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How do gifted students reason about socioscientific issues?: a case study

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ABSTRACT

This study aims to examine the types of informal reasoning and the quality of arguments regarding socioscientific issues among gifted students. A multiple case study design was used in the research. The study group was determined using the criterion sampling method. The data were collected through the 'Participant Information Form,' 'Epistemological Beliefs Scale,' 'Socioscientific Issue Scenarios,' and 'Interviews.' The obtained data were analyzed using descriptive, descriptive statistical, and content analysis methods. The findings showed that the participants tended to engage in rational informal reasoning more frequently during the decision-making process on socioscientific issues and rarely resorted to emotional informal reasoning. Additionally, the majority of the participants developed high-quality arguments that included strong rebuttals. Finally, it was shown that all participants possessed complex epistemological beliefs. The research results indicate that gifted students: (i) have a deep understanding of the general characteristics and production process of scientific knowledge, (ii) demonstrate high-quality informal reasoning, but (iii) have not yet explored the emotional aspects of many socioscientific issues addressed in the study and have not approached these issues from a multifaceted perspective.

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Introduction

While developments in science and technology have brought significant innovations to our daily lives, they have also caused many undesirable problems to emerge through issues such as genetically modified foods, global warming, and nanotechnology (Jho et al., 2014). These kinds of issues often involve disagreements among various actors about the validity or reliability of certain claims related to science (Kolstø, 2001), and due to the scientific and social factors commonly at their core, they are referred to as 'socioscientific issues' (SSIs) (Sadler, 2004). SSIs differ from other topics in science in that they are subject to multifaceted perspectives and solutions, involve the products/processes of science, and generate social debates (Sadler & Zeidler, 2005b). They are centered on moral and ethical implications and have impacts on individual, societal, national, and global levels (Jho et al., 2014).

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In democratic societies, students, as citizens, are highly likely to encounter various SSIs. This situation forces students and their parents to make certain decisions on these matters (Wu & Tsai, 2007). Given the increasing importance of these issues, schools have the responsibility to prepare students for the future as informed citizens capable of making conscious decisions (Simonneaux, 2007). The necessity of advanced decision-making skills in SSIs is associated with the promotion of scientific literacy (Sadler & Zeidler, 2005b). Through SSIs, it is possible to address various aspects of scientific literacy, including inquiry, accessing and evaluating information, argumentation, and making informed decisions (Ekborg et al., 2013). Given the important role that SSIs play in both science education and citizenship education, exploring how students perceive, negotiate, and resolve these issues presents a necessary and significant area of research (Sadler & Zeidler, 2005b). In this regard, a large portion of the studies have focused on *informal reasoning* and *argumentation* in the context of *SSIs*., showing that these three research topics are closely related and widely studied by the science education community (Aziz & Johari, 2023).

Gifted individuals, as bright minds capable of proposing important ideas needed for societal advancement, solving global problems, and ensuring peaceful coexistence both now and in the future (Clark, 2015; Öztürk et al., 2017), are individuals with advanced qualities such as learning, creativity, art, and leadership compared to their peers (Ministry of National Education[MoNE], 2018). While it is possible to find a gifted child whose intellectual development is ahead of their peers among a randomly selected group of a hundred children, identifying children with even higher levels of intellect, such as at the level of Einstein, requires screening millions of children. Therefore, gifted individuals can be found in limited numbers in each generation (Ataman, 2004). Despite this limitation, interest in gifted individuals has increased globally, especially since the 1960s. This increase is due to the recognition of the severity of many global problems, such as dwindling food and energy resources, rising pollution, and issues in maintaining political power balances, and the belief that solutions to these problems may be found in gifted individuals (Davaslıgil, 1995). In line with this expectation, research findings indicate that gifted individuals with high-level thinking abilities can engage in research and inquiry activities to solve problems they encounter, develop models or program designs, and thus provide socially expected levels of feedback (Ayvacı et al., 2023; Dailey, 2014).

Gifted students, who are likely to pursue careers in science and technology, have a high potential to influence both the awareness levels of their social environment and the development of national policies in the context of SSIs (Öztürk et al., 2017). To fully and effectively realize their potential, it is necessary to design educational activities that match their talents. In Türkiye, the most widespread and the only official institution providing education to gifted students is the Science and Art Centers (SaACs) (Kaya, 2013). SaACs are independent, project-based support education institutions established to help gifted students become aware of their individual talents and to develop and utilize their capacities to the fullest extent. In these centers, enriched education programs are implemented during after-school hours, taking into account the students' areas of interest and school curricula. These programs are associated with fields such as fine arts, creative writing, drama, software, foreign languages, leadership, mechatronics, astronomy and space sciences, renewable and sustainable energy, aviation, mind and intelligence

games, thinking education, archaeology, urban culture, and similar areas. In the 394 SaACs operating across all provinces of Türkiye, a total of 104,424 gifted students at the primary, middle, and high school levels are receiving education. The distribution of these students by talent area is as follows: General intellectual ability: 88,362, visual arts: 8,877, and Music: 7,185 (MoNE, 2024).

The identification and selection process of gifted students at SaACs is completed in three main stages: (i) nomination, (ii) preliminary evaluation, and (iii) individual evaluation. This process begins with the nomination of students who are believed to be gifted in the areas of general intellectual ability, visual arts, or music. The nominated students are then subjected to a preliminary evaluation using assessment tools determined by the Ministry, based on their nominated area of talent. In this process:

(1) Students nominated in the area of general intellectual ability are evaluated using tablet-based assessments.
(2) Students nominated in the area of visual arts are evaluated using the Visual Perception Test.
(3) Students nominated in the area of music are evaluated using the Musical Aptitude Test (MoNE, 2019; 2024).

Students who perform at or above the score determined in the preliminary evaluation are included in the individual evaluation stage, using the assessment tools and methods specified by the Ministry based on their talent areas. In this stage:

(1) Students nominated in the area of general intellectual ability are evaluated using standardized intelligence scales. These evaluations are conducted by trained testers working at the Guidance and Research Centers.
(2) Students nominated in the area of visual arts are assessed at centers designated by the Ministry. The necessary materials for the evaluation are made available at these centers. Students are asked to draw pictures based on specific criteria. The drawings are evaluated and scored by a five-member committee.
(3) Students nominated in the area of music are also evaluated by a five-member committee. The necessary materials for the evaluation are provided at the centers. Audio files sent instantly by the Ministry are used as evaluation material, and students are not required to play a musical instrument.

Students who score above the threshold set by the Ministry for each talent area in the individual evaluation gain the right to receive education at the SaACs located in the regions of their registered schools (MoNE, 2019; 2024).

Planning the special education process requires first identifying the individual's current status and needs. In the literature, there are studies examining the decisions, types of informal reasoning, and quality of arguments related to SSIs among participants from various ages and educational levels, such as primary school (Atasoy et al., 2018; Karpudewan & Roth, 2018), middle school (Dawson & Venville, 2022; Uygun, 2022), high school (Patronis et al., 1999; Yang & Anderson, 2003), and university students (Herman et al., 2020; Türköz & Öztürk, 2020). However, research specifically focusing on gifted students in this field is relatively limited (Akbaş & Çetin, 2018; Öztürk et al.,

2017). Understanding the processes and patterns that gifted students use when facing controversial dilemmas in science will help in developing appropriate socioscientific curricula and pedagogical strategies, thereby increasing the promotion and realization of scientific literacy (Sadler & Zeidler, 2005b).

In this context, the research aims to examine the types of informal reasoning and the quality of arguments related to SSIs among gifted students. To achieve this aim, the following sub-questions were addressed:

(1) What are the levels of epistemological beliefs among gifted students?
(2) What types of informal reasoning do gifted students use regarding SSIs?
(3) What is the quality of arguments made by gifted students regarding SSIs?
(4) What is the relationship between the types of informal reasoning and the quality of arguments related to SSIs among gifted students?
(5) Do the types of informal reasoning vary according to the epistemological belief levels of gifted students?
(6) Does the quality of arguments vary according to the epistemological belief levels of gifted students?

Method

Design

This research was conducted using a case study design. Case studies are preferred in research where 'how' or 'why' questions are being explored, where the researcher has little control over events, and the focus of the study is a current event occurring within a real-life context (Yin, 2003).

Study group

In qualitative research, non-probability, purposive sampling is generally used. Since such research aims to explore a specific group rather than to generalize findings, it is not important how well the sample represents a broader population or group (Cohen et al., 2018). As a result of the connection between qualitative research and non-probability sampling, there are no strict rules regarding sample size in qualitative studies. Instead, the size is determined based on 'appropriateness for purpose' (Cohen et al., 2018) or according to the qualitative research design used (such as ethnography, case study, etc.). In this regard, based on a review of the literature on qualitative research, it can be stated that case studies typically involve approximately four to five cases (Creswell & Creswell, 2018). In this regard, the study group was determined using the criterion sampling method (Patton, 2015) and the participants of the study group were selected based on the following criteria:

(1) Being a 7th-grade gifted student actively attending a SaACs in a metropolis,
(2) Not having participated in any specially designed course or program related to SSIs.

In this respect, the research was conducted with a total of 15 students (10 boys and 5 girls) from 6 different SaACs, which are diagnosed as talented in the field of general mental ability and accepted to participate in the research voluntarily. After the data collection process was completed, in line with the research design, a total of 8 gifted students (5 boys and 3 girls) who actively and regularly participated to study from different SaACs were selected as the study group. Throughout the research, the real identities of the students in the study group were kept confidential, and the code names of the gifted student 1–8 (for example GS-1, GS-2, … , GS-8), assigned by the researchers, were used during data analysis and the presentation of findings.

Data collection tools

Participant information form

The form was used to determine the demographic characteristics of the participants. It includes items aimed at identifying students' age, gender, grade level, academic performance, family education level, and general awareness of SSIs.

Epistemological beliefs scale

To determine the participants' epistemological beliefs, the 'Epistemological Beliefs Scale', developed by Conley et al. (2004) and adapted into Turkish by Özkan (2008), was used. The original scale consists of 26 items in a five-point Likert scale format and is composed of four factors: 'Source', 'Certainty', 'Development', and 'Justification'.

The adapted scale consists of 24 items and three factors: 'Source/Certainty', 'Development', and 'Justification'. The Cronbach-α reliability coefficient was calculated as .70, .59, and .77 for these factors, respectively, and .76 for the entire scale (Özkan, 2008).

SSI scenarios

In the study, SSI scenarios were used to determine the informal reasoning types and argument qualities of gifted students regarding SSIs. In this context, scenarios related to a total of 7 different SSIs were developed for the research, including 'use of agricultural pesticides,' 'tissue/organ donation and transplantation,' 'space exploration,' 'solar energy,' 'recycling,' 'global warming,' and 'nanotechnology' (Şenel Zor et al., 2023).

Interviews

In the study, the interview guide approach (Johnson & Christensen, 2017) was used to elaborate and clarify the data obtained through the scenarios. During the interviews, the primary focus was on confirming the informal reasoning pattern identified by the researcher, based on the participant's written responses to the discussion questions in the scenarios.

Data collection process

The data collection process was conducted online due to the ongoing COVID-19 pandemic, which affected the entire world during the research period and led to educational activities being carried out online. Initially, the prepared data collection tools were organized online via Google Forms. In the subsequent phase, sessions were scheduled using

the Zoom application. During these sessions, the prepared online data collection tools were shared with the participants in real-time. To prevent data loss, the online applications were recorded with the participants' consent.

Pilot study

A pilot study was conducted with 7th-grade gifted students (4 boys and 1 girl) from SaACs who shared similar characteristics with the study group but were not included in it. Due to the participants' interview times being aligned, they were brought together in sessions but answered individually. After the sessions were completed, the data from the pilot study were used to evaluate the effectiveness of the scenarios in stimulating informal reasoning and revealing the patterns of informal reasoning and components of arguments in the discussion questions. As a result, it was determined that the content of the scenarios and the discussion questions met the specified criteria, and no changes were needed in the structure of the scenarios.

Main study

After evaluating the pilot study and completing preparations for the main study, contact was made with SaACs located in a metropolis. Similar to the pilot study, the research was announced to 7th-grade students and their parents through SaACs teachers. Following the announcement, the main study was conducted with 15 students (5 girls and 10 boys) who volunteered to participate in the study. During the main application process, due to the varying availability of students for the sessions, multiple sessions were held to complete each data collection tool. Accordingly, a total of 95 sessions were conducted between June 7, 2021, and July 4, 2021. The first session began with introductions between the researcher and the participants. During the session, after completing the Participant Information Form, the Epistemological Beliefs Scale was shared with the participants. They were asked to carefully read the items on the form and select the response category that best matched their opinion from the categories 'Strongly Disagree', 'Disagree', 'Neutral', 'Agree', and 'Strongly Agree'. In the sessions where the scenarios were implemented, participants were asked to carefully read the provided scenario, spend a few minutes thinking about the SSI included in the scenario, and then answer the discussion questions in writing. The data obtained during the application process were subjected to preliminary analysis, which took approximately six weeks. After this process, individual interviews were conducted with 9 volunteer students to detail the data and clarify any uncertainties. Figure 1 summarizes the conceptual and methodological process of the research.

Analysis of data

Participant information form

The data obtained from the form were analyzed descriptively. The findings are presented in Table 1 to describe the characteristics of the study group and provide detailed data for the process of comparing analysis units.

Epistemological beliefs scale

The data obtained from the scale were analyzed using descriptive statistical methods through the SPSS program. In the descriptive analysis, the mean scores from the

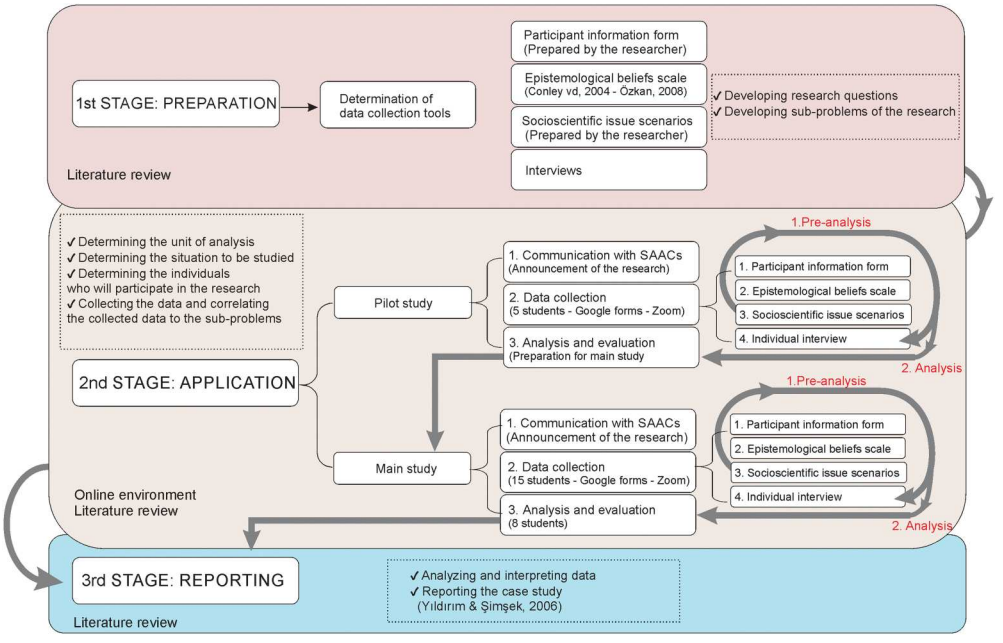


Figure 1. Conceptual and methodological process of the research.

entire scale and its sub-dimensions were used to interpret the epistemological beliefs of the gifted students. After reversing the scores for the scale's 'Source' and 'Certainty' factors, higher scores for each factor were considered indicative of more complex epistemological beliefs (Özkan, 2008).

SSI scenarios

In analyzing the data obtained through the scenarios, content analysis was employed. Content analysis involves examining the content of various forms of communication, such as images, text, and speech, to indirectly study human behavior. This method often reveals a person's or group's conscious and unconscious beliefs, attitudes, values, and opinions (Fraenkel & Wallen, 2009). Accordingly, the data obtained through the SSI scenarios were examined in a two-fold manner to uncover the types of informal reasoning and argument quality of gifted students.

Types of informal reasoning: The analysis of informal reasoning types was conducted based on the patterns developed by Sadler and Zeidler (2005b). These include three main

Table 1. Demographic data of participants.

Participant	Gender	SaACs	Type of program continued at SaAC
GS-1	Boy	A	Program for developing special talents
GS-2	Girl	B	Program for developing special talents
GS-3	Boy	B	Program for developing special talents
GS-4	Boy	C	Support education program
GS-5	Boy	D	Program for recognizing individual talents
GS-6	Boy	E	Program for developing special talents
GS-7	Girl	E	Support education program
GS-8	Girl	F	Program for developing special talents

patterns: rational, emotional, and intuitive informal reasoning, as well as combinations of these three basic patterns. According to these authors:

(1) Rational informal reasoning involves reason-focused and logic-based thoughts.
(2) Emotional informal reasoning is shaped by moral feelings such as empathy and sympathy. It requires concern for others' well-being and care for those affected by the decision.
(3) Intuitive informal reasoning is guided by immediate feelings or instinctive reactions.

In the current study, responses from participants that could be explained based on reason and logic, aligned with their adopted position, considered both the positive and negative aspects of the issue, and ultimately expressed a final decision through a cost–benefit analysis, were evaluated as rational informal reasoning patterns. Responses that include empathetic and sympathetic reactions, such as sadness, happiness, or anxiety, towards other stakeholders who might be affected by the decision, and that clearly express such emotions, have been evaluated as emotional informal reasoning patterns. Since emotional informal reasoning patterns align with both cognition and affect, the clear expression of emotions has been decisive in distinguishing and making decisions between rational and emotional informal reasoning patterns. Responses where participants referred to personal experiences or immediate feelings, reacted to the context of the scenario, could not justify their position with reasonable arguments, were unclear about how the explanations or justifications played a role in their choice, or approached the topic from a one-dimensional perspective, have been evaluated as examples of intuitive informal reasoning. Examples of coding informal reasoning patterns based on quotes are provided in supplementary material.

Argument quality: The quality of arguments was assessed using the analytical framework developed by Erduran et al. (2004). The framework, presented in Table 2, consists of five levels that consider the presence or absence of components such as claim, data, reasoning, support, and rebuttal in determining argument quality.

In evaluating the arguments according to the analytical framework presented in Table 2, the positive or negative responses given by participants to the first discussion question after reading the scenario were considered as *claims*. Additional information provided by the student, such as observations, examples, or numerical values to support their claim or the fundamental thoughts on which they based their claim, were considered as *data*. Statements that generally started with phrases like 'because,' 'therefore,' or 'as a result,' establishing a relationship between the proposed claim and the data used as evidence, were considered *warrants*. Assumptions presented to strengthen the warrant,

Table 2. Analytical framework used for evaluating argument quality.

Quality level	Component(s) of argument				
Level 1	Claim				
Level 2	Claim	+	Data (and/or) Warrants (and/or) Backings		
Level 3	Claim	+	Data (and/or) Warrants (and/or) Backings	+	Rebuttals (weak)
Level 4	Claim	+	Data (and/or) Warrants (and/or) Backings	+	Rebuttal (strong)
Level 5	Claim	+	Data (and/or) Warrants (and/or) Backings	+	Rebuttals (strong-more than one)

explanations based on scientific sources, or expert statements were considered *backing*. Reasons put forward to persuade someone with an opposing view were considered *rebuttal*. Rebuttals consisting of just a claim were considered *weak rebuttals*; those that included elements such as data, justification, or support along with the claim were considered *strong rebuttals*. Examples of the evaluation of argument quality are presented in supplementary material.

Due to the open-ended nature of the questions in the scenarios, the inter-coder reliability technique was used to calculate reliability. Accordingly, 10% (f = 10) of the response forms from the gifted students who participated in the main study were analyzed by two independent researchers specializing in science education, and a written analysis document was created. These documents were then compared, and cases of agreement and disagreement were identified. Discussions were held to reach a consensus on the areas of disagreement. Using Miles and Huberman's (1994) reliability formula [Reliability = Agreement / (Agreement + Disagreement)], the inter-coder reliability coefficient was calculated as .88 for the initial documents, and after resolving differences, it increased to .92 for the final document.

In addition, to increase the validity of the research, the procedures performed and the process that took place were explained in detail, and direct participant statements were included to shed light on the process of determining reasoning patterns and argument quality.

Interviews

The data obtained from the interviews were analyzed using the content analysis method. In this process, the audio recordings taken during the interviews were listened to, and the researcher and participant conversations were transcribed into written form without any modifications. The resulting 73-page document was treated as interview data for analysis.

Trustworthiness

Several strategies were used to ensure the validity and reliability of this study (Erlandson et al., 1993; Lincoln & Guba, 1985; Yıldırım & Şimşek, 2006). In this context, to ensure 'credibility':

(i) multiple interviews were conducted with the data sources of the study (gifted students) in order to strengthen the accuracy of the collected data (prolonged engagement);

(ii) the collected data were examined with a critical perspective, and their adequacy in answering the research questions as well as the accuracy of the findings were evaluated (in-depth data collection);

(iii) participants with different characteristics were included in the study to reveal diverse perceptions and experiences, and the data collected in written form through scenarios were verified through interviews (triangulation);

(iv) after the data collection process was completed, a preliminary analysis of the data was carried out and the results were summarized. During the interviews with the participants, they were asked to share their thoughts on the accuracy of these results (member checking). Additionally, (v) evaluation meetings were held in which the first author shared the entire research process – including the collected data, the results obtained,

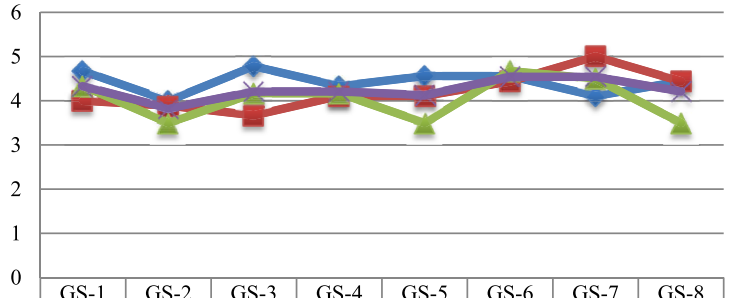
and their own thinking approach throughout – with the second and third authors. During these meetings, the second and third authors asked questions about the research process, reviewed the raw data and analyses, and provided feedback. Furthermore, the first author sent all the collected documents related to the research design, data analysis, and the writing of the results, along with the complete set of raw data, to an external expert. This expert reviewed the research process based on these documents and provided feedback to the researchers (peer debriefing). To ensure 'transferability' in the study: (i) direct quotations were included from both the written data obtained through scenarios and the verbal data collected during interviews (thick description); (ii) purposeful sampling was employed to ensure that the data sources included in the study reflected diversity, with an aim to access both general and specific information (purposeful sampling). To ensure 'dependability' in the study, the researchers examined the research from an external perspective and assessed whether consistency was maintained throughout the research process (dependability audit). Finally, to evaluate the 'confirmability' of the study, an expert conducted an assessment to determine whether the conclusions, interpretations, and recommendations reached in the study could be confirmed by tracing back to the raw data. The research instruments, raw data, codes generated during the analysis phase, and the perceptions, notes, writings, and inferences forming the basis of the research report were all submitted to the expert for evaluation (confirmability audit).

Findings

Findings of epistemological beliefs scale

The graph presented in Figure 2 shows the average scores of gifted students on the Epistemological Beliefs Scale.

Upon examining Figure 2, it can be observed that the average scores obtained by the gifted students participating in the study are similar across both the subdimensions of the scale and the scale as a whole. These scores indicate the presence of high (complex) levels of epistemological beliefs.



	GS-1	GS-2	GS-3	GS-4	GS-5	GS-6	GS-7	GS-8
Justification	4.67	4	4.78	4.33	4.56	4.56	4.11	4.44
Source-Certainty	4	3.89	3.67	4.11	4.11	4.44	5	4.44
Development	4.33	3.5	4.17	4.17	3.5	4.67	4.5	3.5
Entire scale	4.33	3.83	4.21	4.21	4.13	4.54	4.54	4.21

Figure 2. The scores of gifted students on the epistemological beliefs scale.

Findings of SSI scenarios

The decisions, informal reasoning types, and argument qualities of gifted students regarding the SSIs covered in the research are presented in Table 3.

According to Table 3, it is observed that all participants made at least one decision on the SSIs addressed in the study that differed from the decisions they made on other topics. Additionally, the table shows that the rational informal reasoning pattern was predominant for all participants in the decision-making process regarding SSIs, except for GS-1 and GS-2. It is also evident that all participants, except GS-2, utilized more than one type of informal reasoning during this process. Among the findings that can be derived from the table is that emotional and emotionally integrated informal reasoning patterns were the least utilized types of informal reasoning by the participants in the decision-making process. Concerning the section of the study focusing on argument quality, Table 3 shows that fourth-level arguments containing strong rebuttals predominated for all participants except GS-2 and GS-6. GS-2 and GS-6, on the other hand, mostly developed low-quality arguments that lacked rebuttals.

When examining Table 3, it is evident that the gifted students mostly made positive decisions regarding the SSIs covered in this study. In the decision-making process, they predominantly relied on rational informal reasoning and mostly developed fourth-level arguments.

Additionally, in Table 4, the quality of the arguments produced by gifted students for each scenario is coded together with the type of informal reasoning they used, presenting the distribution of the relationship between argument quality and type of informal reasoning. Each student is represented by a different color in the table. Upon examining Table 4, it can be seen that, consistent with Table 3, high-quality Level 4 arguments – based on rational informal reasoning – are predominantly associated with rational and rational-integrated informal reasoning patterns.

Findings of epistemological beliefs scale and SSI scenarios together

The epistemological beliefs mean scores, informal reasoning types, and argument qualities of gifted students regarding the SSIs covered in the research are presented in Table 5.

Upon examining Table 5, it is observed that students with higher scores made greater use of various informal reasoning patterns during the decision-making process and generally developed higher-quality arguments.

Results and discussion

The results of this study, which examined the informal reasoning types and argument qualities of gifted students on certain issues related to daily life with scientific and societal aspects, were addressed in line with the sub-problems. As part of the first sub-problem of the research, the epistemological belief levels of the participants were examined. Differences in individuals' reasoning types or knowledge preferences can reflect their knowledge structures and epistemological beliefs regarding what kinds of information are important in decision-making (Yang & Anderson, 2003). In this context, many studies in the field of science education have examined the influence of epistemological beliefs

Table 3. Decisions, informal reasoning patterns, and argument qualities of gifted students.

			İnformal reasoning pattern			Argument quality				
Scenario	Participant	Decision	Rational	Emotional	Intuitive	1.	2.	3.	4.	5.
Use of agricultural pesticides	GS-8	–	x							x
	GS-4	–	x							x
	GS-7	–	x					x		
	GS-6	–			x		x			
	GS-1	+	x		x					x
	GS-5	+	x						x	
	GS-3	+	x						x	
	GS-2	+			x	x				
Tissue/organ donation and transplantation	GS-8	+	x	x	x					x
	GS-4	+	x	x	x				x	
	GS-1	+	x	x	x				x	
	GS-7	+	x	x					x	
	GS-5	+	x	x					x	
	GS-3	+		x				x		
	GS-6	+		x			x			
	GS-2	–			x		x			
Space exploration	GS-1	–	x						x	
	GS-3	+	x							x
	GS-7	+	x							x
	GS-4	+	x						x	
	GS-5	+	x						x	
	GS-8	+	x						x	
	GS-2	+			x	x				
	GS-6	+			x		x			
Recycling	GS-8	+	x							x
	GS-5	+	x						x	
	GS-3	+	x						x	
	GS-4	+	x						x	
	GS-7	+	x						x	
	GS-1	+	x		x				x	
	GS-6	+	x				x			
	GS-2	+			x		x			
Solar energy	GS-3	–	**x**	x					x	
	GS-8	+	x							x
	GS-4	+	x						x	
	GS-5	+	x		x				x	
	GS-7	+	x		x				x	
	GS-1	+	x					x		
	GS-6	+	x				x			
	GS-2	+			x	x				
Global warming	GS-7	+	x						x	
	GS-1	+	x					x		
	GS-4	+	x		x				x	
	GS-6	+	x		x				x	
	GS-5	+	x		x			x		
	GS-3	+			x				x	
	GS-8	+			x				x	
	GS-2	+			x		x			
Nanotechnology	GS-1	–	x		x				x	
	GS-3	–	x						x	
	GS-4	–	x						x	
	GS-5	–	x					x		
	GS-6	+	x						x	
	GS-8	+	x						x	
	GS-7	+			x		x			
	GS-2	+			x		x			

or views on decision-making regarding SSIs or informal reasoning patterns (Kılıç & Demirbağ, 2020; Liu & Roehrig, 2019; Luan et al., 2022; Uygun, 2022). In the present study, when the scores of gifted students on the Epistemological Beliefs Scale were

Table 4. The relationship between the level of argument quality and the informal reasoning type

	Informal reasoning pattern					
Argument quality	Rational	Rational / Intuitive	Rational / Emotional	Rational / Intuitive / Emotional	Intuitive	Emotional
Level 5	(6) ******	(1) *		(1) *		
Level 4	(16) **********	(6) ******	(3) ***	(2) **	(2) **	
Level 3	(4) ****	(1) *				(1) *
Level 2	(2) **				(7) *******	(1) *
Level 1					(3) ***	

analyzed, it was found that all participants had complex levels of epistemological beliefs, both for the overall scale and its sub-dimensions. Accordingly, it can be said that participants have a deep understanding of the general characteristics of scientific knowledge and the process of its production. In a study conducted by Kılıç and Demirbağ (2020) to determine and compare the epistemological belief profiles of gifted students and their parents, it was found that most gifted students had a certainty-oriented epistemological belief profile. Individuals with a certainty-oriented profile view knowledge as fixed and unchanging, consisting of certain truths (Kuhn, 1992). It can be said that the results of the current research differ. This discrepancy may stem from differences in the data collection tools and techniques, as well as the data analysis methods adopted by the researchers. In the present research, data were collected through a survey method based on participants' self-reports.

In line with the second sub-question of the research, the informal reasoning patterns of gifted students regarding SSIs were examined. Accordingly, it was observed that in the decision-making process, depending on the SSI being addressed and the participants, three different reasoning patterns – rational, emotional, and intuitive – emerged, as well as integrated patterns that included different combinations of these reasoning types. Additionally, it was observed that the participating students could position themselves at different ends of the dilemmas contained within the same SSI. In five out of the seven different SSIs addressed in the study, different positions adopted by the participants emerged. On the other hand, all participants adopted a position different from their stance on other issues in at least one of the seven different SSIs. In other words, different participants held differing views on the same SSI, and the same participants exhibited different approaches to various SSIs. In this respect, the study's findings suggest that participants identified different aspects of the SSIs and considered these aspects during their decision-making process. While SSIs share common characteristics (Sadler, 2004), it is highly likely because each issue has its unique content (Öztürk et al., 2017).

Within the scope of the research, it was determined that the participants tended to use rational informal reasoning more frequently in their decision-making process regarding SSIs. This suggests that students largely rely on logical thinking during the decision-making process (Dawson & Venville, 2009). The preference for rational informal reasoning (Aziz & Johari, 2023) could be associated with the high level of awareness and

Table 5. The relationship between epistemological beliefs scale mean scores, argument quality and the informal reasoning type.

		İnformal reasoning type						Argument quality				
Participant	Epistemological beliefs scale mean scores	Rational	Rational - Intuitive	Rational - Emotional	Rational -Intuitive - Emotional	Intuitive	Emotional	1	2	3	4	5
GS-2	3.83					7		3	4			
GS-5	4.13	4	2	1						2	5	
GS-4	4.21	5	1		1						6	1
GS-8	4.21	5			1	1					3	4
GS-3	4.21	4		1		1	1			1	5	1
GS-1	4.33	3	3		1					2	4	1
GS-6	4.54	3	1			2	1		5		2	
GS-7	4.54	4	1	1		1				2	4	1

cognitive understanding (Toktaş & Genç, 2023) or the advanced understanding (Merritt et al., 2019) of the gifted students in this study's sample group regarding the SSIs being discussed. Additionally, this may be linked to the students' areas of talent and the general expectations of science classrooms. This is because rational thinking patterns generally represent the expectations in science classes, and educators often strive to foster the development of rational thinking skills (Tweney, 1991). Thus, the type of reasoning developed in the classroom often focuses solely on scientific problems, independent of the real-life needs of individuals (Patronis et al., 1999). However, as a fundamental vision of science education, the concept of scientific literacy requires students to use their understanding of science to contribute to societal discussions and make informed decisions about SSIs (Dawson & Venville, 2009). In this context, rational informal reasoning is just one of three ways students might engage with SSIs. Students may also choose to adopt relational perspectives based on empathy and interest or to use other approaches that involve immediate, intuitive responses (Sadler & Zeidler, 2005b). Although there are research findings in the literature that support the results of the current study, showing that participants often resort to rational (Kolarova et al., 2013; Toktaş & Genç, 2023) or evidence-based informal reasoning (Ozturk & Yilmaz-Tuzun, 2017) when seeking solutions to SSIs, it is also known that individuals use not only logic but also emotions and intuitions when discussing SSIs (Ozden, 2020). In the current study, participants also relied on their intuitions during the decision-making process regarding various SSIs. The decision-making process can be managed by an analytical system that involves conscious, logical, and abstract thinking, or it can be guided by an intuitive system that operates unconsciously, is prone to biases, and is related to an individual's past experiences (Hogarth, 2014). When faced with an unstructured problem like SSIs, individuals may first refer to the information obtained from their past experiences and use their intuitive system to form an initial mental model of the situation. As a result, they are likely to make an intuitive decision (Fang et al., 2019). Therefore, the observation of intuitive patterns in participants' decision-making processes regarding some SSIs in the current study may stem from their past experiences, the information obtained from those experiences, or their biased perspectives.

The current study shows that participants used integrated informal reasoning patterns in their decision-making processes regarding certain SSIs. The use of various forms of reasoning in solving socioscientific problems is, at least in part, made possible by individuals being aware of different perspectives that may influence their positions in response to socioscientific scenarios and by utilizing various sources of information (Sadler & Zeidler, 2005b; Yang & Anderson, 2003). This situation can be seen as an indicator that participants are aware of the different dimensions and perspectives of the issue and that they make logical evaluations while also relying on their emotions and intuitions in their decision-making process. These findings underscore the critical need for science classrooms to be environments that value not only logical reasoning but also emotions and intuitions (Kolarova et al., 2013). Additionally, nearly all participants utilized multiple informal reasoning patterns to address at least one of the SSIs presented in the scenarios. However, in the current study, more than two reasoning patterns were only used by three students and were exclusively found within the organ/tissue donation and transplantation scenario. This finding suggests that the gifted students in the study do not possess interdisciplinary thinking about many SSIs (Liu et al., 2011). On the other hand, it was

determined that the emotional informal reasoning pattern appeared less frequently compared to rational and intuitive informal reasoning patterns, and only in two scenarios (organ/tissue donation and transplantation – solar energy). This situation may have developed due to the analytical framework adopted during the data analysis process and the definition of the emotional informal reasoning pattern within this framework. This type of reasoning is directed toward real or imaginary individuals (Sadler & Zeidler, 2005b). Therefore, the absence of real individuals or designed characters in the scenarios may not have triggered the participants' empathetic and sympathetic responses toward the relevant SSI. However, in some scenarios where the direct effects on other living beings or different parties regarding the SSI were presented, the absence of an emotional informal reasoning pattern suggests that the principles and values participants used to resolve the dilemma they encountered varied depending on qualitative differences in their moral sensitivities (Tirri & Pehkonen, 2002) and that gifted students have not yet explored the emotional aspects of their thoughts related to the discussed SSIs (Dawson & Venville, 2009). On the other hand, the emergence or prominence of different types of reasoning in the decision-making processes related to SSIs, both for gifted students and their typically developing peers, suggests that the informal reasoning patterns individuals exhibit can evolve depending on the structure of the issue. For example, while elementary school students with typical development mostly exhibited intuitive informal reasoning regarding organ donation (Ozden, 2020), and middle school students mostly displayed emotional reasoning (Genç et al., 2020), elementary students tended to use rational informal reasoning on the socioscientific issue of energy resources (Merritt et al., 2019), and middle school students did so on the topic of population growth (Zorlu & Ateş, 2022). Similarly, gifted students have mostly demonstrated emotional reasoning regarding the issues of animal testing and biodiversity, while they have exhibited reasoning that can be interpreted as primarily rational on topics such as hydroelectric power plants, plastic waste (Akbaş & Çetin, 2018), and space exploration (Atasoy et al., 2022). In the current study, gifted students predominantly used emotional and emotionally integrated informal reasoning regarding the SSI of organ/tissue donation and transplantation. These research findings indicate that, like their typically developing peers, gifted students tend to show more empathetic and sympathetic responses in SSIs where humans or animals are stakeholders, but they generally engage in more logic-based evaluations on other SSIs.

SSI scenarios, encompassing multiple disciplines such as science, ethics, law, economics, and the environment, are particularly engaging for gifted students who often have interests in more than one field (Zeidler & Nichols, 2009). These scenarios, which evoke moral and ethical reasoning connected to real-world issues, can be used to provide students with explicit connections to the nature of science (Zeidler et al., 2002). Additionally, they can be effectively used in school practices to teach standard science curriculum content (Salvato & Testa, 2012). In this process, teachers can utilize scenarios in various ways to offer students opportunities to engage with socioscientific issues individually, in small groups, or as a whole class. With the inclusion of discussion questions, scenarios can be used to enhance students' argumentation skills to generate higher-quality arguments that include qualifiers, supports, and rebuttals (Dawson & Carson, 2017). Thus, scenarios can be employed not only to introduce socioscientific issues but also to investigate students' argumentation quality and decision-making skills (Dawson & Carson, 2017; Halim & Saat, 2017).

In response to the third sub-question of the study, when the argument quality of participants regarding SSIs was examined, it was found that all participants were able to present either a positive or negative claim related to the SSIs addressed in the research. Considering that a claim represents the simplest form of an argument (Osborne et al., 2004) and is defined as the component of an argument that students find the least challenging to develop (Atabey & Topçu, 2017), the findings of this study are in line with expectations. However, most participants went beyond merely making a claim, using data to justify their claims, developing reasons, and presenting rebuttals. Counterarguments involve applying critical thinking to explore different dimensions of a specific issue. In this respect, the ability to develop counterarguments is associated with better student performance in the negotiation process related to SSIs (Esquivel-Martín et al., 2023). The structure of the discussion questions at the end of the SSI scenarios and their content, which encouraged questioning of counterarguments, may have influenced the participants' ability to identify opposing positions and develop rebuttals by defending their positions. This is because it is known that individuals generally do not consider counterarguments unless they are explicitly presented or asked to think about them (Voss & Means, 1991). In this way, participants were encouraged to think about counterarguments through the discussion questions.

In the current study, although no significant changes were observed in participants' ability to produce rebuttals, it was noted that the quality level of the arguments produced varied depending on the different SSIs. The literature frequently indicates that the arguments individuals develop about SSIs can vary based on the type of teaching strategy used, the topic of the discussion, and the context in which the issue is placed (Cenk & Ercan Yalman, 2022; Kutluca & Aydın, 2017; Simonneaux, 2007). Various contextual factors that influence this difference, such as the characteristics of the topics discussed, familiarity with the issue, number of participants, content knowledge, and personal interest, could be among the reasons for this variation in the present study. Although contextual factors are considered separately, they have an interconnected and interactive structure (Khishfe, 2012; Kutluca & Aydın, 2017). For example, it is expected that participants' informal reasoning quality will show less similarity when dealing with more distantly related scenarios, such as reproductive cloning and global warming, compared to closely related SSI scenarios like different gene therapy scenarios (Topcu et al., 2010). In this regard, the variability in the quality of participants' arguments may be because the seven different SSIs addressed in the study are distantly related to each other. Additionally, the small number of participants in the study might be one of the reasons for the observed variability in argument quality. On the other hand, participants' interest in certain SSIs may have led to more active engagement in the argumentation process and the development of higher-quality arguments for those issues (Akbaş & Çetin, 2018).

In line with the fourth sub-problem of the study, the relationship between gifted students' types of informal reasoning and the quality of their arguments was examined. Argumentation quality is used as an indirect measure in evaluating the quality of informal reasoning (Means & Voss, 1996; Namdar et al., 2020; Sadler & Zeidler, 2005a; Yılmaz-Tüzün, 2013; Zohar & Nemet, 2002), and strong argumentation is considered a valid indicator of strong informal reasoning. This is because advanced arguments must be based on competent informal reasoning (Means & Voss, 1996; Sadler & Zeidler, 2005a; Topcu et al., 2010). In this regard, it can be said that most participants

demonstrated high-quality informal reasoning. One of the noteworthy findings of the study is that participants who developed high-quality arguments mostly relied on rational and rational integrated informal reasoning patterns in their decision-making process, while those who developed low-quality arguments tended to rely on intuitive informal reasoning. In this case, it is possible to associate rational informal reasoning with high-quality arguments (Dawson & Venville, 2009). On the other hands, the presence of high-quality arguments based on intuitive informal reasoning indicates that there is not a one-to-one correspondence between argumentation and informal reasoning (Topcu et al., 2010).

The quality of argumentation and informal reasoning skills of gifted students regarding socioscientific issues is of great importance for their ability to understand complex, multidimensional, and uncertain scientific problems and to make critical and ethically grounded decisions on these issues. High-quality argumentation by gifted students on such topics indicates that they possess advanced cognitive skills and that these skills can be further developed. In this context, integrating more SSI-based activities into the curriculum can support the development of students' higher-order thinking skills. In this way, students can be equipped not only with knowledge but also with the ability to interpret, critique, and evaluate information (Sadler, 2004; Zeidler & Nichols, 2009). In argumentation studies on socioscientific issues, the fact that gifted students use various strategies – such as evidence-based, intuitive, or emotional reasoning – in their informal thinking processes indicates that their thinking is multilayered and that pedagogical approaches should be flexible and enriched accordingly. In this regard, methods such as classroom discussions, case analyses, role-playing, and debates can contribute to the development of students' argumentation skills (Topcu et al., 2010). In this process, when evaluating argumentation quality and informal reasoning, it is recommended to use performance-based assessment tools (e.g. rubrics, portfolios) that reveal students' thinking processes, rather than traditional tests that only measure correct knowledge. This is especially important considering gifted students' ability to generate alternative solutions and develop multidimensional perspectives (Erduran & Jiménez-Aleixandre, 2007). Moreover, studies showing that gifted students are more successful in solving complex problems support the use of differentiated educational practices for them. For example, these students can be included in discussion groups focused on higher-level ethical dilemmas, technological debates, or sustainability issues (King & Ritchie, 2013).

In line with the fifth and sixth sub-problems of the study, the changes in gifted students' types of informal reasoning and argument quality regarding SSIs were examined based on their levels of epistemological beliefs. Individuals who view knowledge as relative rather than absolute also see argumentation as a central process through which science advances, and their active participation in argumentation facilitates the development of this type of epistemology (Nussbaum & Bendixen, 2003). However, although all participants scored similarly and at a high level on the epistemological beliefs scale, not all participants produced high-quality arguments. Therefore, not all participants demonstrated high-quality informal reasoning. Additionally, despite all participants having complex epistemological beliefs, the fact that the informal reasoning patterns they employed in the decision-making process varied from one another is among the noteworthy findings. This finding indicates that participants with complex epistemological

beliefs did not rely solely on logical reasoning, but sometimes trusted their instinctive reactions or their empathetic and sympathetic responses during the decision-making process. There are research results in the literature that align with the findings of the present study. On the other hand, there are research findings indicating that epistemological beliefs can contribute to explaining not only individuals' views on SSIs but also their types and quality of reasoning. These findings show that scientific epistemic views predict decision-making styles (Luan et al., 2022) and that epistemic beliefs and prior knowledge predict the quantity, quality, and diversity of the arguments produced (Baytelman et al., 2020). Additionally, it has been observed that students with sophisticated beliefs present more comprehensive and multifaceted views when evaluating SSIs compared to students with naïve beliefs (Kaplan & Çavuş, 2016). At this point, the current study provides indications that gifted students with more complex epistemological beliefs may use a wider range of informal reasoning types and more quality arguments in their decision-making process regarding SSIs. However, it did not yield findings that clearly establish such a relationship. This situation may be due to the small number of participants in the study group, as well as the fact that the average scores on the epistemological beliefs scale were close to each other and near the upper end of the scale for all participants.

Recommendations

Future research, by identifying and developing both gifted students' and their typically developing peers' informal reasoning and epistemological beliefs based on their needs, will contribute to raising informed citizens capable of discussing and solving SSIs. At this point, several recommendations have been made for future studies.

The socioscientific issues addressed in this study are limited to the following topics identified during the research process: pesticide use, organ/tissue donation and transplantation, space exploration, recycling, solar energy, global warming, and nanotechnology. In future studies, researchers could focus on determining whether gifted students use similar informal reasoning patterns across different SSIs. In this way, it can be identified whether there are common reasoning patterns that gifted students apply to various SSIs (Cebesoy, 2021).

Educators and learning environments should aim to strengthen not only students' rational reasoning but also their intuitive and emotional reasoning and to improve the quality of their reasoning in all situations. For this purpose, in the planning of the teaching process, socio-scientific issues should be addressed not only in terms of technical and scientific dimensions, but also with all the perspectives they contain, such as social, cultural, political and religious dimensions. In this regard, researchers can benefit from SSIs with different components and stakeholders, or from different contexts in which these issues are addressed.

Researchers may consider interdisciplinary educational approaches to holistically address SSIs and all the groups they involve or affect (Esquivel-Martín et al., 2023).

In the current study, the informal reasoning types of gifted students regarding SSIs were examined using the patterns developed by Sadler and Zeidler (2005b). In future research, different patterns or modes can be used in the analysis of informal reasoning to investigate whether different results can be obtained. The fact that the data collection

process was conducted online is one of the limitations of this study. Additionally, in this study, no argumentation training was provided to the gifted students. Researchers interested in similar topics could assess the effectiveness of providing argumentation training to gifted students by examining their types of informal reasoning and the quality of their arguments after such training. Additionally, by ensuring that participants engage in face-to-face discussions during this process, the potential impact of these interactions on informal reasoning types and argument quality could be explored.

More research is needed to explain the relationship between gifted students' epistemological beliefs, their informal reasoning on different SSIs, and the quality of their arguments. In this context, researchers could conduct more detailed qualitative studies or quantitative research with larger samples to fully understand this relationship (Luan et al., 2022; Ozturk & Yilmaz-Tuzun, 2017).

This study was conducted with, a limited number of gifted students. To deal with this limitation and to obtain more detailed findings, more research based on different perspectives is needed with participants selected from various cultures, knowledge domains, and backgrounds (Zidny et al., 2021). Moreover, in future studies, examining the informal reasoning types and argument quality of both gifted and typically developing students within the same study and comparing these groups could contribute to the literature by relating the results to the characteristics of these student groups.

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No potential conflict of interest was reported by the author(s).

Ethics statement

The research permission for this study was obtained from Gazi University Ethics Committee with the decision dated 21.10.2020 and numbered E.113171.

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References

Akbaş, M., & Çetin, P. S. (2018). Üstün yetenekli öğrencilerin çeşitli sosyobilimsel konulara ilişkin argümantasyon kalitesinin ve informal düşünme becerisinin incelenmesi [The investigation of gifted students' argumentation level and informal reasoning related to socioscientific issues]. *Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi*, *12*(1), 339–360. https://doi.org/10.17522/balikesirnef.437794

Atabey, N., & Topçu, M. S. (2017). The development of a socioscientific issues-based curriculum unit for middle school students: Global warming issue. *International Journal of Education in Mathematics, Science and Technology*, *5*(3), 153–170. https://doi.org/10.18404/ijemst.296027

Ataman, A. (2004). Üstün zekalı ve özel yetenekli çocuklar. In M. R. Şirin, A. Kulaksizoğlu, & E. Bilgili (Eds.), *Üstün Yetenekli Çocuklar Seçilmiş Makaleler Kitabı [Gifted children selected articles book]* (pp. 155–168). Çocuk Vakfı.

Atasoy, Ş, Tekbıyık, A., Çalık, M., & Yılmaz Tüzün, Ö. (2022). Development of argumentation based concept cartoons for socioscientific issues: A case of science and art centers. *Education and Science*, *47*(211), 323–367. https://doi.org/10.15390/EB.2022.11327

Atasoy, Ş, Tekbıyık, A., & Yüca, OŞ. (2018). Determining informal reasoning of students for some local socioscientific issues in the black sea region: HEPP, organic tea and green road project. *Hacettepe University Journal of Education*, *34*(2), 1–17. https://doi.org/10.16986/huje.2018045573

Ayvacı, HŞ, Küçük, M., & Bebek, G. (2023). Özel yetenekli öğrencilerin STEM mesleklerine yönelik ilgilerinin bazı değişkenlere göre incelenmesi [Examining the interests of gifted students in STEM professions according to some variables]. *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, *20*(1), 281–303. https://doi.org/10.33711/yyuefd.1122482

Aziz, A. A., & Johari, M. (2023). The effect of argumentation about socio-scientific issues on secondary students' reasoning pattern and quality. *Research in Science Education*, *53*(4), 771–789. https://doi.org/10.1007/s11165-023-10099-5

Baytelman, A., Iordanou, K., & Constantinou, C. P. (2020). Epistemic beliefs and prior knowledge as predictors of the construction of different types of arguments on socioscientific issues. *Journal of Research in Science Teaching*, *57*(*8*), 1199–1227. http://doi.org/10.1002/tea.v57.8

Cebesoy, U. B. (2021). Pre-service science teachers' informal reasoning patterns and risk perceptions in SSI: Case of Gene Therapy. *European Journal of Science and Mathematics Education*, *9*(4), 211–229.

Cenk, A. G., & Ercan Yalman, F. (2022). The observation of pre-service teachers' argumentation skills on different socioscientific issues. *Bartın Üniversitesi Eğitim Fakültesi Dergisi*, *11*(1), 31–53. https://doi.org/10.14686/buefad.900562

Clark, B. (2015). *Üstün zekâlı olarak büyümek evde ve okulda çocukların potansiyellerini geliştirmek [Growing up gifted: Developing the potential of children at school and at home]* (F. Kaya ve Ü. Ogurlu Çev.). Nobel Publications.

Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education*. Routlegde.

Conley, A. M., Pintrich, P. R., Vekiri, I., & Harrison, D. (2004). Changes in epistemological beliefs in elementary science students. *Contemporary Educational Psychology*, *29*(2), 186–204. https://doi.org/10.1016/j.cedpsych.2004.01.004

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage.

Dailey, D. (2014). What's in your refrigerator? Easy ways to spark a love for science at home. *Parenting for High Potential*, *3*(7), 4–8. https://eric.ed.gov/?id = EJ1091864

Davaslıgil, Ü. (1995). Üstün zekâlı çocukların eğitimi [Education of gifted children]. *Yaşadıkça Eğitim*, (43), 21–27.

Dawson, V., & Carson, K. (2017). Using climate change scenarios to assess high school students' argumentation skills. *Research in Science & Technological Education*, *35*(1), 1–16. https://doi.org/10.1080/02635143.2016.1174932

Dawson, V., & Venville, G. J. (2009). High-school students' informal reasoning and argumentation about biotechnology: An indicator of scientific literacy? *International Journal of Science Education*, *31*(11), 1421–1445. https://doi.org/10.1080/09500690801992870

Dawson, V., & Venville, G. (2022). Testing a methodology for the development of socioscientific issues to enhance middle school students' argumentation and reasoning. *Research in Science & Technological Education*, *40*(4), 499–514. https://doi.org/10.1080/02635143.2020.1830267

Ekborg, M., Ottander, C., Silfver, E., & Simon, S. (2013). Teachers' experience of working with socio-scientific ıssues: A large scale and in depth study. *Research in Science Education*, *43*(2), 599–617. https://doi.org/10.1007/s11165-011-9279-5

Erduran, S., & Jiménez-Aleixandre, M. P. (2007). *Argumentation in science education: Perspectives from classroom-based research*. Springer.

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

Erlandson, D. A., Harris, E. l., Skipper, B. L., & Allen, S. T. (1993). *Doing naturaistic inquiry: A guide to methods*. Sage.

Esquivel-Martín, T., Pérez-Martín, J. M., & Bravo-Torija, B. (2023). Does pollution only affect human health ? A scenario for argumentation in the framework of one health education. *Sustainability*, *15*(8), 6984. https://doi.org/10.3390/su15086984

Fang, S. C., Hsu, Y. S., & Lin, S. S. (2019). Conceptualizing socioscientific decisionmaking from a review of research in science education. *International Journal of Science and Mathematics Education*, *17*(3), 427–448. https://doi.org/10.1007/s10763-018-9890-2

Fraenkel, J. R. ve Wallen, N. E. (2009). *How to design and evaluate research in education*. McGraw-Hill.

Genç, M., Orhan, U., Özcan Baykurt, Ö, Engin, Ö, Ikinci, N., Gürbüz, E., & Türk, E. (2020). Organ ve doku bağışı konusunda ortaokul öğrencilerinin kararlarının ve informal muhakeme örüntülerinin incelenmesi [Examining the decisions and informal reasoning patterns of middle school students on organ and tissue donation]. *AJER - Academia Eğitim Araştırmaları Dergisi*, *5*(2), 337–353.

Halim, M., & Saat, R. M. (2017). Exploring students' understanding in making a decision on a socioscientific issue using a persuasive graphic organiser. *Journal of Baltic Science Education*, *16*(5), 813–824. https://doi.org/10.33225/jbse/17.16.813

Herman, B. C., Zeidler, D. L., & Newton, M. (2020). Students' emotive reasoning through place-based environmental socioscientific issues. *Research in Science Education*, *50*(5), 2081–2109. https://doi.org/10.1007/s11165-018-9764-1

Hogarth, R. M. (2014). Deciding analytically or trusting your intuition? The advantages and disadvantages of analytic and intuitive thought. In T. Betsch & S. Haberstroh (Eds.), *The routines of decision making* (pp. 67–82). Psychology Press.

Jho, H., Mijung, H. Y., & Kim, M. (2014). The relationship of science knowledge, attitude and decision making on socio-scientific issues: The case study of students' debates on a nuclear power plant in Korea. *Science & Education*, *23*(5), 1131–1151. https://doi.org/10.1007/s11191-013-9652-z

Johnson, R. B., & Christensen, L. (2017). *Educational research: Quantitative, qualitative, and mixed approaches*. Sage Publications.

Kaplan, AÖ, & Çavuş, R. (2016). Perspectives of 8th grade students with different epistemological beliefs on genetic themed socio-scientific issues. *International Online Journal of Educational Sciences*, *8*(4), 178–198.

Karpudewan, M., & Roth, W. (2018). Changes in primary students' informal reasoning during an environment-related curriculum on socio-scientific issues. *International Journal of Science and Mathematics Education*, *16*(3), 401–419. https://doi.org/10.1007/s10763-016-9787-x

Kaya, N. G. (2013). Üstün yetenekli öğrencilerin eğitimi ve BİLSEM'ler [education of gifted students and BILSEM's]. *Erzincan Üniversitesi Eğitim Fakültesi Dergisi*, *15*(1), 115–122.

Khishfe, R. (2012). Relationship between nature of science understandings and argumentation skills: A role for counterargument and contextual factors. *Journal of Research in Science Teaching*, *49*(4), 489–514. https://doi.org/10.1002/tea.21012

King, B., & Ritchie, S. M. (2013). Academic success in gifted students: The role of informal reasoning in socioscientific argumentation. *Gifted Child Quarterly*, *57*(4), 224–234.

Kılıç, M., & Demirbağ, M. (2020). Üstün yetenekli öğrenciler ile velilerinin epistemolojik inanç profillerinin belirlenmesi ve karşılaştırılması [Identification and comparison of epistemological

belief profiles of gifted students and their parents]. *İstanbul Aydın Üniversitesi Eğitim Fakültesi Dergisi*, *6*(2), 151–173.

Kolarova, T., Hadjiali, I., & Denev, I. (2013). High school students' reasoning in making decisions about socio-ethical issues of genetic engineering: Case of gene therapy. *Biotechnology & Biotechnological Equipment*, *27*(2), 3737–3747. https://doi.org/10.5504/BBEQ.2012.0133

Kolstø, S. D. (2001). Scientific literacy for citizenship: Tools for dealing with the science dimension of controversial socioscientific issues. *Science Education*, *85*(3), 291–310. http://doi.org/10.1002/sce.v85:3

Kuhn, D. (1992). Thinking as argument. *Harvard Educational Review*, *62*(2), 155–179. https://doi.org/10.17763/haer.62.2.9r424r0113t670l1

Kutluca, A. Y., & Aydın, A. (2017). The investigation of pre-service science teachers' socio-scientific argumentation quality: The influence of the context. *Necatibey Faculty of Education, Electronic Journal of Science and Mathematics Education*, *11*(1), 458–480. https://doi.org/10.17522/balikesirnef.356575

Lincoln, Y. S., & Guba, E. G. (1985). *Naturatistic inquiry*. Sage.

Liu, S., Lin, C., & Tsai, C.-C. (2011). College students' scientific epistemological views and thinking patterns in socioscientific decision making. *Science Education*, *95*(3), 497–517. https://doi.org/10.1002/sce.20422

Liu, S., & Roehrig, G. (2019). Exploring science teachers' argumentation and personal epistemology about global climate change. *Research in Science Education*, *49*(1), 173–189. https://doi.org/10.1007/s11165-017-9617-3

Luan, H., Li, T., & Lee, M. (2022). High school students' environmental education in Taiwan: Scientific epistemic views, decision-making style, and recycling intention. *International Journal of Science and Mathematics Education*, *20*(1), 25–44. https://doi.org/10.1007/s10763-020-10136-z

Means, M. L., & Voss, J. F. (1996). Who reasons well? Two studies of informal reasoning among children of different grade, ability, and knowledge levels. *Cognition and Instruction*, *14*(2), 139–178. https://doi.org/10.1207/s1532690xci1402_1

Merritt, E. G., Bowers, N., & Rimm-Kaufman, S. E. (2019). Making connections: Elementary students' ideas about electricity and energy resources. *Renewable Energy*, *138*, 1078–1086. https://doi.org/10.1016/j.renene.2019.02.047

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis*. Sage Publications.

MoNE. (2018). Bilim ve sanat merkezleri öğrenci tanılama ve yerleştirme kılavuzu 2018-2019 [Science and art centers student diagnosis and placement guide 2018-2019]. Ministry of National Education General Directorate of Special Education and Guidance Services.

MoNE. (2019). Millî eğitim bakanlığı bilim ve sanat merkezleri yönergesi [*Directive of the ministry of national education on science and art centers*]. General Directorate of Special Education and Guidance Services.

MoNE. (2024). Özel Eğitim ve Rehberlik Hizmetleri Genel Müdürlüğü Faaliyet Raporu [*Activity report of the general directorate of special education and guidance services*]. Department of Monitoring and Evaluation, General Directorate of Special Education and Guidance Services.

Namdar, B., Aydin, B., & Raven, S. (2020). Preservice science teachers' informal reasoning about hydroelectric power issue: The effect of attitudes towards socio-scientific issues and media literacy. *International Journal of Research in Education and Science*, *6*(4), 551–567. https://doi.org/10.46328/ijres.v6i4.1204

Nussbaum, E. M., & Bendixen, L. D. (2003). Approaching and avoiding arguments: The role of epistemological beliefs, need for cognition, and extraverted personality traits. *Contemporary Educational Psychology*, *28*(4), 573–595. https://doi.org/10.1016/S0361-476X(02)00062-0

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

Ozden, M. (2020). Elementary school students' informal reasoning and its' quality regarding socio-scientific issues. *Eurasian Journal of Educational Research*, *20*(86), 1–24. https://doi.org/10.14689/ejer.2020.86.4

Özkan, Ş. (2008). *Modeling elementary students' science achievement: The interrelationships among epistemological beliefs, learning approaches, and self-regulated learning strategies*. [Doctoral dissertation, Middle East Technical University]. Council of Higher Education Thesis Centre. https://tez.yok.gov.tr/UlusalTezMerkezi/TezGoster?key = UPP_Zu9isEmWGFXFCBYasQdHrsCmliR67GAlGtDxKyOCqUbhhMv9O-F0D5fSBx2x

Öztürk, N., Eş, H., & Turgut, H. (2017). Üstün zekâlı öğrenciler sosyo-bilimsel konularda nasıl karar veriyorlar? Gerekçeler, bilgi kaynakları ve medyanın oynadığı rol [How gifted students reach decisions in socio-scientific issues? Warrants, information sources and role of media]. *International Online Journal of Educational Sciences*, *9*(4), 1111–1124. https://doi.org/10.15345/iojes.2017.04.015

Ozturk, N., & Yilmaz-Tuzun, O. (2017). Preservice science teachers' epistemological beliefs and informal reasoning regarding socioscientific issues. *Research in Science Education*, *47*(6), 1275–1304. https://doi.org/10.1007/s11165-016-9548-4

Patronis, T., Potari, D., & Spiliotopoulou, V. (1999). Students' argumentation in decision-making on a socio-scientific issue: Implications for teaching. *International Journal of Science Education*, *21*(7), 745–754. https://doi.org/10.1080/095006999290408

Patton, M. Q. (2015). *Qualitative research & evaluation methods: Integrating theory and practice*. Sage Publications.

Sadler, T. D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching*, *41*(5), 513–536. https://doi.org/10.1002/tea.20009

Sadler, T. D., & Zeidler, D. L. (2005a). The significance of content knowledge for informal reasoning regarding socioscientific issues: Applying genetics knowledge to genetic engineering issues. *Science Education*, *89*(1), 71–93. https://doi.org/10.1002/sce.20023

Sadler, T. D., & Zeidler, D. L. (2005b). Patterns of informal reasoning in the context of socioscientific decision making. *Journal of Research in Science Teaching*, *42*(1), 112–138. https://doi.org/10.1002/tea.20042

Salvato, E., & Testa, I. (2012). Improving students' use of content knowledge when dealing with socio-scientific issues: The case of a physics-based intervention. *Quaderni Di Ricerca in Didattica (Science)*, (3), 15–36.

Şenel Zor, T., Selvi, M., & Aslan, O. (2023). A socioscientific scenario development process: An example for space research. *Hacettepe University Journal of Education*, *38*(4), 558–570. https://doi.org/10.16986/HUJE.2023.505

Simonneaux, L. (2007). Argumentation in socio-scientific contexts. In S. Erduran & M. P. Jimenez-Aleixandre (Eds.), *Argumentation in science education: Perspectives from classroom-based research* (pp. 179–199). Springer.

Tirri, K., & Pehkonen, L. (2002). The moral reasoning and scientific argumentation of gifted adolescents. *Journal of Secondary Gifted Education*, *13*(3), 120–129. https://doi.org/10.4219/jsge-2002-374

Toktaş, M., & Genç, M. (2023). Examining university students' reasoning patterns for socioscientific issues: The case of space researches. *Journal of Multidisciplinary Studies in Education*, *7*(2), 43–59.

Topcu, M. S., Sadler, T. D., & Yilmaz Tuzun, O. (2010). Preservice science teachers' informal reasoning about socioscientific issues: The influence of issue context. *International Journal of Science Education*, *32*(18), 2475–2495. https://doi.org/10.1080/09500690903524779

Türköz, G., & Öztürk, N. (2020). Fen bilgisi öğretmen adaylarının bazı sosyo-bilimsel konularla ilgili kararlarının çok boyutlu bakış açısı ile incelenmesi [Examination of pre-service science teachers' decisions about some socioscientific issues with a multidimensional point of view]. *Cumhuriyet International Journal of Education*, *9*(1), 175–197. https://doi.org/10.30703/cije.550533

Tweney, R. D. (1991). Informal reasoning in science. In J. F. Voss, D. N. Perkins, & J. W. Segal (Eds.), *Informal reasoning and education* (pp. 3–16). Erlbaum.

Uygun, C. B. (2022). *Middle school students' informal reasoning modes and argumentation quality in socioscientific issues: Epistemological beliefs and issue familiarity as predictors*. [Master's thesis, Middle East Technical University]. Council of Higher Education Thesis Centre. https://tez.yok.gov.tr/UlusalTezMerkezi/TezGoster?key = sELqxhTlFGAjsbjOuuiyCOrsiXIERNpEJtHVtcD1y0lq-5MB4fNdr3RipECdG2IK

Voss, J. F., & Means, M. L. (1991). *Learning to reason via instruction in argumentation*. Learning Research and Development Center.

Wu, Y. T., & Tsai, C. C. (2007). High school students' informal reasoning on a socio-scientific issue: Qualitative and quantitative analyses. *International Journal of Science Education*, *29*(9), 1163–1187. https://doi.org/10.1080/09500690601083375

Yang, F. Y., & Anderson, O. R. (2003). Senior high school student's preference and reasoning modes about nuclear energy use. *International Journal of Science Education*, *25*(2), 221–244. https://doi.org/10.1080/09500690210126739

Yin, R. K. (2003). *Case study research design and methods*. Sage Publications.

Yıldırım, A. ve Şimşek, H. (2006). *Sosyal bilimlerde nitel araştırma yöntemleri [Qualitative research methods in social sciences]*. Seçkin Publications.

Yılmaz-Tüzün, Ö. (2013). Fen derslerinde sosyobilimsel konuların işlenişine yönelik kuramsal ve uygulamalı yaklaşımlar [Theoretical and practical approaches regarding teaching socioscientific issues in science courses]. *Cito Eğitim: Kuram ve Uygulama*, (22), 9–20.

Zeidler, D. L., & Nichols, B. H. (2009). Socioscientific issues: Theory and practice. In B. J. Fraser, & K. G. Tobin (Eds.), *Second international handbook of science education* (pp. 763–779). Springer.

Zeidler, D. L., Walker, K. A., Ackett, W. A., & Simmons, M. L. (2002). Tangled up in views: Beliefs in the nature of science and responses to socioscientific dilemmas. *Science Education*, *86*(3), 343–367. https://doi.org/10.1002/sce.10025

Zidny, R., Laraswati, A. N., & Eilks, I. (2021). A case study on students' application of chemical concepts and use of arguments in teaching on the sustainability-oriented chemistry issue of pesticides use under inclusion of different scientific worldviews. *EURASIA Journal of Mathematics, Science and Technology Education*, *17*(7), 1–17. https://doi.org/10.29333/ejmste/10979

Zohar, A., & Nemet, F. (2002). Fostering students' knowledge and argumentation skills through dilemmas in human genetics. *Journal of Research in Science Teaching*, *39*(1), 35–62. https://doi.org/10.1002/tea.10008

Zorlu, E., & Ateş, S. (2022). Ortaokul öğrencilerinin karar verme biçimleri ve informal muhakeme becerilerinin incelenmesi [Examining the decision making styles and informal reasoning skills of secondary school students]. *Journal of Research in Education and Society*, *9*(2), 352–378. https://doi.org/10.51725/etad.1153058