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A Socioscientific Scenario Development Process: An Example for Space Research*

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ABSTRACT

The purpose of this study is to develop a socioscientific scenario related to space research. The study consists of four parts: preparation of a draft scenario, obtaining expert opinions, revising and implementing the scenario. The selection of the topic, space research, was based on the following criteria: (i) being current, (ii) being realistic, (iii) including different aspects, (iv) familiarity of students with these topics, and (v) being part of the science curriculum. In developing the scenario content, various sources such as newspaper articles, research findings, scientific publications, popular science materials, teaching resources, websites, blogs, and reports were utilized. The scenario concludes with discussion questions. After developing the draft scenario, experts in science education, special education, and Turkish language education were consulted to evaluate the readability, comprehensibility, suitability for the study, and age level appropriateness. Based on the experts' feedback, the final version of the scenario was prepared and pilot tested with five gifted students. The pilot test results demonstrated that the scenario was effective in stimulating informal reasoning and revealing patterns of informal reasoning through the discussion questions. The research findings were discussed in the context of the literature, and recommendations for future research were provided.

Keywords: Socioscientific issues, scenario development, space research, informal reasoning

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1. INTRODUCTION

Advancements in science and technology not only provide solutions to societal problems but also frequently give rise to new uncertainties and risks. In many cases, the application and even development of various technologies based on scientific knowledge lead to new issues that trigger social debates and disagreements (Bossér & Lindahl, 2019; Lederman, Antink, & Bartos, 2014; Sadler, 2004). It is proposed that complex scientific issues that are both controversial and socially significant be addressed within the scope of "socioscientific issues" due to the common scientific and social factors at their core. Socioscientific issues emerge from the connection between science and society. By their nature, these controversial issues are not well-structured, and they lack direct answers or solutions, making them inherently open-ended. Moreover, they cannot be meaningfully addressed through memorized or well-rehearsed responses. They are complex in structure and lack definitive solutions. In this respect, socioscientific issues tend to be interpreted from multiple perspectives and have multiple potential solutions (Dawson & Carson, 2017; Eggert & Bögeholz, 2009; Klosterman, Sadler, & Brown, 2012; Lederman, Antink, & Bartos, 2014; Ratcliffe & Grace, 2003; Sadler, 2009b; Sadler & Zeidler, 2004; Yahaya, Nurulazam, & Karpudewan, 2016).

Socioscientific issues, while not new, primarily encompass real-world problems related to the environment and health that 21st-century individuals face. Current socioscientific issues often stem from dilemmas concerning biotechnology, environmental problems, and human genetics. Additionally, socioscientific situations are inherently part of students' daily lives and social experiences, making them topics they frequently encounter and are curious about (Evren & Kaptan, 2015). In this context, especially in the last 20 years, scientific studies related to socioscientific issues have been extensively addressed in the science education literature worldwide. Socioscientific issues such as global warming, climate change, alternative

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energy sources, recycling, conservation of biodiversity, animal experimentation, genetically modified organisms, stem cell research, cloning, gene therapy, and genome projects are among the socioscientific issues frequently discussed in the field of science education (Khishfe, 2013; Levinson, 2006; Mueller & Zeidler, 2010; Pedretti, 2003; Sadler & Zeidler, 2005; Topçu, Yılmaz-Tüzün, & Sadler, 2011).

In science education, by including socioscientific issues, the aim is to enhance students' skills and character development in decision-making, analysis, synthesis, evaluation, questioning, analytical and critical thinking, scientific discourse, ethical and moral reasoning, and understanding the relationships between socioscientific issues (Dolan & Zeidler, 2009; Evren & Kaptan, 2015; Öztürk & Yenilmez Türkoğlu, 2018; Zeidler, 2003). Thus, socioscientific issues provide effective contexts for the development of knowledge and processes contributing to scientific literacy, including evidence-based argumentation, consensus-building, ethical reasoning, and understanding and application of scientific content knowledge (Dolan & Zeidler, 2009; Eastwood et al., 2012; Sadler, 2009a; Sengul, 2019; Zeidler, 2003). Promoting scientific literacy, which involves discussing, interpreting evidence, and drawing conclusions in response to socioscientific issues, represents a fundamental goal of science education, and socioscientific decision-making embodies an integral component of this goal (Sadler & Zeidler, 2005). It is considered important for students to gain awareness of these issues, analyze different perspectives on the subject, and actively participate in evaluating the resulting dilemmas in detail when making final decisions, in order for them to become scientifically literate individuals (Lenz & Willcox, 2012; Öztürk & Yenilmez Türkoğlu, 2018). In this context, science educators expect to involve students in a kind of "real-world" problem-solving process where socioscientific issues are brought into the science classroom, and scientific knowledge and ways of thinking are integrated with discussions and decision-making related to issues directly relevant to students' lives (Abd-el-khalick, 2003). In this direction, one of the frequently used instructional tools in learning environments where socioscientific issues are addressed is scenarios (Dolan, Nichols, & Zeidler, 2009; Evren Yapıcıoğlu & Kaptan, 2017; Topçu, 2008). Socioscientific issues are represented by various names such as case studies, dilemmas, or short stories, but they are more commonly presented through the concept of scenarios (Atabey, Topçu, & Çiftçi, 2018; Knight & Mcneill, 2015; Shea, Duncan, & Stephenson, 2015; Tomas & Ritchie, 2015).

1.1. Socioscientific Issue Scenarios

Scenarios are texts that address a problem situation, completely derived from real life or entirely fictional, and consist of questions related to finding a solution (Evren & Kaptan, 2015). In the context of socioscientific context, scenarios are used to reflect situations that are relevant to students' daily lives, involving local, national, or global issues (Hartikainen-Ahia, Sormunen, Jäppinen, & Kärkkäinen, 2014). In scenarios where controversial topics are presented to the reader, a problem-based approach is adopted, where not all facts about the topic are known, the subject can be viewed from various perspectives, and the outcome is not predetermined. These types of problem-based role-playing scenarios empower participants to explore their beliefs, attitudes, and values surrounding an issue (Errington, 1997; Jarmon, Keating, & Toprac, 2008). Furthermore, socioscientific issue scenarios should have the capacity to enable ethical and moral evaluations, focusing on aspects such as society's lifestyle and solidarity, as well as the social impacts of the subject within the community. Considering the reality of the scenarios presented, it is expected that students will perceive them as interesting and relevant (Gustafsson & Öhman, 2013).

Socioscientific issue scenarios are generally characterized as attention-grabbing and intriguing as a data collection tool (Urhan, 2016). However, despite the availability of sources that provide scenario examples related to different socioscientific issues (Güven Yıldırım and Önder, 2020), how scenarios should be written is a topic that has not been sufficiently discussed in the literature (Atabey et al., 2018). At this point, the literature review conducted by Atabey et al. (2018) has shown that scenarios share some common characteristics. Accordingly, there is no consensus on how much and in what order to address them, but it has been observed that scenarios related to the subject include neutral, positive, and negative information as well as discussion questions. Additionally, certain features that scenarios should possess have been identified by various studies and researchers. One of these features is providing sufficient content to understand the topic in the scenarios (Dawson & Carson, 2017). In contrast, the presented content should not contain detailed information about the topic (Atabey et al., 2018). The reason for providing a limited information base is to ensure that students have some data to work with if they choose to use it and to eliminate the possibility of a lack of topic knowledge in their dialogues if they decide not to use any data (Iordanou & Constantinou, 2014). This is also associated with the aim of not providing participants with readily available information, evidence, or data to support their own opinions (Atabey et al., 2018). Scenarios should present a clear contrast that will bring out a range of positions and create discussions among students (Dawson & Carson, 2017). Throughout this process, it is essential to represent positive and negative views in a balanced manner without one prevailing over the other (Tsai, 2018).

In the preparation of socioscientific issue scenarios, apart from the general structure of the scenario, another important aspect to consider is the selection of the scenario topic. When choosing scenario topics, criteria such as contextual relevance, students' familiarity with the subject, current relevance, environmental or economic significance, realism, and alignment with the curriculum can be taken into account. After completing the topic selection, the literacy level of the target audience should be considered during the writing process, and the scenarios should be prepared in simple language. In this process, it is possible to draw upon different sources of information, such as science-related online news and local media (Atabey et al., 2018; Dawson & Carson, 2017; Tsai, 2018).

1.2. Statement of the Problem

This study is presented as part of more comprehensive research that examines the informal reasoning of gifted students on socioscientific issues including agricultural pesticide use, organ donation, space exploration, recycling, solar energy, global warming, and nanotechnology.

Informal reasoning is a form of reasoning conducted outside the formal contexts of mathematics and symbolic logic. It involves reasoning about causes and effects, as well as the advantages and disadvantages or pros and cons of specific propositions or decision alternatives (Means & Voss, 1996; Perkins, 1985). This type of reasoning aligns with the dilemmas faced by students when dealing with real-world problems that are dynamic, meaning that the premises can change as new information and perspectives emerge (Zeidler, Sadler, Simmons, & Howes, 2005). When attempting to learn and solve these controversial problems that lack definite solutions, individuals cannot rely solely on formal thinking processes, and they engage in informal reasoning processes (Kuhn, 1991; Perkins, Farady, & Bushey, 1991). In this regard, additional elements come into play in the process of arriving at possible solutions to controversial issues, which require the evaluation of moral or ethical concerns to some extent, as well as the conduct of critical inquiry into the matter (Gustafsson & Öhman, 2013; Zeidler & Nichols, 2009). Therefore, informal reasoning becomes particularly important in situations where information is less accessible or problems are more open-ended, controversial, complex, or poorly structured, especially when the subject requires an individual to construct an argument to support a claim. The skills of constructing and evaluating an argument are fundamental not only to formal reasoning but also to informal reasoning (McDonald & McRobbie, 2012; Means & Voss, 1996). Argumentation through socioscientific issues is a unique strategy that enables students to engage in critical thinking about real social problems (Dolan & Zeidler, 2009). In this regard, argumentation frameworks are widely used in the science education literature to analyze reasoning within the context of students engaged in socioscientific discourse (Dawson & Carson, 2017; Karışan, Yılmaz Tüzün, & Zeidler, 2017). One of the commonly used tools in examining informal reasoning, argumentation qualities, and decision-making skills related to socioscientific issues is scenarios (Dawson & Carson, 2017; Halim & Saat, 2017; Sadler & Zeidler, 2005; Settelmaier, 2003).

In the literature, similar or different scenarios have been developed for the socioscientific issues focused on in this study, with different purposes and involving participants of various ages and educational levels. For example, in studies involving middle school students, scenarios related to socioscientific issues such as biodiversity (Özcan, 2019), organ donation (Sevgi, 2016), space pollution (Kaya, 2019; Tezel & Günister, 2018), recycling (Akbaş, 2017; Burek, 2012), solar energy (Karamanlı, 2019), and global warming (Halim & Saat, 2017; Türe, 2018) have been utilized. Similarly, studies conducted with high school students have utilized various scenarios related to socioscientific issues such as global warming (Khishfe, Alshaya, BouJaoude, Mansour, & Alrudiyan, 2017; Sadler, Chambers, & Zeidler, 2004). Additionally, research carried out with undergraduate students has made use of scenarios related to socioscientific issues like biodiversity (Alred & Dauer, 2020), organ donation (Saylan, 2014), recycling (Tekin, 2018), and global warming (Al, 2015). Furthermore, in a study conducted with academics on the subject of global warming (Bell & Lederman, 2003), socioscientific issue scenarios were used.

When examining the scenarios used in these studies, it is observed that the scenarios have both similar and different characteristics. The prominent common features of the scenarios are the inclusion of neutral information and presenting dilemma situations (Bell & Lederman, 2003; Halim & Saat, 2017; Khishfe et al., 2017; Sadler et al., 2004; Sevgi, 2016). On the other hand, some scenarios are prepared in a news format (Al, 2015; Saylan, 2014; Sevgi, 2016), contrasting views are presented within different scenarios (Al, 2015; Saylan, 2014), concepts that can be related to multiple socioscientific issues are used together in the same scenario (Türe, 2018), and scenario lengths vary significantly, exemplifying the different characteristics of the scenarios. Therefore, socioscientific scenario development for different research purposes exhibits structural variations. This indicates the need for developing socioscientific scenario templates with similar structures for all the socioscientific issues addressed in this study. Furthermore, another important factor that played a significant role in the selection of the space research topic and the need for scenario development on this subject is that space research was still not extensively addressed in the literature at the time of this research. In this context, it is believed that developing a socioscientific scenario related to space research will contribute to the relevant literature. Additionally, it is believed that to provide researchers with the guidance they need to make scenario selections and develop their own scenarios according to their research objectives, it is necessary to enhance the diversity of socioscientific issue scenarios available in the literature.

1.3. Purpose of the Study

The purpose of this study is to develop a scenario that can be used both as a teaching tool and as a data collection tool for the socioscientific issue of space research.

2. METHODOLOGY

This research consists of four stages: preparation of the draft scenario, obtaining expert opinions, revising the scenario, and implementing the scenario.

2.1. Preparation of the Draft Scenario

The preparation of the draft scenario was completed in three stages: selection of the socioscientific issue, preparation of the scenario text, and creation of discussion questions.

2.1.1. Selection of the socioscientific issue

In this stage, the selection of the socioscientific issue to be addressed in the research was carried out. Multiple criteria were taken into account in choosing the socioscientific issue. These criteria were determined as follows: (i) being current, (ii) being realistic, (iii) encompassing various social, economic, ecological, and ethical aspects, (iv) being familiar to students, and (v) being part of the science curriculum (Baytelman, Iordanou, & Constantinou, 2020; Dawson & Carson, 2017; Öztürk, Eş, & Turgut, 2017; Sadler & Zeidler, 2004; Topçu, Muğaloğlu, & Güven, 2014). In this regard, the middle school science curriculum (Ministry of National Education, 2018) was examined by the researchers at the unit, topic area, concept, and achievement levels to identify topics and concepts that could be evaluated as socioscientific issues. During this process, various socioscientific issues such as biodiversity, organ donation, recycling, global climate change, solar energy, and power plants were found to be distributed throughout the curriculum's learning areas. In this study, the focus was on the socioscientific issue of space research, chosen as one of the socioscientific issues present in the curriculum.

2.1.2. Preparation of the scenario text

Before preparing the socioscientific scenario on space research, a literature review was conducted. During this process, studies that addressed space pollution as a socioscientific issue and the scenarios used in these studies were examined. In developing the content of the scenario, various sources were utilized, including newspaper articles presenting the current state of space research and reflecting different perspectives, research findings and scientific publications from various fields in the literature, popular science publications, teaching resources, websites, blogs, and reports of relevant institutions and organizations.

In the presentation of the space research scenario, some preliminary information about space research was provided to prevent potential bias arising from students' prior knowledge (Chang & Chiu, 2008) and to ensure that students have a basic understanding of the key concepts central to the topic. Structurally, the scenario adopted the approach of including neutral information, positive information, negative information, and discussion questions related to the topic (Atabey et al., 2018). As a result, the scenario was structured into four sections. In this context, the first section presented neutral information (95 words) about the space research and its outcomes, introducing the key concepts of the topic. The second section included positive information (199 words) about space research, while the third section presented negative information (195 words) related to the topic. The final section included discussion questions that would guide participants toward making decisions regarding the continuity of space research. In writing the scenario, the relevant age and educational level were taken into consideration. The necessary content to understand the topic was provided in sufficient and simple language. The information presented is scientifically accurate.

2.1.3. Creation of discussion questions

At the end of this study's developed “Space Research” socioscientific scenario, there is a questionnaire consisting of open-ended questions prepared with the aim of eliciting informal reasoning regarding the dilemma presented in the scenario. Due to the expression of informal reasoning through argumentation (Sadler, 2004) and the examination of argumentation as an effective tool for accessing individuals' informal reasoning (Means & Voss, 1996; Zohar & Nemet, 2002), the questions included in the questionnaire at the end of the scenario have been created with a focus on the elements of argumentation (Toulmin, 2003). Additionally, while preparing the questions, similar studies in the literature were consulted for the same purposes (Sadler & Zeidler, 2005; Topçu et al., 2011; Wu & Tsai, 2007).

2.2. Obtaining Expert Opinions

After developing the draft scenario, experts in the fields of science education, special education, and Turkish language education were consulted to evaluate the readability, comprehensibility, suitability for the age level of the study group and clarity of the open-ended questions in the scenario. Initially, a list of experts who have researched socioscientific issues, reasoning, and argumentation in the literature, and whose opinions could be sought, was prepared based on the literature. Following the listing process, the experts were contacted via email or phone, and they were provided with information about the purpose of the study and requested to provide their expert opinions. Out of the seven contacted experts in the field of science education, six (two Prof. Dr., four Assoc. Prof. Dr.), one expert in special education (Assistant Prof. Dr.), and one expert in Turkish language education (Assistant Prof. Dr.) provided positive feedback and agreed to participate in the research. In the process of obtaining expert opinions, a form created by the researcher was utilized. The preparation of the expert opinion form took into account the characteristics that socioscientific issues, related scenarios, and discussion questions should possess, as described in the literature. Accordingly, ten criteria were established to assess the content and features of the scenario and discussion questions. Additionally, one more criterion was added to inquire about the suitability of the scenario

for the research's objectives and its potential use within the study. The provided criteria in the form required experts to choose between "yes," "no," or "partially" options and provide explanations for their selected choice in a two-stage format. The expert opinion form, along with the draft scenario, was sent to the experts. Consequently, the content and semantic appropriateness of the prepared scenario for use within the study were assessed through the expert opinion form.

2.3. Revision of the Scenario

After completing the expert opinions, the draft scenario was revised based on the feedback received from the experts. In this process, both the evaluations provided by the experts according to the criteria in the expert opinion form and their direct assessments of the scenario, which were not included in the form, were taken into account. The expert opinions and the modifications made to the draft scenario based on those opinions were detailed and explained to the experts with assigned code names.

Regarding the "Space Pollution" scenario, expert A mentioned that different perspectives on space research were presented clearly and understandably, but suggested providing the full names of abbreviations (such as GPS, MRI). Experts B, D, E, and F found the prepared scenario suitable for the research's purpose and sufficient in terms of the criteria stated in the expert opinion form, without making any modification suggestions. Expert C expressed that the scenario title could be guiding for students and therefore recommended revising it as "Space Research" for more appropriateness. Expert G pointed out that positive views were relatively dominant in the scenario and suggested that the scenario could be shortened.

Following the expert opinions, the title of the draft scenario has been revised to "Space Research" and the explicit explanation of abbreviations has been added to the scenario. The paragraphs containing contrasting views have been reexamined, and no changes were made to this section as they were approximately equal in length.

The expert opinions provided above include specific explanations and suggestions related to the socioscientific issue addressed in the scenario. In addition to those, the following actions were taken:

- Spelling errors identified by the experts were corrected, and the structure of some sentences and the terminology used were rearranged to be more suitable for the target age group.
- The verbs conjugated in the present continuous tense, as suggested by Expert C and due to students' higher consideration, have been rearranged to a more formal form.
- Expert C suggested that the questions at the end of the scenario should be clearer. In response to this, Expert A made some modifications to the wording and added new questions. The question group proposed by Expert A was adopted in the scenario, taking into account both Expert C's recommendation for clearer questions and Expert A's changes to the questions.

After the evaluations of the subject matter experts, the revised scenarios were sent to a Turkish language expert to assess their appropriateness in terms of language, expression, and spelling.

- Expert H stated that the scenario is suitable in terms of readability and comprehensibility for the target audience.
- The "Space Research" scenario, after the language, expression, and spelling corrections suggested by the Turkish language expert, is presented in Appendix.

2.4. Implementation of the Scenario and Analysis of Data

The pilot implementation of the developed "Space Research" socioscientific scenario was carried out with gifted 7th-grade students studying at Science and Art Centers to identify informal reasoning related to socioscientific issues. Initially, the research was announced to 7th-grade students and their parents at two different Science and Art Centers in Ankara. It was emphasized that participation would be voluntary, and the contact information of the first author was shared with the parents of students who expressed willingness to participate. After providing the necessary information about the implementation process, the Informed Consent Form was sent to the parents. As a result, the pilot application was conducted with 4 male and 1 female student who voluntarily participated in the research.

The implementation process was conducted online due to the ongoing Covid-19 pandemic, which has affected both our country and the whole world, leading to the continuation of education activities in an online format. During this process, the prepared scenario was conducted online through Google Forms, which allowed the creation, sharing, and real-time analysis of forms and surveys. In the following step, a meeting was scheduled using Zoom, a communication application that provides video and audio conferencing, phone systems, chat, and webinars, accessible through devices such as smart phones, tablets, laptops, PCs, and phones. Due to the participants' availability, they were collectively taken for the meeting during the pilot implementation, but each participant provided individual responses. During the session, the online scenario was shared with the participants. The session was completed within approximately 30-40 minutes, and to prevent data loss during the online application, the session was recorded with the participants' consent.

After the completion of the implementation, the data obtained through the scenario was analyzed according to the informal reasoning patterns developed by Sadler and Zeidler (2005). These patterns consist of three basic patterns: "Rational reasoning," "Emotional reasoning," and "Intuitive reasoning," along with various combinations of these three. According to

these authors, rational informal reasoning involves reasoning that is focused on reasons and based on logic. Emotional informal reasoning is a type of reasoning in which moral emotions such as empathy and sympathy shape decisions. It involves caring for the well-being of others and being considerate of those who might be affected by the decision. Intuitive informal reasoning, on the other hand, is a type of reasoning where decisions are influenced by immediate emotions or instinctual responses.

In the process of determining the patterns, the content analysis method was used to analyze the data obtained through socioscientific scenario narratives. Content analysis is a technique that allows for the examination of human behavior indirectly by analyzing the content of their communications, including all forms of communication such as textbooks, newspapers, cookbooks, songs, political speeches, advertisements, and images. Through this method, conscious and unconscious beliefs, attitudes, values, and ideas of an individual or group can often be revealed (Fraenkel & Wallen, 2009).

3. FINDINGS

The informal reasoning of the participants regarding the socioscientific issue of space research was interpreted by directly quoting their written responses to the discussion questions. When making quotations, the real identities of the participants were kept confidential, and code names provided by the researchers were used. In this context, a paragraph quoted from Işıl's written responses is presented below.

> *Işıl: I think we should not send [new satellites into space]... The space debris around the Earth [has influenced my decision]. Because if we send too many satellites into space, it could cause us significant troubles in the future. For instance, old satellite debris can collide with new satellites and cause damage. Or it could prevent space probes or spacecraft from reaching other places in the universe... Because in the pictures, it seems like the space around Earth is filled with satellites... Yes, satellites can make our lives easier. But if someone can give me good examples of how we can clean up space debris, I might be convinced...*

Işıl stated that we should not send new satellites into space. While explaining her reasons, she pointed out the potential satellite accidents that could occur if we continue sending satellites. She also mentioned that these accidents could prevent space vehicles from fulfilling their missions, highlighting the disadvantages of space research. On the other hand, by mentioning that satellites make our lives easier, she showed that she is aware of the advantages of space research and the opposing views on the topic. Additionally, when expressing that examples addressing the issue of space debris could be convincing for her, she evaluated that opposing views could also have reasonable and acceptable aspects. Thus, Işıl demonstrated rational informal reasoning by approaching the topic of space research from different perspectives.
A paragraph quoted from Arda's written responses is presented below.

> *Arda: No [we should not continue to send satellites to space]… As mentioned in the text, space debris can cause the following consequences: it can fall to Earth, collide with other satellites in space, and make space research infeasible due to fragmentation... He may want them to be sent because he might believe that sending more satellites could lead to obtaining more data... He may be right about gathering information about space, and he can convince me with solutions such as sending satellites less frequently or bringing back decommissioned satellites to Earth...*

Arda has decided that we should not continue to send satellites to space. While explaining his views, he utilized information from the scenario text and mentioned potential accidents that satellites could cause, thus drawing attention to some disadvantages of space research. By stating that more data could be obtained by continuing space research, he demonstrated awareness of opposing views on the topic. However, he also acknowledged that someone with a contrary opinion could be right in asserting that information could be gathered through this method. In doing so, he highlighted the advantageous aspects of space research. Additionally, Arda offered alternative solution proposals, such as sending satellites less frequently or ensuring that decommissioned satellites return to Earth. Overall, Arda exhibited rational informal reasoning by taking a multidimensional perspective.

A paragraph quoted from the written responses of another participant in the study, Cem, is presented below.

> *Cem: I think we should continue [sending various satellites to space]... When making my decision, the future influenced me the most. I believe that in the future, with new technologies, we will need more satellites. As the human population increases, there will be greater demand for satellites... He may think that we should not send more satellites due to the increase in space debris. He can persuade me by explaining that satellites can be damaged due to space debris...*

As seen in the above excerpt, Cem has decided in favor of continuing to send various satellites to space. He explains that he is most influenced by the future and believes that with new technologies, there will be a greater need for satellites in the future. In his explanation, he also infers that the increasing human population will contribute to this need. Thus, Cem makes a forward-looking prediction. Additionally, by mentioning the increase in space debris and the potential damage to satellites, he

acknowledges the opposing views and the validity of someone holding such a perspective. With these considerations, Cem demonstrates rational informal reasoning by taking into account different aspects of space exploration.

A paragraph quoted from Alp's written responses is presented below.

> *Alp: Yes, [we should continue sending satellites to space]... My decision was influenced by the belief that there are planets in space with different forms of life, similar to Earth, and we should continue sending satellites to explore them... The reason behind this thought is my belief that in space, which contains billions of solar systems, there cannot be only humans... Space is vast... If we launch satellites into space, we can discover new planets and find new materials on those planets, which can help us prevent pollution...*

As seen in the given excerpt, Alp has explained the reasons for his positive decision regarding sending satellites to space. He expresses that there are different planets in space, similar to Earth, and we should continue sending satellites to explore these planets. In continuation of his explanation, he mentions that space is vast and believes that there are not only humans in space. Furthermore, he mentioned that the new materials that can be discovered on these planets could be used to prevent space pollution. With these statements, Alp demonstrates intuitive informal reasoning, providing a response based on instinct rather than a logical evaluation.

Finally, a paragraph quoted from Mert's written responses is presented below.

> *Mert: I believe we should continue sending new satellites into space... My personal opinion is that we should keep developing ourselves as human beings. The technology we use was initially just a component used in space rockets. Later on, it evolved into dimensions that we can use. The presence of many more elements that can be discovered influenced my decision... I would tell my friend that human beings should continue to evolve and learn... His thoughts might be about not polluting space. Because everyone can think differently and provide different answers to certain things…*

According to the above excerpt, Mert has made a positive decision in favor of continuing to send new satellites to space. In explaining this decision, he pointed out the technologies that have become an integral part of our daily lives thanks to space research and mentioned that there could be even more such advancements in the future. Thus, Mert considered the advantages of space research during his decision-making process. Additionally, by expressing the need for continuous development and learning, he demonstrated a rationale-focused thinking approach. As a result, Mert utilized rational informal reasoning in the context of sending new satellites to space.

At the end of the implementation, each participant stated that they did not encounter any expressions they could not understand in the scenario. The pilot implementation results indicated that the space research scenario was effective in eliciting informal reasoning and revealing informal reasoning patterns through the discussion questions. Consequently, it was concluded that the scenario content and discussion questions met the specified criteria, and no editing was necessary in the scenario structure.

4. RESULTS, DISCUSSION AND RECOMMENDATIONS

This study is presented as part of a more comprehensive research aiming to examine the informal reasoning of gifted students regarding socioscientific issues. Within the scope of the study, the process of developing a socioscientific scenario on the topic of space research has been shared in detail.

According to expert opinions; it is observed that the "Space Research" scenario addresses a socioscientific issue; the scenario includes neutral information, counterarguments, and discussion questions related to the topic; opposing views are presented in a balanced manner within the scenario; the scenario has the potential to trigger informal reasoning and question elements of argumentation, and finally, it is prepared in accordance with the age and developmental level of the target group. Thus, the developed scenario possesses qualities that make it suitable as both a teaching tool in the instructional process and a data collection tool in the data gathering process for socioscientific issues. In this context, the scenario can be used by teachers in various ways to provide students with opportunities to engage with the socioscientific topic of space research, either in the classroom setting, in small groups, or individually. For instance, scenarios can be utilized to introduce socioscientific issues to students, and they can also be employed to explore students' argumentation skills and decision-making abilities (Dawson & Carson, 2017; Halim & Saat, 2017). Furthermore, by providing discussion questions, scenarios can be used to enhance students' argumentation skills, leading to the generation of more quality arguments that include qualifiers, evidence, and rebuttals (Dawson & Carson, 2017). Moreover, scenarios can be utilized in the investigation of informal reasoning. When used as a tool to address controversial issues, these dilemma-based stories can engage students in actions and processes such as empathizing with others, accepting alternative viewpoints, and reflecting on their own and others' emotions. This engagement can challenge students' rational, social, and emotional skills (Settelmaier, 2003).

Similar to the current research, there are studies in the literature that use scenarios related to space pollution socioscientific issues. For instance, in a study conducted by Kaya (2019), the impact of socioscientific-based science teaching on middle school students' scientific literacy and environmental literacy levels was examined. In the research process, a socioscientific text on space pollution was used. The text included neutral, negative, and positive information along with discussion questions. In the study conducted by Tezel & Günister (2018), a review was prepared by examining the existing studies in the field on the use of socioscientific issues in science education. Additionally, within the research scope, an example of an activity involving a science story related to space pollution socioscientific topic was presented. The story focused on space mining and its implications on space pollution as a socioscientific issue. As previously mentioned, different research purposes have resulted in diverse scenario structures. The current research also aims to contribute to the diversity of socioscientific scenarios found in the literature.

In future studies, researchers can contribute to the literature by developing various socioscientific issue scenarios for similar or different participant groups. In these studies, sharing the detailed development process of scenarios can serve as a guiding resource for researchers in making appropriate scenario selections according to their objectives. Additionally, by using the developed scenarios and sharing their outcomes, the characteristics of the scenarios can be evaluated, guiding the creation of new scenario-based studies.

Research and Publication Ethics Statement

The research complies with research and publication ethics.

Contribution Rates of Authors to the Article

Tuba Şenel Zor: Conceptualisation, data collection, data analysis, writing-original draft, writing-revision and editing. Mahmut Selvi: Conceptualisation, data analysis, writing-revision, editing and supervision. Oktay Aslan: Conceptualisation, methodology, data analysis, writing-revision, editing and supervision.

Statement of Interest

The authors do not have any conflict of interest in the study.

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APPENDIX

UZAY ARAŞTIRMALARI

İnsanlığın en büyük hayallerinden biri olan uzay yolculuğu, geçen yüzyılın ikinci yarısında Sovyetler Birliği tarafından, 4 Ekim 1957'de "Sputnik 1" adlı ilk uydunun uzaya fırlatılmasıyla gerçeğe dönüştü. Bu gelişmeden sonra sıra insanlı uzay yolculuğu yapmaya geldi ve yine Sovyetler Birliği tarafından 12 Nisan 1961'de "Vostok 3KA" roketiyle birlikte "Vostok 1" uzay kapsülü uzaya fırlatıldı. Böylece kapsülde bulunan Rus kozmonot Yuri Gagarin uzaya çıkan ilk insan olarak tarihe geçti. Uzay çalışmaları adına atılan bu ilk adımları, farklı devletler tarafından uzaya; uydular, roketler, teleskoplar, sondalar, uzay mekikleri ve uzay istasyonları gibi araçların gönderildiği birçok gelişme takip etti.

İlk uydunun uzaya gönderilmesiyle başlayan ve uzay çağı olarak ifade edilen bu dönem hayatımıza pek çok yenilikler getirmiştir ve getirmeye de devam etmektedir. Örneğin iletişim uyduları dünyadaki çok uzak noktalar arasında ses, görüntü ve veri aktarımını mümkün kılmıştır. Bugün kullandığımız ve iletişimi sağlayan; televizyon ve cep telefonu teknolojisi dünyanın yörüngesine gönderilen uydular sayesinde gerçekleşmektedir. Uydular, dünya üzerindeki geniş alanları kapsayabildikleri için yer gözlem görevlerinde de yoğun olarak kullanılmaktadır. Özellikle meteorolojik olayların takip ve ölçümünde, madencilik, okyanus ve deniz bilimleri, şehir planlama gibi çeşitli kamusal, ticari ve bilimsel uygulamalarda uydulardan faydalanılmaktadır. Bilmediğimiz bir yerde ya da bölgede yolumuzu bulmak için sıklıkla kullandığımız küresel konumlama sistemi (GPS) hizmeti de uydular aracılığıyla sağlanmaktadır. Uzay araçlarının insanlığa sağladığı bu doğrudan avantajlarının yanı sıra günlük yaşamımızın çeşitli alanlarında dolaylı avantajları da bulunmaktadır. Örneğin tıp alanında iç organların görüntülenmesini sağlayan Manyetik Rezonans Görüntüleme (MRI) cihazı, uzay araştırmaları sayesinde keşfedilen bir teknolojidir. Şarjlı elektrik süpürgesi de dâhil olmak üzere tüm kablosuz elektronik eşyalar, ilk kez uzay mekiklerinde kullanılan ve sonra insanlığın kullanımına sunulan teknolojilerdendir. Son zamanlarda oldukça popüler olan çizilmez güneş gözlükleri, yeni doğmuş bebeklerin vücut sıcaklığını ölçmek için kullanılan kulak termometreleri, toz bebek mamaları ve toz puding gibi gıda ürünlerinin temeli de uzay araştırmalarına dayanmaktadır.

Diğer yandan uzaya gönderilen tüm araçların Dünya'ya tekrar dönmediği bilinmektedir. Dünya'nın çevresinde, değişik yörüngelerde dönen ve artık herhangi bir işlevi olmayan, insan yapımı cisimlerin tümü, uzay çöpü olarak adlandırılmaktadır. Bunların arasında uzay aracı parçaları, bir uzay aracından kopan küçük boya lekeleri, roketlerin parçaları, artık çalışmayan uydular ve yörüngede oluşan patlamaların artıkları bulunmaktadır. Dünya'nın çevresinde yaklaşık 8.400 ton çöp olduğu tahmin edilmektedir. Bu çöp parçalarının çoğunun çok hızlı bir şekilde hareket ettiği ve saatte 28.968 km hıza ulaşabileceği bilinmektedir. Bu nedenle, çöp parçaları mevcut ve gelecekteki uzay araştırmaları ve araçları, bunların sağladığı hizmetler, uzaydaki ve yeryüzündeki insanlar için bir güvenlik riski oluşturmaktadır. Nasıl mı? Örneğin 1983'te, sadece tırnak büyüklüğündeki bir boya parçasının uzay mekiği Challenger'ın camına çarparak ciddi ve tehlikeli bir hasara yol açtığı bilinmektedir. Çöp parçalarının bir kısmının kütle çekimi ya da Güneş ışıması etkisiyle zamanla Dünya'ya düşebilecek olması, yeryüzündekiler için tehdit oluşturmaktadır. Asıl kaygı duyulan durum ise gelecekteki uzay araştırmalarına yöneliktir. Zaman içinde artan çöp miktarı sebebiyle bir dizi zincirleme çarpışmanın başlayacağı, çarpışmalar sonucunda büyük parçaların daha küçük parçalara bölüneceği ve çöp parçalarının da daha fazla artacağı düşünülmektedir. Bu artışın, bir gün uzay çalışmalarına onlarca yıllık bir ara verilmesine yol açabileceği ihtimali üzerinde durulmaktadır.

1. Sizce uzaya çeşitli uydular göndermeye devam etmeli miyiz?
2. Konu ile ilgili kararınızı nasıl verdiniz? Karar vermenizde ne/neler etkili oldu?
3. Bu düşüncenizin (kararınızın) nedenini gerekçeleri ile açıklayınız.
4. Sizinle aynı düşüncede olmayan bir arkadaşınızı hangi gerekçe/gerekçelerle ikna edersiniz?
5. Bu düşüncenizi kanıtlamak için söyleyebileceğiniz başka bir şey var mı? Var ise nelerdir?
6. Bir arkadaşınız bu konuda sizinle aynı görüşte değil. Onun düşünceleri neler olabilir? Neden farklı düşüncelere sahip olabilirsiniz?
7. Arkadaşınız kendi görüşünü destekleyecek ne tür açıklamalar (gerekçeler) sunabilir?
8. Sizinle farklı düşüncede olan bu arkadaşınız hangi durumda haklı olabilir ve sizi nasıl ikna edebilir?
9. Arkadaşınıza karşı kendi düşüncenizi (kararınızı) nasıl savunursunuz? Konu ile ilgili başvuracağınız kaynak/kaynaklar neler olur?

*Metin üzerinde kararınızı en çok etkileyen kelime/cümle/paragrafın altını çiziniz.