. (2019). Managing uncertainty in argumentation. *Science Education*, *103*(5), 1235-1276. http://dx.doi.org/10.1002/sce.21527

Cohen, E. (2022). Outer space mobilities and human health. *Tourism Geographies*, *24*(6-7), 1123-1133. http://dx.doi.org/10.1080/14616688.2020.1868020

Demirci, N. (2008). *Toulmin'in bilimsel tartışma modeli odaklı eğitimin kimya öğretmen adaylarının temel kimya konularını anlamaları ve tartışma seviyeleri üzerine etkisi.* [Unpublished Master's thesis]. Gazi University, Ankara.

Demircioğlu, T. & Uçar, S. (2014). Akkuyu nükleer santrali konusunda üretilen yazılı argümanların incelenmesi. *İlköğretim Online, 13*(4), 1373-1386. https://doi.org/10.17051/io.2014.31390

Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education*, *84*(3), 287-312. https://psycnet.apa.org/doi/10.1002/(SICI)1098-237X(200005)84:3%3C287::AID-SCE1%3E3.0.CO;2-A

Durak, B. (2022). Sosyobilimsel konuların uygulamaları. In M. Genc & H. Ö. Arslan (Eds.), *Fen Eğitiminde Disiplinlerarsı Yaklaşımlar ve Uygulamaları.* (pp. 99-131). Nobel Akademik Yayıncılık.

Ekşi, İ.G., Boztepe, İ., Kurban, D., Özcan, L., Uçar, İ., Bilgin K.B., & Öztürk Ö. (2019). Uzay ve tıp neredeyiz? Ne yapmalıyız?. *Medical Journal of SDU, 26*(4):498-504. https://doi.org/10.17343/sdutfd.565423

Erduran, S., & Jiménez-Aleixandre, M. P. (2008). *Argumentation in science education*. Perspectives from classroom-based Research, Springer, Dordre-cht.

Erduran, S., Simon, S., & Osborne, J. (2004). TAPping into argumentation: Developments in the application of Toulmin's argument pattern for studying science discourse. *Science Education, 88*(6), 915-933. http://dx.doi.org/10.1002/sce.20012

Frost, J., & Frost, W. (2022). Exploring prosocial and environmental motivations of frontier tourists: Implications for sustainable space tourism. *Journal of Sustainable Tourism, 30*(9), 2254-2270. https://doi.org/10.1080/09669582.2021.1897131

Genç, M. (2020). Sosyobilimsel konular ile bilim-tutum ilişkisi. In *Kuramdan Uygulamaya Sosyobilimsel Konular* (pp. 1-13). Ankara: Nobel Akademik.

Kerman, N. T., Noroozi, O., Banihashem, S. K., Karami, M., & Biemans, H. J. A. (2022). Online peer feedback patterns of success and failure in argumentative essay writing. *Interactive Learning Environments*, *32*(2), 614–626. https://doi.org/10.1080/10494820.2022.2093914

Kuhn, D., & Udell, W. (2007). Coordinating own and other perspectives in argument. *Thinking & Reasoning, 13*(2), 90-104. https://doi.org/10.1080/13546780600625447

Latifi, S., & Noroozi, O. (2021). Supporting argumentative essay writing through an online supported peer-review script. *Innovations in Education and Teaching International*, *58*(5), 501–511. https://doi.org/10.1080/14703297.2021.1961097

Lazarou, D. (2010). Learning to TAP: An effort to scaffold students' argumentation in science. In G. Çakmakçı ve M. F. Taşar (Eds.), *Contemporary science education research: scientific literacy and social aspects of science*, a collection of papers presented at ESERA 2009 conference (pp. 43-50): Ankara: Pegem Akademi.

MoNE (Ministry of National Education) (2013). İlköğretim kurumları (ilkokullar ve ortaokullar) fen bilimleri dersi (3, 4, 5, 6, 7 ve 8. sınıflar) öğretim programı. [Foundational education institutions (primary schools and middle schools) science course (3rd, 4th, 5th, 6th, 7th and 8th grades) curriculum]. Ankara, Turkey: T.C Milli Eğitim Bakanlığı Talim ve Terbiye Kurulu Başkanlığı.

MoNE (Ministry of National Education) (2018). Fen bilimleri dersi öğretim programı (İlkokul ve Ortaokul 3, 4, 5, 6, 7 ve 8. Sınıflar. [Science curriculum (Primary school and middle school grades 3, 4, 5, 6, 7 and 8]. Milli Eğitim Bakanlığı Talim Terbiye Kurulu Başkanlığı, Ankara.

Ogan-Bekiroglu, F., Eskin, H. (2012). Examination of the relationship between engagement in scientific argumentation and conceptual knowledge. *Int J of Sci and Math Educ 10*, 1415–1443. https://doi.org/10.1007/s10763-012-9346-z

Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the qualitiy of argumentation in school science. *Journal of Research in Science Teaching, 41*(10), 994-1020. http://dx.doi.org/10.1002/tea.20035

Paladini, S., & Saha, K. (2022). The quest for sustainability in lower orbit: Conceptual models for space tourism. *International Journal of Tourism Research*, *25*, 333–349. http://dx.doi.org/10.1002/jtr.2568

Robertshaw, B., & Campbell, T. (2013). Constructing arguments: Investigating pre-service science teachers' argumentation skills in a socio-scientific context. *Science Education International*, *24*(2), 195-211.

Sadler, T. D. (2004). Moral and ethical dimensions of socioscientific decision-making as integral components of scientific literacy. *The Science Educator, 13*, 39-48.

Sadler, T. D. (2006). Promoting Discourse and Argumentation in Science Teacher Education. *Journal of Science Teacher Education*, *17*(4), 323–346. https://doi.org/10.1007/s10972-006-9025-4

Sadler, T. D., Chambers, F. W., & Zeidler, D. L. (2004). Student conceptualizations of the nature of science in response to a socioscientific issue. *International Journal of Science Education, 26*(4), 387-409. http://dx.doi.org/10.1080/0950069032000119456

Sadler, T. D., & Zeidler, D. L. (2005). Patterns of informal reasoning in the context of socioscientific decision making. *Journal of Research in Science Teaching, 42,* 112-138. http://dx.doi.org/10.1002/tea.20042

Sampson, V., & Clark, D. B. (2008). Assessment of the ways students generate arguments in science education: Current perspectives and recommendations for future directions. *Science Education, 92,* 447-472. http://dx.doi.org/10.1002/sce.20276

Şahin, D. (2014). *Dördüncü ve beşinci sınıf öğrencilerinin argüman yapıları.* [Unpublished Doctoral Dissertation]. Gazi University Institute of Educational Sciences, Ankara, Turkey.

Toktaş, M. & Genç, M. (2023). Üniversite öğrencilerinin sosyobilimsel konulara yönelik muhakeme örüntülerinin incelenmesi: Uzay araştırmaları örneği. *Journal of Multidisciplinary Studies in Education, 7*(2), 43-59.

Toulmin, S. (2003). *The uses of argument.* Cambridge University Press.

Untereiner, B. (2013). Teaching and learning the elements of argumentation (Degree of Master of Arts). Univercity of Victoria, Department Curriculum and Instruction, Canada.

Yıldırım, A., & Şimşek, H. (2016). *Sosyal bilimlerde nitel araştırma yöntemleri*. Seçkin Yayınları

Yurgiden, H. (2023). An evaluation on the effects of space tourism on space economy. *Ufkun Ötesi Bilim Dergisi, 23*(1), 42-61. https://doi.org/10.54961/uobild.1283430

Valero Haro, A., Noroozi, O., Biemans, H., & Mulder, M. (2020). Argumentation competence: students' argumentation knowledge, behavior and attitude and their relationships with domain-specific knowledge acquisition. *Journal of Constructivist Psychology*, *35*(1), 123–145. https://doi.org/10.1080/10720537.2020.1734995

Zeidler, D. L. (2003). *The role of moral reasoning on socioscientific ıssues and discourse in science education.* Kluwer Academic Press.

Zhang, Y., & Wang, L. (2022). Progress in space tourism studies: A systematic literature review. *Tourism Recreation Research*, *47*(4), 372-383. https://doi.org/10.1080/02508281.2020.1857522

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