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| Research Article / Araştırma Makalesi |

The Effect of Argumentation-Based Practices on 8th Grade Students' Views on Socioscientific Issues

Argümantasyon Temelli Uygulamaların 8. Sınıf Öğrencilerinin Sosyobilimsel Konulara İlişkin Görüşlerine Etkisi

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1.Argumentation
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Abstract

Purpose: This study aims to examine the impact of argumentation-based practices on eighth-grade students' perspectives on socioscientific issues.

Design/Methodology/Approach: The research employed a case study design, one of the qualitative research methods. The study group consists of 31 students enrolled in a public school affiliated with the Ministry of National Education in Aydın. Participants were selected using a purposive sampling method. Data were collected through semi-structured interviews, classroom discussions, video recordings, and students' written worksheets. For data analysis, the argumentation assessment rubric developed by Sadler and Fowler (2006) was utilized.

Findings: The findings indicate that integrating socioscientific issues with argumentation positively influences students' perspectives on these topics.

Highlights: Argumentation-based approaches enhance students' understanding of socioscientific issues. Socioscientific argumentation fosters critical thinking and decision-making skills. Classroom implementation of argumentation can improve students' engagement with complex scientific and social topics.

Öz

Amaç: Bu çalışma, argümantasyon temelli uygulamaların sekizinci sınıf öğrencilerinin sosyobilimsel konulara yönelik bakış açıları üzerindeki etkisini incelemeyi amaçlamaktadır.

Tasarım/Yöntem/Uygulama: Araştırmada, nitel araştırma yöntemlerinden biri olan durum çalışması deseni kullanılmıştır. Çalışma grubunu, Aydın ilinde Milli Eğitim Bakanlığı'na bağlı bir devlet okulunda öğrenim gören 31 öğrenci oluşturmaktadır. Katılımcılar, amaçlı örnekleme yöntemiyle belirlenmiştir. Veriler, yarı yapılandırılmış mülakatlar, sınıf içi tartışmalar, video kayıtları ve öğrencilerin yazılı olarak sundukları çalışma kâğıtları aracılığıyla toplanmıştır. Verilerin analizinde, Sadler ve Fowler (2006) tarafından geliştirilen argümantasyon değerlendirme rubriği kullanılmıştır.

Bulgular:Araştırma bulguları, sosyobilimsel konuların argümantasyon yöntemiyle işlenmesinin öğrencilerin bu konulara yönelik bakış açılarını olumlu yönde etkilediğini göstermektedir.

Önemli vurgular: Argümantasyon temelli yaklaşımlar, öğrencilerin sosyobilimsel konulara yönelik anlayışını geliştirir. Sosyobilimsel argümantasyon, eleştirel düşünme ve karar verme becerilerini destekler. Sınıf ortamında argümantasyon uygulamaları, öğrencilerin bilimsel ve toplumsal konulara ilgisini artırabilir.

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INTRODUCTION

Science and technology, which have been constantly developing from past to present, have also caused the social structure to change. The change from the hunter society structure in the first civilizations to today's society structure with science and technology is a result of this change (Çalık & Çınar, 2009). With the invention of fire, human beings gained features such as warming, enlightenment, protection and cooking, and with the invention of the wheel, they found the opportunity to carry their loads more easily and started to travel farther. The further acceleration of technological developments with the realization of the industrial revolution accelerated the change in the social structure. Since the 21st century includes the fourth industrial revolution, science and technology are developing faster than ever before (Babacan, 2017). This acceleration of developments in science and technology also rapidly changes the needs of individuals. Individuals need to keep up with changes in order to survive and adapt to the developing world. This adaptation process is supported by the knowledge and skills individuals acquire through education (Karaca, 2018; Karışan, 2011). In a qualified education process, individuals are expected to acquire skills such as thinking, criticizing, questioning, researching, making informed choices, and transferring the knowledge acquired to daily life (Alkın-Şahin et al., 2014; Meral, 2018). In order to have these skills, individuals need to analyze, research, critically evaluate and question the events they encounter (Meral, 2018). Today, with the rapid development of technology, access to information has become quite easy. However, although individuals can access so much information, they may accept the information they obtain without questioning and may have difficulty in choosing the right information.

In today's rapidly evolving world of science and technology, fostering science literacy among all individuals has been established as a fundamental goal. Science literacy empowers individuals to comprehend scientific concepts and advancements, equipping them with the knowledge and skills necessary to navigate an increasingly complex world (Başar, 2018). Science-literate individuals are those who actively research, question, and solve problems, make informed and effective decisions, communicate proficiently, collaborate effectively, embrace lifelong learning, think analytically, and approach issues with a reflective and critical mindset (MoNE, 2013). As a multidimensional competency, science literacy encompasses cognitive, affective, and psychomotor skills related to science (Durant, 1993). Furthermore, science literacy enables individuals to understand, track, internalize, and apply scientific and technological advancements, allowing them to utilize scientific knowledge and innovations effectively in their daily lives. By fostering a habit of scientific thinking, it equips individuals with the skills and competencies necessary to make informed choices and enhance their quality of life (Özdemir, 2010). Science, society, and the environment are interconnected and continuously influence one another. Societal needs have driven the emergence and advancement of science. However, scientific developments are not always received uniformly by all members of society. This disparity in perspectives often leads to disagreements and societal divisions. To describe the societal dilemmas that influence science, the concept of "socioscientific issues" has been introduced (Sadler, 2004; Sadler & Zeidler, 2004). Integrating socioscientific issues into science education allows students to recognize real-life problems, critically analyze them, generate possible solutions, and bridge the gap between school learning and everyday experiences (Sevgi, 2016).

Socioscientific issues are topics that encompass both scientific and societal dimensions, lack a single definitive answer, are open to debate, and can be evaluated from multiple perspectives, often involving ethical and moral considerations (Sadler & Zeidler, 2005; Sadler & Fowler, 2006; Zeidler & Nichols, 2009). Examples of such issues include cloning, genetically modified organisms (GMOs), chemical pesticides, global warming, flu vaccines, stem cell research, alternative fuels, and nuclear energy (Birdal, 2019; Karamanlı, 2019; Levinson, 2006). For a topic to be classified as a socioscientific issue, it must be grounded in scientific principles and hold significance in social life (Eastwood et al., 2012). Sadler and Zeidler (2005) emphasize that socioscientific issues also have ethical and moral dimensions, making them crucial for fostering societal character development and virtues.

Given the complex and multifaceted nature of socioscientific issues, individuals must engage in thoughtful reasoning and informed decision-making when addressing them. One of the key methods for navigating these issues is argumentation. Argumentation is defined as a process in which individuals present their goals and interpretations in a logical and structured manner (Patronis et al., 1999). The Turkish Language Association defines the term "argument" as "claim, evidence, assertion, thesis." Therefore, in argumentation, claims and explanations must be supported by evidence (Türköz, 2019).

Through argumentation, individuals propose solutions to real-life problems. To effectively present their arguments and refute counterarguments, individuals must have a strong command of the topic, think critically about the problem, consider multiple perspectives, possess strong communication skills, and provide compelling evidence to persuade others (Prain, 2006). Examining the characteristics of individuals with argumentation skills reveals that this method fosters higher-order thinking and promotes long-term, meaningful learning.

Importance of the Research

The importance of this research lies in its alignment with the rapid advancements in science and technology and their transformative effects on social structures. As science and technology have progressed from early human inventions like fire and the wheel to the acceleration brought by the fourth industrial revolution, they have continuously reshaped society and the needs of individuals (Babacan, 2017; Çalık & Çınar, 2009). This fast-paced development creates a need for individuals to adapt, which is facilitated through education that equips them with skills such as critical thinking, problem-solving, and making informed decisions (Alkın-Şahin et al., 2014; Karaca, 2018). In an era of easy access to vast amounts of information, the ability to critically evaluate and select reliable knowledge is more important than ever (Meral, 2018).

This research is significant as it addresses the critical need to foster science literacy in students by focusing on socioscientific issues topics that blend scientific knowledge with societal concerns, such as global warming, genetically modified organisms (GMOs), nuclear energy, and others. Through the use of argumentation, a method that enhances critical thinking, students are better able to analyze problems, engage in informed discussions, and make reasoned decisions. The study aims to develop higher-order thinking skills in students and equip them with the ability to engage with real-world issues, promoting informed, responsible citizenship. Additionally, this research highlights the importance of integrating socioscientific issues with argumentation in science education, especially at the 8th-grade level, where there is a noticeable gap in the literature regarding this integration. The findings of this study are expected to contribute to the growing body of research in this field, helping to enhance science literacy and the development of scientifically informed citizens capable of making thoughtful decisions in a rapidly evolving world.

Purpose of the Research

The purpose of this research is to investigate the impact of argumentation-based practices on 8th-grade students' perspectives on socioscientific issues. Specifically, this study aims to explore how engaging students in discussions on various socioscientific topics such as endangered species, nuclear energy, global warming, and others can influence their ability to critically analyze these issues, develop informed opinions, and effectively communicate their viewpoints. By integrating argumentation as a method for decision-making, the research seeks to enhance students' skills in reasoning, problem-solving, and making evidence-based decisions. Additionally, the study aims to examine how argumentation helps students bridge the gap between scientific knowledge and real-world applications, fostering science literacy and promoting thoughtful, ethical decision-making in the context of societal challenges. Furthermore, the study seeks to explore the impact of argumentation-based practices on students' perspectives, particularly in how they engage with and understand current socioscientific issues through scientific knowledge and real-world applications.

Research question: What are the opinions of 8th-grade students on discussing current socioscientific issues through the argumentation method following argumentation-based practices?

METHOD

In this study, qualitative methods were used to examine the impact of argumentation-based practices on students' perspectives regarding socioscientific issues. Qualitative research is a methodological approach that focuses on understanding and interpreting the meaning of individuals' experiences, perspectives, and behaviors. This type of research emphasizes exploring complex phenomena within their natural settings, providing rich and detailed insights into specific contexts (Creswell, 2013).

The case study research method guided this study, which is an in-depth, contextually rich investigation of a particular phenomenon within a real-life setting (Yin, 2018). Case study research is particularly valuable when exploring new, complex, or under-researched areas, providing a detailed understanding of the subject in question. In this study, the case study approach allowed the researcher to analyze how argumentation practices influenced the students' argumentation skills and their views on socioscientific issues.

Participants

The participants in this study were 31 eighth-grade students from a public school in Aydın, Turkey. Their backgrounds were diverse, encompassing a wide range of academic abilities, interests, and learning styles. The group included students who were highly engaged in science and showed a natural curiosity about societal issues, as well as those who appeared less motivated and often needed additional encouragement to participate in class discussions. Many of the students came from families with varying levels of education, which influenced their prior knowledge and understanding of science-related topics. While some students had an advanced understanding of environmental issues and were able to discuss topics like climate change, GMOs, and renewable

energy with a high degree of insight, others struggled to grasp the complexities of these issues and often relied on simple, factual explanations.

To deepen the insights into how argumentation skills were developed, purposive sampling was used to select groups for face-to-face interviews. Purposive sampling is a targeted approach often used in qualitative research to focus on specific cases that represent extreme or particularly informative instances related to the research problem. This method enabled the researcher to gain a more nuanced understanding of the variables at play by selecting participants who exhibited rich and varied levels of argumentation (Yıldırım & Şimşek, 2018). Specifically, the study aimed to investigate the perspectives of three distinct groups based on the quality of their arguments: high-level, moderate-level, and low-level argument producers. By focusing on these extreme cases, the study sought to capture the breadth of students' argumentative development and provide a detailed examination of how different levels of argumentation manifested in the context of socioscientific issues.

In terms of their interaction with the content, students exhibited a range of engagement during argumentation-based activities. Some actively participated, presenting well-structured arguments, providing evidence, and engaging in respectful debates with their peers. Others, however, were more reserved, often waiting for their classmates to take the lead in discussions. Despite these differences, over the course of the study, many students showed significant improvement in their ability to formulate arguments, ask critical questions, and consider multiple perspectives. These changes were particularly evident in their increased confidence and willingness to engage in discussions that required deeper reasoning and reflection.

The students' personal engagement with the socioscientific issues discussed in class also varied. For some, topics like the use of pesticides or nuclear energy sparked strong emotional reactions, leading them to actively seek out information and challenge existing viewpoints. For others, these issues seemed distant, and their engagement was more passive, focusing on memorizing facts rather than critically engaging with the material. However, the structured nature of the argumentation activities allowed students to gradually build their argumentative skills, transforming their initial passive engagement into more active participation. The influence of the classroom environment, teacher guidance, and peer interactions also played a crucial role in shaping how the students approached the socioscientific topics and how effectively they developed their argumentation skills.

This thick description highlights not only the academic profiles of the students but also their personal motivations, the socio-cultural context that influenced their learning, and how these factors interacted to shape their experiences during the study. Through this detailed portrayal, the study provides a nuanced understanding of how students' backgrounds, their engagement with the content, and the learning environment contributed to the development of their argumentation abilities.

Study Context

This study was conducted over a 14-week period and aimed to investigate students' argumentation skills through the integration of Toulmin's model of argumentation in socioscientific contexts. The procedure consisted of several phases, including instruction, argumentation activities, data collection, and evaluation. In the initial phase, students were introduced to Toulmin's model of argumentation and engaged in sample activities to familiarize themselves with the structure of claims, evidence, and rebuttals. This preparatory phase lasted four weeks (eight class hours), ensuring that students had a solid understanding of the model before engaging in structured argumentation tasks. Following this, the main argumentation phase began, where students participated in discussions on predetermined socioscientific issues. Each session started with a short video, cartoon, or newspaper presentation providing engaging and relevant background information. This was followed by structured discussions in which students expressed their ideas, challenged opposing viewpoints, and attempted to persuade their peers by refuting counterarguments. Ample space and time were given for students to engage in argumentation-based discourse.

Eight student-generated activity sheets covering topics such as Endangered Species, Weight Loss Drugs, Geothermal Energy, Nuclear Energy, Base Stations, Agricultural Pesticides, Genetically Modified Organisms, and Climate Change were utilized. Students were encouraged to apply Toulmin's model throughout the discussions, and they documented key points. Each activity was discussed over a one-week period, with discussions being video- and audio-recorded for further analysis. Data collection involved multiple methods to assess students' argumentation skills and development over time. Pre- and post-interviews were conducted to examine students' initial perspectives and any changes in their reasoning abilities after the intervention. In addition, written argumentation responses were evaluated using the argumentation assessment rubric developed by Sadler and Fowler (2006).

To gain deeper insights, post-interviews were conducted with three students representing different proficiency levels high, middle, and low argumentation performance on a voluntary basis. These interviews were audio-recorded and analyzed to understand how students' argumentation skills evolved throughout the study. The recorded discussions, written argumentation assessments, and interview data provided a comprehensive understanding of students' engagement with socioscientific issues and the effectiveness of Toulmin's model in fostering structured argumentation skills.

Data collection tools

The data for this study were collected using three main tools: activity worksheets, classroom discussion videos, and face-to-face interview recordings.

Activity Worksheets: These worksheets were designed to guide students through structured tasks related to socioscientific issues and argumentation. They provided insights into the students' ability to engage with the content, organize their thoughts, and construct arguments.

Classroom Discussion Videos: Video recordings of classroom discussions were made to capture students' interactions during the argumentation activities. These videos allowed for an in-depth analysis of how students articulated their arguments, responded to peers, and engaged with the socioscientific topics under discussion.

Face-to-Face Interview Recordings: After the implementation of the activities, face-to-face interviews were conducted with selected students. These interviews aimed to gain a deeper understanding of students' reflections on the activities, their thought processes, and their perspectives on the socioscientific issues discussed. The interviews were audio-recorded to ensure accurate data capture for subsequent analysis.

These data collection tools provided a rich and multifaceted view of the students' engagement with the argumentation process and their development of argumentation skills.

Validity and Reliability

After the student activity sheets were created, they were theoretically grounded in the literature. To evaluate their appropriateness specifically, whether they aligned with Socioscientific Issue-Based Instruction and argumentation practices expert opinions were sought. One expert was a science education specialist, while the second was a science teacher with a master's degree in SSI and expertise in science education. Based on their feedback, the theoretical soundness of the activities and their suitability for 8th-grade students were assessed separately. Necessary revisions were made in accordance with their suggestions. To enhance the validity and reliability of the qualitative data, multiple strategies were applied. First, the triangulation strategy was implemented. Triangulation involves using data obtained through different methods such as observations, interviews, document analysis, video, and audio recordings to cross-validate findings (Yıldırım & Şimşek, 2018). In the second phase, participant confirmation was conducted to further ensure validity and reliability. This process involved presenting research findings back to the participants to prevent misinterpretation of the data (Yıldırım & Şimşek, 2018). Additionally, face-to-face interviews were carried out with students selected through outlier sampling, allowing for a deeper exploration of varying perspectives. This approach strengthened the data triangulation process by complementing written arguments with oral argumentation data. Furthermore, the qualitative data analysis process was described in detail using thick description, ensuring transparency and rigor in interpretation. Lastly, an expert review strategy was applied to reinforce the reliability of the study. In this stage, specialists in qualitative research methods critically examined all aspects of the study including data collection, analysis, and conclusions offering constructive feedback to enhance research quality (Yıldırım & Şimşek, 2018).

Data Analysis

In analyzing the data obtained from student activity sheets, Sadler and Fowler (2006) was used in the argumentation assessment rubric. The argumentation levels assessment rubric consists of five levels. The rubric levels are shown in Table 1.

Table 1. Argumentation Evaluation Rubric Developed by Sadler and Fowler (2006)

Score	Description
0	No Justification
1	Justification with no grounds
2	Justification with simple grounds
3	Justification with elaborated grounds
4	Justification with elaborated grounds and a counterposition

When analyzing students' argumentation levels, not every sentence was accepted as justification. Instead, emphasis was placed on the coherence between their justifications and arguments. Additionally, in the section on persuading the opposing view,

students were not simply attempting to convince their opponents but were primarily engaged in refuting counterarguments, sometimes even challenging their own initial ideas. The analysis was conducted in two different stages by the researcher. During this process, students with varying levels of argumentation skills attempted to convince each other through structured discussions. At the conclusion of the study, students participated in three data collection methods: discussion sessions , written argumentation tasks , and oral interviews . The results were presented in tables and graphical formats, displaying students' argumentation levels, their ability to defend socioscientific issues, and their perspectives based on argumentation performance.

FINDINGS

The study includes a total of eight activities, and reporting on all of them could excessively broaden the scope of the article, potentially hindering the reader's ability to develop a deep understanding of the topic. Additionally, detailed explanations for each activity could disrupt the flow of the article, leading to a shift in focus. In this context, only three activities, genetically modified organisms, nuclear energy, and agricultural pesticides, were selected to allow for a more in-depth analysis and a more effective presentation of the study's findings. This choice begins with addressing the activities at the start of the study, then moves on to more complex and impactful topics, which reflect the essence of the subject. Furthermore, these activities are not only scientifically controversial but also have significant societal implications, making it possible to place these findings within a broader academic context. As a result, focusing solely on these three activities was a strategic decision aimed at enhancing the scientific depth and academic value of the study.

In first activity, students' argumentation skills about GMOs were examined. The students were asked the question "Do you think the genetics of living organisms should be changed?" and students were asked to write down their ideas. The results of written argumentation In light of the data, student levels are shown in Figure 1.

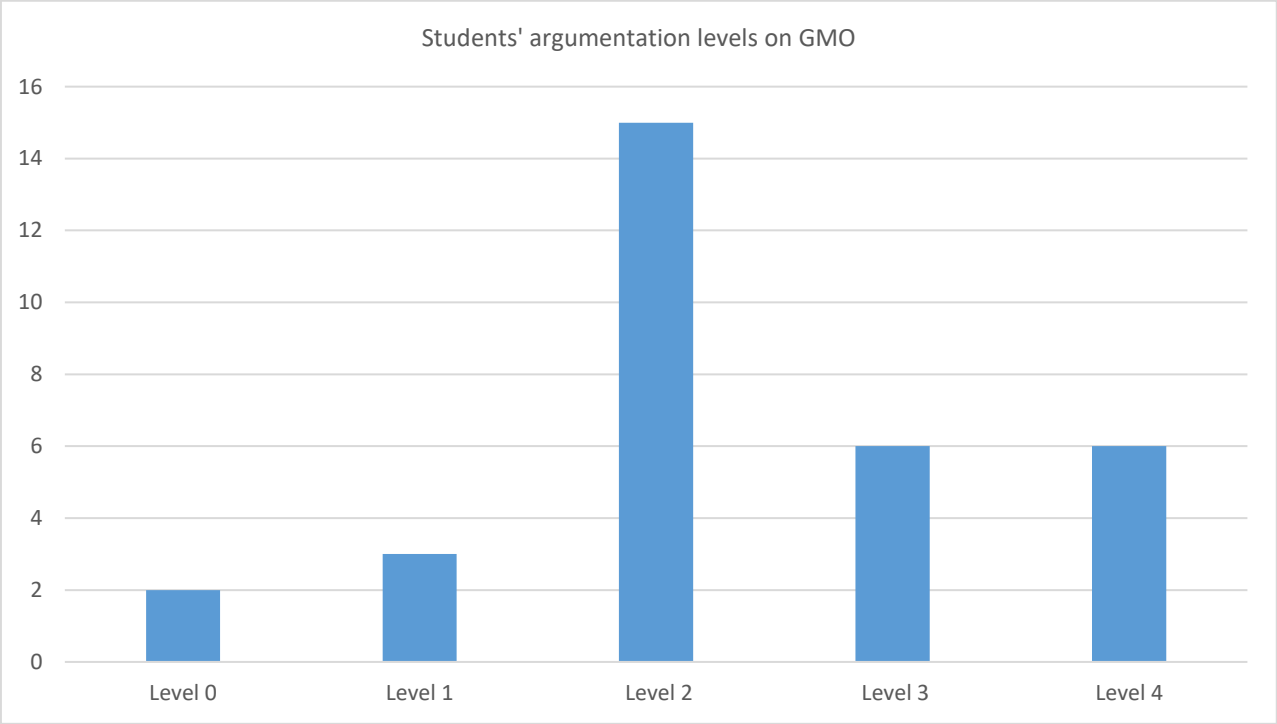

Figure 1. Students' argumentation levels on genetically modified foods

When analyzing the Figure 1, it is observed that 2 students are at Level 0, 3 students at Level 1, 15 students at Level 2, 6 students at Level 3, and 6 students at Level 4. The results indicate that students demonstrated varying levels of argumentation skills. Additionally, their views on GMOs were diverse: 4 students supported GMOs, while 28 opposed them.

Table 2. Arguments For and Against GMOs Based on Preservice Teachers' Responses

Category	Code	Frequency	Excerpt
For GMO	Yield and quality Increase	4	GMOs increase the yield of crops.
	Nutritional need	3	Hunger thanks to GMO crops problems can also be prevented
	Pesticide use reduction	2	Reduces the use of pesticides
	Economy	1	So we can grow more resilient crops our economy grows.
Against GMO	Health	24	GMO products cause cancer
	Ecological balance	20	It also destabilizes the ecosystem
	Biological pollution	8	Genetic pollution occurs when GM pollen is released into the environment
	Economy	3	GMOs will bankrupt farmers

When Table 2 is analyzed, it is evident that most students oppose GMOs. Those in favor of GMOs argue that they enhance crop yield and quality, alleviate food shortages, offer economic benefits, and reduce pesticide use. Conversely, students against GMOs believe they pose health risks, disrupt ecological balance, contribute to biological pollution, and threaten biodiversity. Table 4.26 below presents students' views on GMOs based on their argumentation levels.

Table 3. Distribution of Student Views on GMOs Across Reasoning Levels

Student views	Level 0	Level 1	Level 2	Level 3	Level 4
Increasing yield and quality		1	1	1	1
Nutritional needs			1	1	1
Reducing pesticide use			2		
Economy				1	
Health		2	14	5	3
Ecological balance		2	12	4	2
Biological pollution			3	2	3
Death of living organisms		1	3	1	1
Economy			2	1	

Table 3 presents the distribution of student views on genetically modified organisms (GMOs) across five reasoning levels (Level 0 to Level 4). The thematic categories encompass both supportive and critical perspectives. The majority of higher-level reasoning responses are concentrated in the "health" and "ecological balance" categories, indicating a deeper engagement with the potential risks of GMOs. Conversely, themes such as "reducing pesticide use," "nutritional needs," and "increasing yield and quality" are represented by fewer students and are generally associated with lower or mid-level reasoning. These findings suggest that students are more likely to provide detailed and complex reasoning when discussing perceived negative consequences of GMOs. At the conclusion of the evaluation, interviews were conducted with students representing high, medium, and low argumentation levels. The following excerpt is from an interview with a student at the medium argumentation level:

Researcher: Do you think there are people who hold different views from yours?
Participant: Of course, there are.
Researcher: How do you think they perceive the issue?
Participant: They likely believe that GMOs contain harmful chemicals, making them more dangerous for human health. That's their perspective.
Researcher: How would you persuade those who disagree with you by challenging their arguments?
Participant: If we use GMOs, we can produce higher yields, increase economic gains, and protect crops from pests. Without

GMOs, pests could destroy nearly half of our crops, leading to lower yields and financial losses. Eventually, this could result in food shortages. Countries might even engage in conflicts to secure food supplies, and societal tensions could rise. To prevent such consequences, we should embrace GMOs.

Researcher: Thank you for sharing your thoughts.

In this activity, students' argumentation skills regarding agricultural pesticides were examined. They were asked the question, *"Do you think agricultural pesticides should be used?"* and were requested to write down their opinions. Based on the data obtained from their written argumentation, students' argumentation levels are presented in Figure 2.

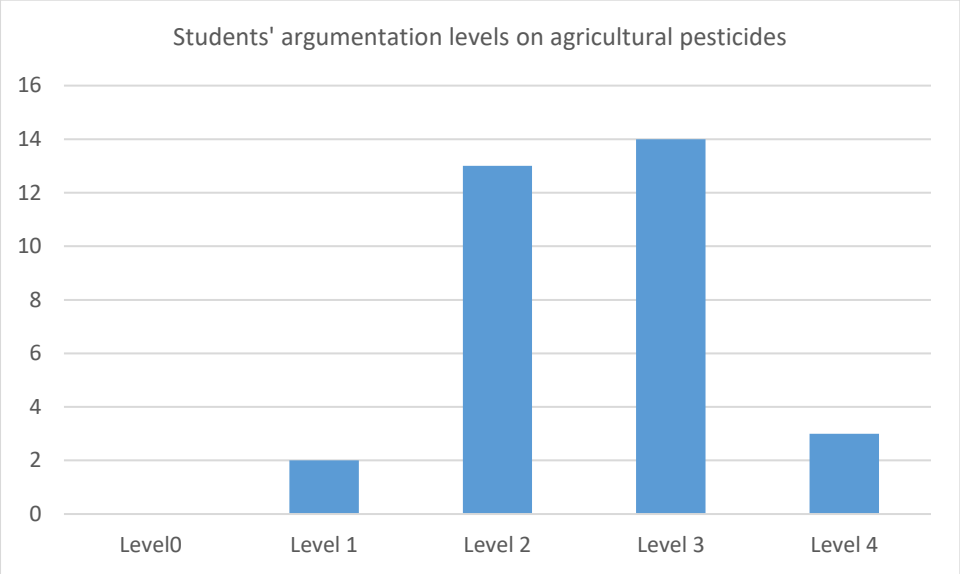

Figure 2. Students' argumentation levels on agricultural pesticides

Upon examining the figure, it is evident that no students were at level 0. Two students demonstrated level 1 argumentation, 13 students reached level 2, 14 students achieved level 3, and 3 students demonstrated level 4 argumentation. Students' stances on the establishment of base stations are presented in Figure 2. It is observed that 19 students support the use of agricultural pesticides, while 13 students oppose it. The number of students who support the establishment of base stations and those who oppose it are very close to each other. The students' views on the use of agricultural pesticides are shown in Table 4.

Table 4 Arguments For and Against the Use of Agricultural Pesticides Based on Student Responses

Category	Code	Frequency	Sample Quote
Agricultural Pesticides Should Be Used	Protects Plants	15	"It protects the plants from harmful insects."
	Increases Yield	18	"Thanks to these pesticides, the yield of our products increases."
	Economy	9	"Without agricultural pesticides, our crops wouldn't grow, and we would face financial difficulties."
	Prevents Famine	8	"Since it increases the productivity of trees, more people can be fed."
	Prevents Trees from Drying	10	"Our trees don't dry out thanks to these pesticides."
Agricultural Pesticides Should Not Be Used	Health	12	"Agricultural pesticides cause cancer."
	Harm to Living Creatures	5	"If we spray pesticides, we also kill harmless creatures."
	Ecological Balance	5	"If we use pesticides, all insects die, and the ecological balance is disrupted."
	Environmental Pollution	4	"It causes soil and environmental pollution."

Upon reviewing Table 4, it becomes evident that students hold diverse perspectives on the use of agricultural pesticides. Those in favor of their use argue that these pesticides protect plants, enhance crop yields, prevent famine, and safeguard trees from drying out. Conversely, students who oppose the use of agricultural pesticides emphasize their detrimental effects on health, the

death of living organisms, the disruption of ecological balance, and environmental pollution. Table 5, presented below, illustrates Distribution of Student Views on Agricultural Pesticides Across Reasoning Levels.

Table 5. Distribution of Student Views on Agricultural Pesticides Across Reasoning Levels

Student Views	Level 0	Level 1	Level 2	Level 3	Level 4
Protects Plants	1	5	7	2	
Increases Yield	1	6	9	2	
Economy	3	5	1		
Prevents Famine	1	3	3	1	
Prevents Trees from Drying	3	5	2		
Health	1	6	4	1	
Harm to Living Creatures	1	2	2		
Ecological Balance	2	2	1		
Environmental Pollution	1	1	1		

Table 5 illustrates the distribution of student responses regarding the use of agricultural pesticides across five levels of reasoning (Level 0 to Level 4). The thematic categories reflect both supportive and opposing views, with frequencies indicating how many students expressed each view at the respective reasoning level. The data reveal that justifications related to "increasing yield" and "protecting plants" are more commonly associated with higher levels of reasoning, suggesting a more developed understanding. In contrast, arguments concerning "environmental pollution" and "ecological balance" tend to be concentrated at lower reasoning levels, indicating less elaboration and conceptual depth in those areas. At the end of the evaluation, interviews were conducted with students who had the highest, medium, and lowest argumentation levels. A part of the interview with a student who demonstrated medium-level argumentation is as follows:

Researcher: So, should agricultural pesticides be used, in your opinion?
Participant: Yes, they should be used.
Researcher: What data do you base your thoughts on?
Participant: They increase the yield significantly. One becomes ten, and ten becomes fifty. It maximizes the yield, and it's already been proven.
Researcher: What are the reasons behind your way of thinking?
Participant: Since they increase the yield, we earn more money, and it's better financially.

In this activity, students' argumentation skills regarding nuclear energy were examined. The question "Do you think nuclear power plants should be built?" was asked to the students, and they were asked to write down their opinions. Based on the written argumentation, the students' argumentation levels are shown in Figure 3.

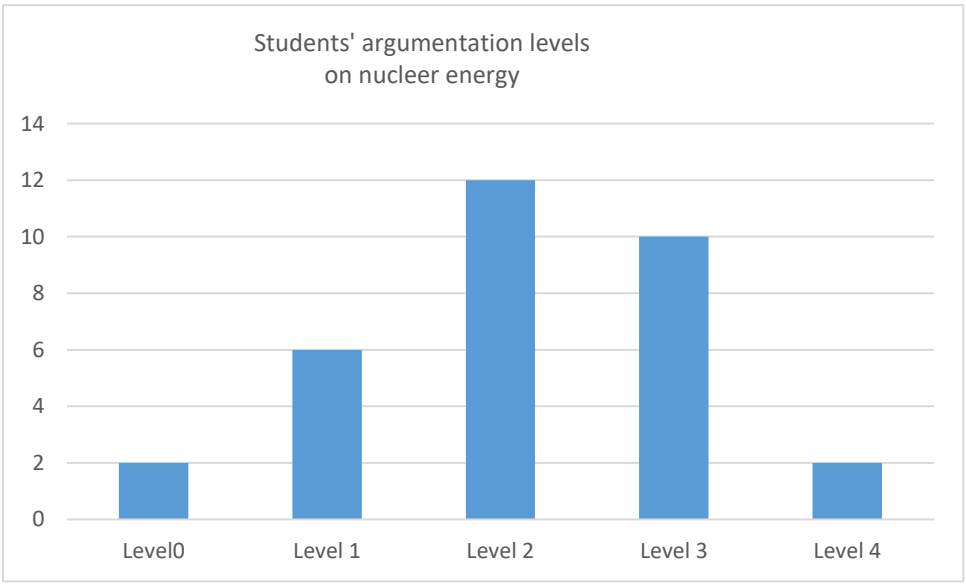

Figure 3. Students' argumentation levels on nucleer energy

When examining Figure 3, it can be seen that 2 students demonstrated level 0 argumentation, 6 students demonstrated level 1, 12 students demonstrated level 2, 10 students demonstrated level 3, and 2 students demonstrated level 4 argumentation. The students' views on the establishment of nuclear power plants are shown in Table 6.

Table 5. Student Arguments For and Against the Construction of Nuclear Power Plants

Category	Code	Frequency	Sample Quote
Nuclear Power Plants Should Be Built	Increased Development	7	"Thanks to nuclear energy, we could become one of the more developed countries in the world."
	High Energy Production	14	"It produces more energy than wind turbines and coal."
	Minimal Environmental Impact	13	"Nuclear energy has very low greenhouse gas emissions."
	Safety	7	"Nuclear power plants are as reliable as airplanes."
	Independent Energy Production	2	"Production can be maintained at the same capacity throughout the year."
	Economic	3	"Nuclear energy would also improve our economy because we wouldn't need to buy energy."
Nuclear Power Plants Should Not Be Built	Risk of Explosion	9	"If nuclear power plants explode, millions of people could die."
	Weapon Production	3	"Weapons that kill people are also produced in these plants."
	Harm to Living Creatures	10	"The radioactive materials it emits cause cancer in people."
	Radiation Emission	6	"The radiation emitted by nuclear energy would make the world uninhabitable."
	Birth Defects and Deaths	6	"Nuclear energy increases the chances of children being born dead or with disabilities."

When examining Table 5, it can be seen that students have very different views on nuclear power plants. Students who support nuclear power plants argue that the establishment of these plants would increase the country's level of development, allow for high levels of energy production, enable electricity generation independent of climate conditions, positively impact the economy, and be reliable. On the other hand, students who oppose nuclear power plants believe that these plants pose a risk of explosion, harm living creatures, emit radiation, could lead to birth defects and stillbirths, and could be used for weapon production. Table 6 below shows Distribution of Student Views on Nuclear Power Plants Across Reasoning Levels

Table 6. Distribution of Student Views on Nuclear Power Plants Across Reasoning Levels

Student Views	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**
Increase in Development	3	3	1		
High Energy Production	3	5	5	1	
Minimal Environmental Harm	3	5	3	1	
Safety	1	3	2	1	
Ability to Produce Energy Independent of Climate	1	1			
Economic	2	1			
Explosion Risk	1	5	2	1	
Weapon Production	2	1			
Harm to Living Creatures	2	4	3	1	
Radiation Emission	1	3	2		
Birth Defects and Stillbirths	1	2	1	1	

Table 6 displays the distribution of student perspectives on nuclear power plants across five levels of reasoning. The categories include both positive and negative views. Themes such as "high energy production" and "explosion risk" are prominent across multiple reasoning levels, indicating varied depth in students' understanding. Positive aspects like "minimal environmental harm" and "safety" generally appear at mid to higher reasoning levels, while concerns such as "weapon production" tend to cluster at lower levels. This distribution suggests that students engage with both the benefits and risks of nuclear energy, though the complexity of their reasoning varies by theme. At the conclusion of the evaluation, interviews were conducted with students

representing the highest, medium, and lowest levels of argumentation. Below is an excerpt from the interview with a student demonstrating high-level argumentation:

Researcher: Do you think nuclear energy should be established?
Participant: Yes, I believe nuclear energy should be established.
Researcher: And what evidence supports your opinion?
Participant: Nuclear energy should be established because, compared to other power plants, it can generate electricity many times more efficiently and can provide energy year-round.
Researcher: What are the reasons behind your perspective?
Participant: The risk of explosion in nuclear power plants is very low, about one in a thousand. While they do emit radioactive material, it is not harmful. This does not cause significant problems, and in the long term, establishing nuclear plants would bring us closer to other developed countries in terms of advancement. Additionally, it would reduce our dependency on foreign energy.

DISCUSSION, CONCLUSION AND SUGGESTIONS

This study aims to investigate the impact of argumentation-based activities on 8th-grade students' views on socioscientific issues. To achieve this objective, students' perspectives on socioscientific topics were examined following the implementation. Additionally, students' opinions on discussing current socioscientific issues using the argumentation method were explored. Based on these findings, recommendations were provided to guide researchers planning similar activities in future studies.

The students' argumentation skills regarding GMOs were examined, and they were asked, "Do you think the genetics of living organisms should be altered?" It was found that most students were against GMOs. Students supporting GMOs argued that GMOs increase the yield and resilience of crops and prevent food shortages. However, it was observed that these students were fewer in number and less effective in the argumentation process compared to those who opposed GMOs. Literature supports these findings. Bilen and Özel (2012) found that middle school students supported GMOs because they believed it would allow farmers to produce more. Similarly, Topaloğlu (2019) found that seventh-grade students were more likely to support GMOs due to the positive impacts they believed GMOs have on humans, animals, and plants. Students against GMOs argued that they are harmful to human health, disrupt the ecological balance, cause biological pollution, and lead to the death of organisms. Analyzing the students' responses, it was evident that they opposed GMOs primarily due to their perceived harmful effects on health and the ecological balance. Supporting literature, such as the study by Yılmaz, Üner, and Ercan (2015), found that 83.2% of university students believed GMOs are harmful to health, and 78.5% thought GMOs disrupt the ecological balance. Additionally, Çankaya and İşçen (2015) found that almost all science teacher candidates considered GMOs harmful. In this activity, students who opposed GMOs were more successful in generating arguments and refuting the opposing side's points. However, due to students' limited exposure to GMOs and the remote learning setting during their eighth-grade year, many struggled to generate strong arguments. Several students repeated the same arguments raised by others, which were also reflected in their written arguments. As a result, approximately 20 students produced arguments at level 2 or below, highlighting how foundational knowledge plays a crucial role in debates.

The students' argumentation skills regarding agricultural chemicals were also assessed by asking, "Do you think agricultural chemicals should be used?" Nineteen students supported the use of agricultural chemicals, while thirteen opposed them. All students participated in the discussion, expressing their opinions. Many students' families are engaged in farming, and these chemicals are commonly used, which may explain their higher level of interest in the topic. It can be concluded that students are more engaged with socioscientific issues they encounter in daily life, and such topics can lead to more effective learning by fostering active participation. Students supporting the use of agricultural chemicals argued that they protect plants, enhance their resistance, increase yield, prevent tree death, boost economic income, and prevent shortages. Research by Gültekin (2019) aligns with this view, finding that farmers use agricultural chemicals to address plant diseases, harmful insects, and weeds, thereby improving the yield and quality of their crops. Similarly, Uzundumlu, Kılıç, and Tozlu (2017) found that farmers in hazelnut production used agricultural chemicals to eliminate pests, including the hazelnut worm. Students opposing agricultural chemicals argued that these substances harm health, cause deaths, contribute to environmental pollution, and disrupt ecological balance. This view is supported by Özkan, Akçaöz, and Karadeniz (2003), who found that 70.4% of citrus producers in Antalya believed agricultural chemicals left residues in products, and 96.8% of them noted the negative environmental impact of excessive pesticide use. During the discussion, students who actively used these chemicals were particularly vocal, developing diverse arguments to persuade the opposing side. Only two students produced arguments below level 2, indicating their limited knowledge and interest in the topic. Socioscientific issues often involve dilemmas and do not have clear-cut answers (Sadler, 2004). As a result, individuals must make choices when faced with such topics. Even though students recognized the potential harms of agricultural chemicals, some argued that they were necessary, reflecting the complex nature of socioscientific issues. Additionally, some students pointed out that the negative impacts of agricultural chemicals were unethical or even sinful from a religious perspective. This illustrates that engaging with socioscientific topics contributes to the development of students' moral and ethical understanding. Teaching

such issues through argumentation is crucial for nurturing individuals who can think critically, evaluate different perspectives, and contribute to solving real-world problems (Driver, Newton, & Osborne, 2000).

The students' argumentation skills regarding nuclear energy were also explored with the question, "Do you think nuclear power plants should be established?" During the discussion, it was observed that students did not show as much interest in nuclear energy power plants as they did in geothermal energy systems, and fewer students actively participated. This is likely because nuclear power plants are not present in their region, and the students lacked sufficient knowledge about them. While 20 students supported nuclear power plants, 12 were opposed. Those in favor argued that nuclear power plants produce large amounts of electricity, cause less environmental damage, are reliable, generate energy independent of climate conditions, are cost-effective, and contribute to the development of the country. These students highlighted the importance of energy production and self-sufficiency for national development, reflecting an awareness of the challenges faced by a country with growing energy demands and limited resources (Çalışkan, 2009). Furthermore, the fact that most students emphasized the lower environmental impact of nuclear energy indicates that they care about environmental sustainability. Research by Sağlam (2016) found that most teacher candidates supported the construction of nuclear power plants, aligning with the students' views in this study. Similarly, Tekgöz and Yalman (2020) found that science teachers supported nuclear power plants due to their potential to meet energy needs and reduce dependence on foreign sources. Opponents of nuclear energy argued that nuclear power plants pose a risk of explosions, release harmful radiation, harm living organisms, and cause stillbirths. These students were particularly concerned about the health and safety risks associated with nuclear power plants, suggesting that they valued human health over energy production. Sürmeli, Duru, and Duru (2017) found similar concerns among teachers regarding the risks of nuclear accidents and environmental degradation caused by nuclear energy. Although 130 students made efforts to defend their positions, the lack of participation from some students prevented the discussion from reaching the desired level of argumentation. The fact that students had never seen a nuclear power plant or fully understood how they generate energy contributed to their inability to produce advanced arguments. Therefore, it is important to select socioscientific issues that students are likely to encounter in their daily lives, as they are more likely to engage deeply with these topics. Furthermore, it is essential to provide foundational knowledge before debates to ensure that students can participate in meaningful discussions.

This study aimed to assess students' argumentation skills regarding genetically modified organisms, agricultural pesticides, and nuclear energy. The findings revealed that most students expressed opposition to GMOs, emphasizing health risks and ecological imbalance. However, those in favor of GMOs presented arguments related to increased crop yield, resilience, and food security. Similarly, in the debate about agricultural pesticides, students who supported their use highlighted benefits such as pest control and increased agricultural productivity, while opponents raised concerns about health risks and environmental harm. In the discussion on nuclear energy, while some students supported it due to its potential for high energy production and environmental benefits, others expressed concerns about safety risks and the potential for harm to living organisms.

The results underscore the importance of students' knowledge in shaping their arguments, as well as the influence of real-life experiences with socioscientific issues on their engagement and perspectives. It also became evident that while students demonstrated an understanding of the issues, many struggled with higher-level argumentation due to limited exposure to relevant information and limited opportunities for in-depth discussions.

It is recommended that researchers enhance informational support for future studies. To improve argumentation skills, students need a solid foundation of knowledge on complex socioscientific issues. This can be achieved by incorporating more detailed lessons, case studies, and debates that present diverse perspectives. On the other hand, Teachers should cultivate an environment that promotes active student engagement, particularly in debates on controversial topics. Encouraging all students to express their views, critically evaluate opposing opinions, and construct well-supported arguments can significantly enhance their critical thinking and argumentation skills. Further, effective facilitation of complex debates requires specific skills. Teachers should receive training to guide students in forming coherent arguments, critically analyzing opposing viewpoints, and using evidence to substantiate their claims. Such training could be integrated into ongoing professional development programs for science educators.

By implementing these recommendations, educators can better prepare students to engage thoughtfully with socioscientific issues, enhancing their understanding of complex problems and their ability to argue and debate effectively.

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Statements of publication ethics

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

Author Contribution Statement:

The research process's theoretical framework, methodology, and design were carried out in collaboration with the first and second authors. Data collection was carried out by the second author. Data analysis, evaluation of the findings was carried out by both authors, and manuscript drafting were carried out by the first author. The first author contributed to revising the study's methodological approach and the manuscript's final editing. Both authors read and approved the final version of the article.

Researchers' contribution rate

The study was conducted with equal collaboration of the researchers however it was reported by the first author.

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Ethics committee approval for the study was obtained at the Aydin Adnan Menderes University Ethics Commission meeting dated 17.11.2020 and numbered E.59911 with the research code 2020/18-III.

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