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Abstract

In this study, Q methodology was used to explore science teachers' socioscientific decision-making. In Q methodology, participants are presented with a number of statements about a topic and are asked to sort these statements according to a guideline. The methodology allows researchers identify more information about participants' decision-making by putting them at the center of analysis. The participants of the study consisted of 8 science teachers (5 females, 3 males), who were asked to sort a number of 22 statements about socioscientific issues; and as they completed their sorting, they were interviewed. Findings revealed two distinct perspectives that science teachers had about socioscientific decision-making: (i) traditional and (ii) universal. Even though all science teachers were aware of the value and importance of environment and human health, their perspectives differed in the subject areas of science, policy and sociology/culture, and in the intellectual baggage of experience and value.

Introduction

Hurd (1958), one of the researchers carrying out the earliest studies regarding scientific literacy, expressed it as an objective of science education and characterized it as a 'concept' in the literature. National Science Education Standards defines the concept of scientific literacy as "the knowledge and understanding of scientific concepts and processes required for personal decision-making, participation in civic and cultural affairs, and economic productivity" (NRC, 1996, p.22). Scientific literacy requires individuals to use their scientific knowledge in the social issues they encounter in their daily life coming with science and scientific events. In this way, by means of being aware of the responsibility towards their community, individuals take active roles in making decisions about the issues that are influential on the future of the country (Burek, 2012; Stefanova et al., 2010).

Social issues, associated with science in conceptual and technological terms, have been in the agenda of some countries in recent years. These scientific, open-ended (Presley et al., 2013) and contradictory issues like cloning, stem cell studies, genome project, global warming, alternative fuels (Sadler, 2004a; Sadler & Donnelly, 2006; Sadler & Zeidler, 2005), climate change and nuclear energy are called *Socioscientific Issues* [SSIs] (Sadler, 2004a). SSIs are important in that they are associated with several disciplines such as biology (cloning and genetic engineering), chemistry (DDT and Dioxin), medicine (gene therapy and vaccination), physics (nuclear power) and environmental science (global warming), and that they are likely to be influential at a large

scale from local to global (Chang Rundgren & Rundgren, 2010). They are also important contexts for individuals in developing discussing, reasoning and decision-making skills, since they require individuals make informed decisions by considering the issues from different perspectives such as social, political or scientific (Hodson, 2003; Sadler & Zeidler, 2005; Zohar & Nemet, 2002). Being able to make informed decisions in social problems related to science and technology, and in situations that affect the future is an indicator of being a scientifically literate individual, in turn (Bossér et al., 2015; Chang & Chiu, 2008; Eggert & Bögeholz, 2010; Lee, 2007; Sadler, 2004a; Zeidler et al., 2005). In other words, covering multi-dimensions and having a controversial and argumentative nature, SSIs offer individuals the opportunity to question, to develop scientific literacy, and to make their decision-making skills work in progress (Applebaum et al., 2010).

SSIs and Decision-making

SSIs are complex, open-ended and controversial issues without a single and simple solution (King & Kitchener, 2004; Kolstø, 2001; Sadler, 2004a). Although their origin is science, judging these issues does not solely rely on scientific considerations (Eggert et al., 2013). SSIs have features like, moral and ethical values (Bell & Lederman, 2003; Ratcliffe & Grace, 2003; Sadler, 2003; Sadler, 2004b; Sadler & Zeidler, 2004; Sadler & Donelly, 2006), social dilemmas with scientific content (Sadler & Zeidler, 2005), local, regional and global dimensions with political and societal frameworks (Ratcliffe & Grace, 2003), economy (Sadler, 2005a; Zeidler et al., 2005; Chang Rundgren & Rundgren, 2010) and environment (Ekborg et al., 2013). These features result in a complex nature of SSIs and create challenges in the process of defending one's own proposals or considering and comparing the pros and cons of the proposals of others, and positing final decisions.

The importance of decision-making as part of science education (more specifically, as a skill that contributes to scientific literacy) has long been emphasized by several scientific communities (e.g., AAAS, 1989; NRC, 1996) and science educators (e.g., Aikenhead 1985; Eggert & Bögeholz, 2010; Kolstø, 2006; Zeidler et al. 2005). In Turkey, the science curriculum states that developing reasoning abilities, scientific thinking habits and decision making skills through the use of SSIs is one of the basic aims of science education (MoNE, 2018, p.9). It is stated in such curricular assertions and by the scientific communities that, individuals should be able to examine complex SSIs and make socially responsible and informed decisions about them. In other words, making informed decisions is accredited as an essential ability to negotiate SSIs. In decision-making process, individuals make rational choices among alternatives based upon judgments consistent with their values (Heath, White, Berlin and Park, 1987). The rationale and conclusions that individuals put forward while making a decision on SSIs is of importance in their evaluation of the issue and reaching a final decision. In other words, individuals exhibit different patterns of considerations as they negotiate and make decisions about SSIs. Yang and Anderson (2003), for example, determined two different modes, as scientifically-oriented and socially-oriented, associated with the type of information used in making decision about nuclear power. Patronis et al. (1999) identified four dimensions that shaped the decisions as: social, ecological, economic and practical. Many researchers, on the other hand, state that moral and ethical considerations have a significant influence on the decision-making process (Bell and Lederman, 2003; Sadler, 2003; Sadler, 2004b; Zeidler et al., 2002). Besides values and moral judgement; local, national and global considerations in social and political terms, and cost-

benefit analyzes of the issue for sustainable development where the risk factor is important, are also defined as influential on the decisions about SSIs (Ratcliffe & Grace, 2003). Individuals consider SSIs from these dimensions, make use of their reasoning skills, engage in relevant information search, and defend own and negotiate others' proposals in the process of developing their decision-making strategies (Fang et al., 2019).

It is seen that, several studies have highlighted the emerging and cross-disciplinary features of SSIs, and the results of these studies indicate several dimensions involved in the process of reasoning about SSIs (Christenson et al., 2012). At this point, Chang Rundgren and Rundgren (2010) offer a holistic analytical framework that covers six cross-disciplinary dimensions that individuals use as they make decisions about SSIs. The framework is called as 'SEE-SEP Model', including the abbreviations of six subject areas of SSIs regarding Sociology/culture (S), Environment (E), Economy (E), Science (S), Ethics/ Morality (E) and Policy (P), which are connected with the three aspects of Knowledge, Value and Personal experience (KVP). The model aims to determine individuals' use of resources in supporting their arguments on SSIs, and reveals how these six dimensions interact with values, knowledge and personal experiences in the decision-making process (see Figure 1). When used in education, the model enables students to be aware of the multi-dimensional structure of SSIs and provide them with a holistic view of the issues (Chang Rundgren & Rundgren, 2010).

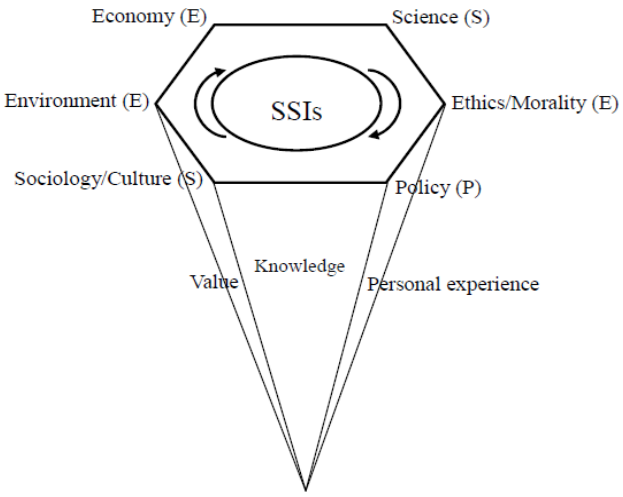

Figure 1. The SEE-SEP Model

Each dimension in the SEE-SEP model represent a different perspective to be referred when dealing with SSIs, and the model suggests that these dimensions are closely related to individuals' values, knowledge and personal experiences. These three elements are thought to be meaningful in informal reasoning and revealing arguments about the issues (Chang and Chiu, 2008). Individuals may use one or more of the dimensions, or they may not use some dimensions at all in their decision-making processes (Chang Rundgren & Rundgren, 2010). Sociology/culture (S) dimension of the model represents the inclusion of individuals' personal experiences and the structure of the society and culture in making decisions. Environment (E), on the other hand, is the inclusion of individuals' either positive or negative evaluations of the environment in local, regional or global sense. Economy (E) dimension refers to an economic evaluation of the issue within the framework of sustainable development. Science (S), on the other hand, can be expressed as one's integration of scientific knowledge in the

decision-making processes. Ethics/Morality (E) dimension means an ethical or moral approach (e.g. religious beliefs) to SSIs. Finally, Policy (P) dimension refers to taking government's policy into account (or, being affected by it) when making a decision on SSIs. Recently, Eş and Öztürk (2021) added the Technology (T) dimension to the model, and introduced the model of SEE-STEP, where they separated technology from science.

Research Problem

Due to the fact that their results affect all society, citizens should make decisions about SSIs even if they are not professionals of science or technology (Zoller, 1982). For this reason, SSIs together with decision-making have come to the agenda of many curricular actions after the science-technology-society movement in science education in 1980s (Yager, 1996). As a result of these actions, they became a part of science curricula in many countries. Many science educators, then, have put emphasis on the need to develop students' scientific literacy regarding socioscientific decisions (e.g. Aikenhead, 1985), and studies investigating socioscientific decision-making have taken place in the literature.

In the literature, there are studies investigating participants' ways of socioscientific reasoning (e.g., Fleming, 1986a, 1986b; Sadler & Zeidler, 2005). In these studies, researchers identified several reasoning modes or perspectives that participants referred as they posited decisions about the SSIs in focus. Kolstø (2001), for example, investigated students' ways of evaluating information and knowledge claims for making decisions about power lines and cancer, and determined four strategies of decision making, which are (i) acceptance of knowledge claim, (ii) evaluation of statements using reliability indicators and through explicitly thinking for themselves, (iii) acceptance of researchers or other sources of information as authoritative, and (iv) evaluation of sources of information in terms of interests, neutrality or competence. Similarly, Sadler and Zeidler (2005) examined college students' ways of discussing genetic engineering, and identified three patterns of informal reasoning in decision making, which are (i) rationalistic informal reasoning consisting of reason-based considerations without the influence of emotions (ii) emotive informal reasoning consisting of care-based consideration, and (iii) intuitive informal reasoning consisting of considerations based on immediate reactions to the context. Both Sadler and Zeidler (2005) and Kolstø (2001) found that students generally used combinations of the reasoning patterns as they resolve the SSIs in concern. The SEE-SEP model was also used as an analytical framework in a number of studies that examine participants' justifications about SSIs (Christenson et al., 2012; Christenson et al., 2014; Eriksson & Rundgren, 2012). Christenson et al. (2012), for example, studied with high school students on the SSIs of global warming, genetically modified organisms, nuclear power and consumption, and found that in all the four SSIs, students applied more reasons from the dimensions of environment and science and least from the dimensions of economy and policy in their arguments.

The present study is separated from all these studies mainly because of using Q methodology. Even though Q methodology has been in use for many years, its applications in science education are so rare. Except for the study by Young and Shepardson (2018), where Q methodology was used to investigate the attitude of undergraduate students towards geology, it is difficult to talk about the use of Q methodology in science

education research. Nonetheless, despite the strength of Q method in investigating decision-making processes (Durning & Brown, 2007), it has not been found to be used in the studies related to SSIs. Related studies in the literature were conducted mainly based on the written responses of the participants, and interviews were carried out in some studies mainly after the questionnaires for clarification purposes. Both questionnaires and interviews are preferred by the researchers due to their advantages, as they either provide in terms of time and effort spent on data analysis, or are efficient in collecting detailed information. The present study, however, introduces the use of Q methodology in exploring socioscientific decision-making. For that reason, it is believed that the current study will be a pioneer in this sense. In Q methodology, a by-person factor analysis is employed to identify groups of participants who make sense a group of statements in comparable ways (Watts & Stenner, 2005). In other words, combinations or configurations of themes preferred by the participants are revealed (Watts & Stenner, 2005). The details of Q methodology and its relation to decision-making are presented in the following section, but it is hoped that the present study brings an important methodological alternative to investigations on decision-making about SSIs. The socioscientific decision-making processes of students at different grade levels are important. Along with that, science teachers' approaches and decision-making processes about SSIs are also problems of research that need to be investigated, since they are the most significant factor that brings science education and SSIs to students. In light of these, this study describes an investigation of the patterns of decision-making in the context of SSIs of a sample of science teachers through the use of Q methodology. Accordingly, the following research questions were proposed for the present study:

1. What are the different perspectives of science teachers concerning decision-making about SSIs?
2. What are the descriptions associated with the perspectives that science teachers posit as they make decisions about SSIs?

Q Methodology and Decision-making

Being introduced firstly by the British psychologist and physicist William Stephenson (1953) and suggesting that variables can be replaced by individuals in the factor analysis and that interpersonal factor analysis can be done, Q methodology is defined in general terms as a method examining the self-referenced perspectives of individuals and revealing the similarities and differences of these perspectives, -in other words, where they are positioned relative to each other-, in a holistic structure (Brown, 1993; Stainton Rogers, 1995; Watts & Stenner, 2012). Q methodology is known as "the best-developed paradigm for the investigation of human subjectivity" (Dryzek & Holmes, 2002, p.20). It provides a conceptual framework and systematic procedure for both incorporating the perspectives of participants and putting them at the center of the analysis (Durning & Brown, 2007). In this method, participants are presented with a number of statements about a topic and are asked to sort these statements according to a guideline [e.g., agree/disagree, like/dislike, regard/disregard] (Van Exel & De Graaf, 2005). Then, factor analysis is done with the data; however, unlike classical factor analysis, correlations between individuals are analyzed. This can be interpreted simply as a displacement of the rows and columns in the dataset, but as Stephenson proposed, Q method later became more than that. With Q method, Stephenson presented an approach that emphasized diversity and subjectivity against the approach that adopted the hypothesis-based deductive logic (Watts & Stenner, 2005). He argued that outputs that stand out with diversity and subjectivity can be accessed with psychometric tools. Brown (1996), who made important contributions to

the use and dissemination of Q method, stated that the method puts the strengths of the quantitative and qualitative traditions together.

Q methodology is different from the traditional R approach (factor analysis), and the two may be distinguished from each other in several ways. The simplest way is to look at the variable (Webler et al., 2009). In R method, the variable is a survey item, while in Q method, it is the Q sort made by the participant; relatedly, in R method, the subject is the person, while the subject is the Q statement in Q method (Webler et al., 2009). R methodology identifies correlations between variables across the sample of participants; whereas Q methodology identifies correlations between participants across the sample variables, that is, the patterns in the placement of Q statements across all Q sorts made in the study. These patterns show that there is an "inter-subjective orderings of beliefs" that groups of people share (Webler et al., 2009, p.8). The social perspectives, in other words, are revealed. Q methodology differs from the Likert scales. Likert scales, together with other types of surveys like interviews, reveal a partial picture of the perspective held by the participant about an issue since the statements are considered as discrete pieces of information (Brown & Ungs, 1970). Unlike Likert scales where individual statements are rated according to participants' rate of agreement, relative rankings of the statements in Q methodology give a more complete picture of the perspectives that participants have about the issue (McKeown, 2001). As stated previously, each statement is ranked relative to every other statement in Q methodology, leading to a more complete picture. In a Likert scale with 22 statements, for example, there are only 22 choices. In Q methodology, on the other hand, a person has to make ½N(N–1) choices (Brown and Ungs, 1970), where N is the number of statements (the number of choices is calculated as 231 for 22 statements). The larger number of choices gives a much more complete picture of each participant's decision-making process on SSIs and leads to his/her own segment of subjectivity.

A major characteristic of decision-making is that it involves freedom of choice (Durning & Brown, 2007). Choices reveal preferences and the decision maker prefers one over another, with a subjective choice (Durning & Brown, 2007). The number of choices may change but they exist. Otherwise, decision cannot be made. Q methodology, at this point, is relevant to decision-making as it provides a subjective approach (Brown, 1980, 2004; Brown et al., 1999; McKeown & Thomas, 1988; Robbins, 2005; Stephenson, 1953) and as it makes it easier to make decisions (Durning & Brown, 2007). In Q methodology, the decision maker systematically explicates his viewpoints, values and thoughts, and contributes to the study of decision-making. It provides insights into decision-making process that is generally not accessible in traditional methods. Through the use of this methodology, decision makers', stakeholders' or society's subjectivity can be examined, and their beliefs, values, interests and the information that converges and influences their views and decisions can be revealed (Durning & Brown, 2007).

Method

As mentioned previously, Q methodology was used in this study aiming to explore science teachers' socioscientific decision-making process. For this purpose, eight science teachers were asked to sort a number of 22 statements; and as they completed their sorting, they were interviewed.

Participants

The participants of the study consisted of eight science teachers working in the Black Sea Region of Turkey, more specifically in the city of Sinop. The participants participated in the study on a voluntary basis. In Q methodology, a 3:1 ratio of statements to the number of participants is offered but a ratio of 2:1 is said to be acceptable (Webler et al., 2009). As there are 22 statements in the current study, a number of 8 participants seem to be satisfying. Throughout the study, any identifying information about the participants was not made available but the participants were coded depending on their year of experience as a teacher and their gender. That is, for example, a male teacher with one-year experience was coded as S01M and a female teacher with fourteen-year experience was coded as S14F. Namely, S means Science, numbers (01, 06 etc.) are the years of experience, and M means male and F means female.

The Q Sort Design

The 22 statements that participants sorted in this study are listed in Table 1. The statements in a Q study can be formed by taking them directly from the related literature (Young and Shepardson, 2018) or they are produced by the researcher if the literature on the subject is limited (Yıldırım, 2017). In this study, the related literature was examined, and categories affecting individuals' decision-making processes regarding SSIs were determined. As the categories in the literature are determined, statements related to these categories were produced (Table 1).

The statements are grouped under three main categories: (i) *subject area* (Chang Rundgren & Rundgren, 2010; Eş & Öztürk, 2021), (ii) *intellectual baggage* (Rundgren et al., 2016) and (iii) *risk* (Kolstø, 2006). The *subject area* category is made up of 7 dimensions. The dimensions are taken from the SEE-STEP model which was introduced by Eş and Öztürk (2021) based on the model of SEE-SEP developed by Chang Rundgren and Rundgren (2010). In the SEE-SEP model, there are six dimensions: Sociology/Culture, Environment, Economy, Science, Ethics/Morality and Policy. In the SEE-STEP model, on the other hand, Technology is separated from Science and added to the SEE-SEP model as a distinct dimension. In the *intellectual baggage* category, there are three dimensions of Knowledge, Value and Experience which are taken from the study of Rundgren et al. (2016). Finally, the category of *risk* was taken from the study of Kolstø (2006) and is made up of just one dimension that is the Risk itself.

An equal distribution of positive and negative items is offered in Q statements (Koçak, 2010; Yıldırım, 2017). For this reason, two Q statements, -one positive and one negative-, is developed for each dimension in the current study (that is, a total of 22 statements for 11 dimensions), and they were randomly distributed. The statements were examined by two science education professionals (two associate professors) whose areas of study covered SSIs. Feedback of the professionals included suggestions about language compatibility and clarity of the statements. The necessary arrangements were carried out in line with the feedbacks and the statements were finalized.

Table 1. Statements together with their Corresponding Categories, Dimension and Factor Scores

				*Q sort value	
Cat.	**Dimensions**	**No.**	**Statements**	**P1**	**P2**
Subject areas	Sociology/ Culture	3	My social and cultural background is influential on my decisions regarding SSIs.	2	1
		10	I approach SSIs with a universal sense, independent from the values of the community and the culture I live in.	0	2
	Environment	4	The effects of SSIs on environment are influential on my decisions about them.	3	4
		12	My decisions regarding SSIs are independent from their effects on environment.	-2	-4
	Economy	17	The contribution of SSIs to economy affects my decision about them.	1	0
		5	The effect of SSIs on economy is insignificant on my decision-making process regarding the issues.	-1	0
	Science	13	I search and use the necessary scientific information in the decision-making process regarding SSIs.	2	0
		19	I can make my decisions about SSIs without searching scientific information about the issues.	-3	0
	Technology	1	The contribution of SSIs on technological development affects my decision.	0	2
		6	Technological dimension of SSIs is not important on my decision-making process.	-2	-2
	Ethics/ Morality	14	I consider ethical and moral issues, such as human and animal rights, while deciding about SSIs.	3	2
		20	Ethical and moral concerns do not affect my decision-making process regarding SSIs.	-3	-2
	Policy	9	The approaches of the government or the political or civil organizations that I support affect my decision over SSIs.	0	-3
		7	Decisions regarding SSIs should be away from political evaluations or approaches.	1	3
Intellectual baggage	Knowledge	15	I use the information I have attained throughout my education in decision-making process regarding SSIs.	1	1
		21	The information I have attained throughout my education is insufficient in decision-making regarding SSIs.	-1	-2
	Value	8	The decision of my family regarding SSIs is important for me and affects my decision.	0	-1
		16	The values I have taken from my family is not effective in my decisions regarding SSIs.	-1	1
	Experience	11	My positive or negative experiences regarding SSIs affect my decisions about them.	2	-1
		18	My personal experience/life is insufficient in my decisions regarding SSIs.	-2	-1
Risk	Health	22	The effect of SSIs on human health and life affects my decision.	4	3
		2	While making a decision regarding SSIs, I ignore their effect on human health.	-4	-3

*P1 and P2 indicate the perspective that is described by the Q sort values in the corresponding column.

The Q sort layout used in this study is given in Figure 2. In this Q sort, there are 9 levels of agreement, and each level has such a set number of spaces (boxes) to place the statements in: one +4, two +3s, three +2s, three +1s, four 0s, three –1s, three –2s, two –3s, and one –4 (see Figure 2). Participants were to put one statement in each box. This organization forces a normal distribution of the statements, which is a standard practice in Q methodology (Webler et al., 2009).

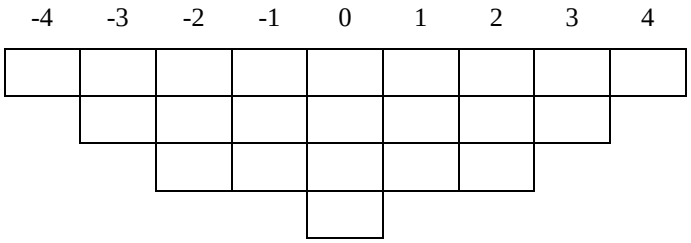

Figure 2. The Q Sort Layout used in This Study

In Q methodology, statements are sorted based on the participant's level of agreement with each statement relative to the other statements. Sorting is not based on 'correctness' but on the degree of agreement; that is, how strongly the participant agrees or disagrees with each statement relative to the others. This type of sorting allows the operation to be totally subjective since it characterizes each participant's specific perspective (Brown, 1993). The way that a participant places the statements in the vertical column does not matter; meaning that they are at the same level of agreement. Of course, a participant could agree more with one statement ranked at +2 than the other statement ranked at that same level, but the placement on the Q sort board does not reflect that difference.

Data Collection and Analysis

During data collection process, the participants were handed out a sheet of paper having the Q sort layout and the Q statements as written on pieces of papers. They were allowed to read the statements and asked to group them as they agreed with the statement, disagreed with the statement, or if it was neutral or not applicable to them. They were then asked to focus on the statements they agreed with, and sort the statement they agreed the most in + 4, then +3, +2 and +1, respectively. Following that, they were asked to focus on the statements they disagreed with, and follow the same procedure for these statements as -4, -3, -2 and -1 this time.

Finally, they were asked to place the statements for which they were neutral in 0. Throughout the sorting process, participants were told that they were free ask questions regarding the statements. After the placement of the statements on the layout, the participants were asked to express their views about the statements they ranked at most (that is, +4 and -4) in written form in a few sentences.

Data obtained through Q sorts were analyzed via PQ Method 2.35 software package program. The program correlated each Q sort with every other Q sort and produced an inter-correlation matrix. Principal component analysis and rotations were then made to maximize the variance explained on minimum number of factors possible.

Interviews

In Q methodology, a Q sort followed by an interview is recommended (Brown, 1993). A standard interview procedure however, is not defined for this process but in order for better understanding participants' views, asking questions about the statements that were ranked at most (that is, +4 and -4) is a common practice (Brown, 1993). In this study, participants' views about the statements ranked at most were taken in written form just after the placement of the statements on the layout. In the interviews, therefore, participants were asked to mention their views about the statements that made a statistically significant difference between the two perspectives (that is, the distinguishing statements of 7, 8, 9, 10, 11, 13, 16 and 19). By this way, it was aimed to take participants' views about these statements and the dimensions of these statements as well.

Findings

As a result of the analysis carried out, two different perspectives were obtained (see Figure 3). Perspectives emerging in Q method studies are generally named by the researchers in deference to the distinguishing statements (Young & Shepardson, 2018). The perspectives emerged in this study were named as "Traditional" and "Universal" by the researchers of the study based on the findings. The two perspectives explained 82% of the variance among 8 sorts. Factor loadings of the participants are shown in Table 2 and Figure 3. The symbol X indicates the participants in the relevant factor. As seen in the table, each perspective has more than one person defining himself/herself (that is, 5 people in the first and 3 in the second) and each participant was defined with a perspective (that is, no one is left behind).

Table 2. Factor Loadings of the Participants

		Perspective	
	Q-Sort	**P1 (Traditional)**	**P2 (Universal)**
1	S04F	0.4213	0.7087X
2	S20M	0.2078	0.9342X
3	S01M	0.7285X	0.4533
4	S01F	0.7127X	0.6030
5	S14F	0.5220	0.7819X
6	S06M	0.8297X	0.4753
7	S11F	0.8527X	0.2173
8	S15F	0.7182X	0.5189
% expl.Var.		43	39

When Table 2 is analyzed, it is seen that five participants are in the traditional perspective and three are in the universal perspective. In addition, participants' gender and years of experience seem not to be influential on their distribution to the perspectives (see Figure 3).

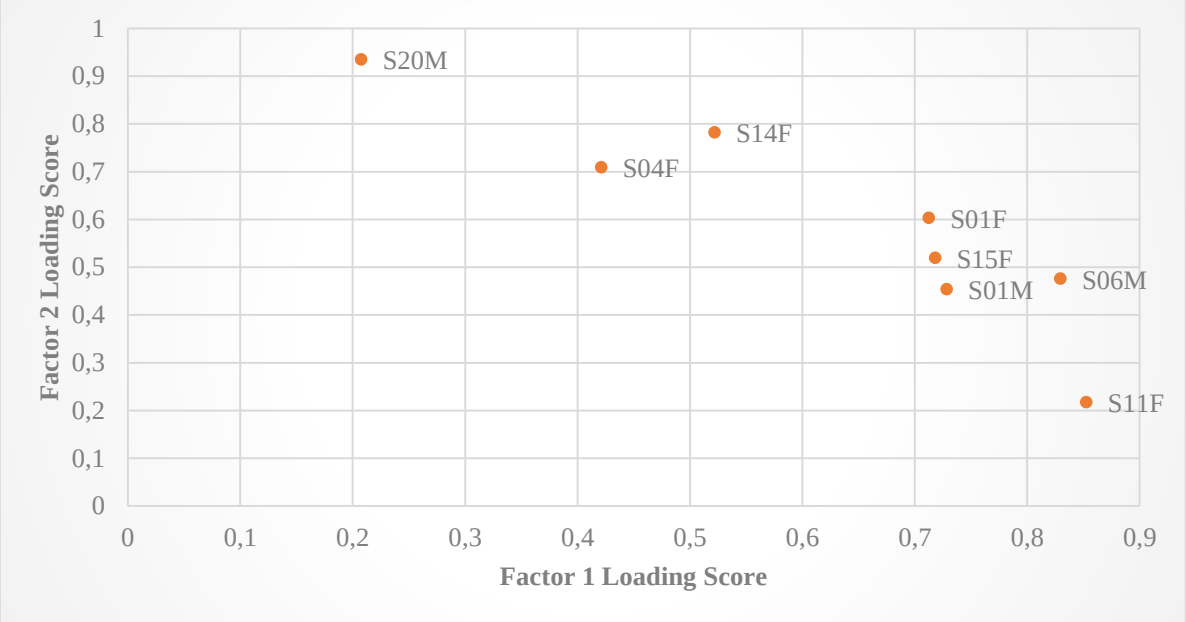

Figure 3. Factor Loadings of the Participants

Table 3 lists the top and bottom three statements for the 'traditional' and 'universal' perspectives.

Table 3. Top Three Most Agreed/Disagreed Statements for the Two Perspectives

Pers.	No.	Statement	z-score	Grid Position
Traditional	22	The effect of SSIs on human health and life affects my decision.	1.762	+4
	4	The effects of SSIs on environment are influential on my decisions about them.	1.557	+3
	14	I consider ethical and moral issues, such as human and animal rights, while deciding about SSIs.	1.349	+3
	20	Ethical and moral concerns do not affect my decision-making process regarding SSIs.	-1.190	-3
	19	I can make my decisions about SSIs without searching scientific information about the issues.	-1.564	-3
	2	While making a decision regarding SSIs, I ignore their effect on human health.	-1.835	-4
Universal	4	The effects of SSIs on environment are influential on my decisions about them.	1.882	+4
	22	The effect of SSIs on human health and life affects my decision.	1.442	+3
	7	Decisions regarding SSIs should be away from political evaluations or approaches.	1.258	+3
	9	The approaches of the government or the political or civil organizations that I support affects my decision over SSIs.	-1.415	-3
	2	While making a decision regarding SSIs, I ignore their effect on human health.	-1.638	-3
	12	My decisions regarding SSIs are independent from their effects on environment.	-1.817	-4

As it is seen in Table 3, the most agreed two statements in both perspectives (that is, statements 4 and 22) are the same. While statement 22 is in the first place in traditional perspective, it is in the second place in universal perspective. Similarly, statement 4 is in the second place in traditional perspective and is in the first place in universal perspective. In addition, statement 2 is in the position of -4 in traditional perspective and in the position of -3 in universal perspective. This finding shows that the teachers in both perspectives mind the risks regarding human health and environment in their socioscientific decisions.

Table 4 lists participants' most agreed and most disagreed statements. As seen in the Table, the three science teachers in universal perspective overrated mostly environment and human health in their decisions regarding SSIs. Teachers in traditional perspective were similar; they overrated environment and human health together with ethical and moral issues and reliable information. The importance of human health comes out in the most disagreed statements as well (See Table 4).

Table 4. Participants' Most Agreed/Disagreed Statements

		Grid position	
Pers.	**Part.**	**+4**	**-4**
Traditional	S01M	**14.** I consider ethical and moral issues, such as human and animal rights, while deciding about SSIs.	**20.** Ethical and moral concerns do not affect my decision-making process regarding SSIs.
	S01F	**13.** I search and use the necessary scientific information in the decision-making process regarding SSIs.	**2.** While making a decision regarding SSIs, I ignore their effect on human health.
	S06M	**22.** The effect of SSIs on human health and life affects my decision.	**2.** While making a decision regarding SSIs, I ignore their effect on human health.
	S11F	**4.** The effects of SSIs on environment are influential on my decisions about them	**19.** I can make my decisions about SSIs without searching scientific information about the issues.
	S15F	**22.** The effect of SSIs on human health and life affects my decision.	**2.** While making a decision regarding SSIs, I ignore their effect on human health.
Universal	S04F	**4.** The effects of SSIs on environment are influential on my decisions about them.	**2.** While making a decision regarding SSIs, I ignore their effect on human health.
	S20M	**4.** The effects of SSIs on environment are influential on my decisions about them	**12.** My decisions regarding SSIs are independent from their effects on environment.
	S14F	**22.** The effect of SSIs on human health and life affects my decision.	**2.** While making a decision regarding SSIs, I ignore their effect on human health.

When participants' written explanations about the most agreed and the most disagreed statements (that is, +4 and -4, respectively) are examined, it is seen that S01M mentions about moral and ethical values as being the most important decision-making criteria. He stated that:

> "*Ethical and moral concerns inevitably affect my decision-making process* (S01M, written response)*."*

S01F, on the other hand, stated that she cannot decide without searching the positive and negative sides of the issue. Similarly, S11F pointed out that *"There is information pollution about SSIs. For that reason, it is important to me to make research* (S11F, written response)*".* Besides the need to search, human health was also placed in the most agreed and disagreed positions. According to S01F, for example, the second most important factor in the decision-making is human health (which comes after making research. Below are sample responses asserting the importance on human health:

> *"I believe that human health or human life is over everything* (S14F, written response)*."*
>
> *"Human health is something that is over everything* (S06M, written response)*."*

While S06M, S15F and S14F regarded human health as the most important thing over everything, S04F stressed the importance of environment by placing statement 4 in position +4. She placed the statement regarding human health in position -4 on the other hand, and seemed to make a balance between them. S20M, on the other hand, appears to have an attitude against the sense that environment exists for human use with his expression of:

> *"What is more important than human life for me is the life of other living things. When we have a look around the world, it is the human being destroying everything. Other organisms live in harmony* (S20M, written response)*."*

Science teachers in both perspectives may seem to have similar views in their ways to decide about SSIs, however, they are distinguished from each other in some ways. The statements that distinguish the perspectives, that is the distinguishing statements, are given in Table 5. As given in Table 5, statement 19 is one of the leading ones that distinguish traditional and universal perspectives. The positive expression of this statement is the 13th one, and there is a statistically significant difference between the perspectives for this statement as well ($p<.01$). While teachers in traditional perspective pointed out that they cannot decide without searching for scientific information, teachers in universal perspective remained neutral in this issue.

Moreover, as seen in statements 7 and 9, perspectives are also distinguished in terms of political and social attitudes of teachers. These statements were formed to investigate the possible impacts of political and social approaches of science teachers on their socioscientific decision-making, and it is likely to say that teachers in universal perspective posited a more apolitical approach in their decisions when compared to the teachers in traditional perspective. Moreover, as seen in statement 11 that is about personal experience, teachers in the traditional perspective are affected by their positive or negative experiences with the issue as they decide ($p<.01$). In addition, teachers in this (that is, traditional) perspective pointed out that values taken from the family are also effective in their decisions (statements 8 and 16), with a statistically significant difference from the universal perspective ($p<.05$).

Table 5. The Distinguishing Statements

		Traditional		Universal	
No.	**Statement**	**Grid Position**	**Z-score**	**Grid Position**	**Z-score**
19*	I can make my decisions about SSIs without searching scientific information about the issues.	-3	-1.56	0	0.15
7*	Decisions regarding SSIs should be away from political evaluations or approaches.	+1	0.22	+3	1.26
9*	The approaches of the government or the political or civil organizations that I support affects my decision over SSIs.	0	-0.38	-3	-1.42
10*	I approach SSIs with a universal sense, independent from the values of the community and the culture I live in.	0	-0.34	+2	0.67
13*	I search and use the necessary scientific information in the decision-making process regarding SSIs.	+2	1.15	0	0.22
11*	My positive or negative experiences regarding SSIs affect my decisions about them.	+2	0.68	-1	-0.23
16	The values I have taken from my family is not effective in my decisions regarding SSIs.	-1	-0.46	+1	0.43
8	The decision of my family regarding SSIs is important for me and affects my decision.	0	0.16	-1	-0.72

Note: All statements are significant at .05 level; statements that are significant at .01 level are indicated by an *.

Interviews

During the interviews, science teachers were asked to elaborate on the distinguishing statements (that is, statements 19, 7, 9, 10, 13, 11, 16, and 8). Statements 19 and 13 take place in 'science' dimension of 'subject areas' category, while 7th and 9th statements are in 'policy' dimension and 10th statement is in 'sociology' dimension. 11th statement, on the other hand, takes in the 'experience' dimension, and 16th and 8th statements are in 'values' dimension of the 'intellectual baggage' category. The statements taking place in the same dimension (as in the case of statements 13 and 19 being in 'science' dimension) were presented to the participants together for negotiation. Findings are reported below.

Statements 13 and 19

Statements 13 and 19 take place in 'science' dimension of subject areas category, and there is a statistically significant difference between the perspectives for both statements ($p<.01$). Participants holding traditional perspective pointed out that it is of importance to search and employ scientific information in socioscientific decision-making. Participants holding universal perspective, on the other hand, stated that they remained neutral on this issue for two reasons:

"Scientific knowledge has a controversial and tentative nature. SSIs, on the other hand, are also

controversial; and even scientists cannot reach a consensus about them, mostly. Because the issues are contemporary, knowledge about them tend to change rapidly. Information presented us as 'true' yesterday – for instance, egg causes cholesterol – might be defined as 'wrong' today. For that reason, it is not easy to prioritize scientific knowledge about SSIs (S04F, interview).

As seen in the sample expression above, S04F (and S14F, as well) remained neutral in statements 13 and 19 because of the tentative nature of scientific knowledge. S20M, on the other hand, pointed out that different branches of science may exhibit different approaches regarding the same SSI:

"Different disciplines offer different recommendations regarding the same SSI. For example; while physicists support nuclear power plants, biologists oppose it. We can duplicate examples of this. This raises the question: which branch of science should we prioritize if we consider scientific knowledge? (S20M, interview)*."*

Statements 7 and 9

Statements 7 and 9 are in the 'policy' dimension of the subject areas category, and there is a statistically significant difference between the perspectives for both statements ($p<.01$). It was found that participants in universal perspective are not affected by policy in their decisions about SSIs, while participants in traditional perspective remained neutral about being influenced by policy (Table 5). It was found in the interviews that participants in universal perspective had a strict attitude against policy, as is seen in the sample expression below:

"Policy means benefit. I am an individual and I should not allow the benefits of different power groups to manipulate my decisions (S14F, interview)*."*

Participants in traditional perspective, on the other hand, emphasized the social nature of human, and expressed their trust and reliance on the government or the authorities.

"... man is, in the end, a social creature and could be a part of various entities such as political parties, unions etc. or could someway establish a bond of affection. This bond can inevitably have an impact on our decisions. What's more, even if I sometimes think dissent about the SSI, I also think that the government has a serious power in its hand, and it has the data I do not have; and I happen to think that they have decided in a way by taking necessary considerations (S06M, interview)*."*

Statement 10

This statement takes place in the 'sociology' dimension of subject areas category, and there is a statistically significant difference between the two perspectives ($p<.01$). The participants holding universal perspective expressed that SSIs should be handled with a universal approach. On the other hand, participants in the traditional perspective approve the universal approach in principle, but state that this is not easy in practice since individuals cannot think independently from their culture and society they belong:

"Of course, many issues like GMOs, nuclear energy, -perhaps almost all of the SSIs-, are of interest to

> *all societies in the world which is a global village, but, it is very difficult for an individual being not affected by the society and culture he belongs to in making decisions* (S01M, interview)*".*

Statement 11

This statement takes place in the 'experience' dimension of subject areas category, and there is again a statistically significant difference between the perspectives ($p<.01$). By pointing out their limited experience regarding SSIs, two of the participants in universal perspective (S20M and S14F) stated that it is not possible for them to assert personal experience as an influential dimension in decision-making. The participants in traditional perspective, on the other hand, expressed that their experiences would generally be effective on their decisions regarding SSIs. One of them exemplified it with her own experience as:

> *"I think, background [experience] is important because the village where my family lived in is under the dam water formed as a result of a hydroelectric power plant. And this caused me to develop a negative attitude towards them [hydroelectric power plants]* (S11F, interview)*".*

Statements 8 and 16

Statements 8 and 16 take place in the 'values' dimension of subject areas category, and there is a statistically significant difference between the perspectives related to this statement ($p<.05$). During the interviews, participants holding the universal perspective exhibited a similar approach as they displayed about politics. They stated that, as being adults, they should handle the SSIs with a universal approach. Below is a sample excerpt:

> "*Although we learn many things from our families, it is important to be a self-actualized individual. No matter what the issue is, we should reflect this [being a self-actualized individual] in our decisions* (S04F, interview)".

In contrast with the universal perspective, participants holding traditional perspective expressed that it is difficult for individuals to think independently from their families and the societies (and cultures) in which they are grown up, and that the values taken from them (that is, from family and society) inevitably affect the subsequent life and decision-making processes.

Discussion

The current study identified two unique perspectives of science teachers towards making decisions about SSIs; five of the teachers had a *traditional* perspective, while three of them had a *universal* perspective. The findings showed that teachers in both perspectives had similar views over the risk factors related to human health and environment. In other words, they all ranked human health and environment in the first place in their decisions about SSIs. The reason behind prioritizing human health and environmental might be a result of the fact that today's societies are constantly facing socioscientific discussions about these issues (Kolstø, 2006). In the related literature, it was found that prospective teachers also prioritized human health and environment in their

decisions regarding SSIs (Eş et al., 2016). Similarly, high school students took health risk (Rundgren et al., 2016) and environment (Christenson et al., 2012) into consideration in their decisions about the SSIs in concern. Together with setting priority to human health and environment in socioscientific decision-making, some teachers set human health- and environment-related issues apart with a clear line. While S06M and S14F, for example, displayed a human-centric attitude by stating that human health is more important than anything else; S20M argued the reverse: environment is more important than anything else.

The two perspectives emerged in this study diverged dramatically from each other in science, policy and sociology/culture dimensions of the subject areas category and in experience and value dimensions of the intellectual baggage category. For the teachers holding traditional perspective, reliance on scientific knowledge in decision-making about SSIs was very important. For the teachers holding universal perspective, on the other hand, science dimension fell behind in the decision-making process. They brought two reasons forward, and stated that, due to the tentative nature of scientific knowledge and the fact that different scientific disciplines (i.e., physicians and biologists) have differing perspectives on the same issue (i.e., nuclear power), prioritizing science makes no sense. As it is observed in this finding, epistemological beliefs are known to affect individuals' mental thinking and reasoning processes (Hofer, 2000). When it comes to the policy dimension, it was found that science teachers in the universal perspective had a more apolitical approach in socioscientific decision-making when compared to the teachers in the traditional perspective. More specifically, the ones in the universal perspective stated that, political entities or civil society foundations to which they are affiliated or feel sympathy, do not affect their socioscientific decision-making. There is a similar situation in the sociology/culture dimension. Teachers holding traditional perspective pointed out that individuals are affected by their socio-cultural structure and thence, their socioscientific decision-making is affected by this structure as well. Teachers in the universal perspective, on the other hand, are of the opinion that SSIs should be handled with a universal perspective, free from personal features. Findings about the values dimension also pointed to a similar result; that is, teachers in the universal perspective exhibited a similar approach to the ones in the dimensions of policy and sociology/culture. They emphasized that, as being adults, people should take independent decisions regarding SSIs. Teachers in the traditional perspective, on the other hand, expressed that it is difficult for an individual to think independently from the family and society in which s/he is grown up and that the values taken from the family inevitably affect the future life and decision-making processes as well. Two of the teachers in the universal perspective expressed their limited personal experience with SSIs, and by referring to this limitation they stated that it is not possible for them to assert personal experience as an influential dimension in decision-making. The other teacher holding this perspective, on the other hand, stated that personal experience is important in decision-making processes, as similar to the teachers in the traditional perspective. As observed in the findings of the current study, findings of previous studies show that the intellectual baggage interacts to drive students' decision-making on SSIs (Chang Rundgren & Rundgren 2010; Rundgren et al., 2016; Christenson et al. 2012; Eriksson & Rundgren 2012; Eş & Öztürk, 2021; Kolstø 2006). Upon the review of the related literature, it is seen that decisive value comes to the forefront in decision-making processes (Christenson et al., 2012; Christenson et al., 2014; Eş & Öztürk, 2021; Grace & Ratcliffe 2002; Jiménez-Aleixandre & Pereiro-Muñoz, 2000), together with personal experience (Sadler & Zeidler, 2004; Tytler et al., 2001; Chang & Chiu, 2008). As Kolstø (2006) points out, all these research findings show that, even

though the same knowledge base is used when making a decision on a topic, different decisions will arise due to different values.

Conclusion

The current study was mainly an exploration of science teachers' patterns of decision-making behavior and the range of perspectives about SSIs. In the study, it was argued that Q methodology could be used as a valuable research tool for investigating socioscientific decision-making, and through the use of this methodology two diverse perspectives of decision-making behavior were uncovered. To put it in different way, this finding exhibited that there is no single socioscientific decision-making behavior among science teachers. It is observed that science teachers having the *traditional* perspective were generally affected by power groups such as scientists, political authorities and social values, while teachers in the *universal* perspective were of the opinion that SSIs should be handled with a universal perspective, that is, free from personal features and traditions. The study highlighted the typical descriptions associated with the two perspectives and helped in identifying the main issues of concern defined by the teachers in terms of SSIs. To confirm the validity of these patterns and perspectives, however, replication of the study is needed particularly with other science teachers from different regions or countries. The findings of this study can direct more comprehensive quantitative and qualitative research to better understand the factors associated with each perspective. For example, the characterizing and distinguishing statements used in the study can be converted to a set of questions to conduct survey research for the purpose of investigating decision-making behavior of a larger population and to identify the socio-demographic factors that are associated with the perspectives. In addition, the effect of the perspectives of science teachers on teaching processes regarding SSIs may be subject of research. Brown (1980) suggests that test-retest reliability of Q sort may range from 0.80 to 0.90. At this point, studies using Q methodology to test student learning before and after discussing any SSI could also be informative. Besides that, Q methodology could be used in investigating the decision-making processes on many local or global SSIs such as cloning, stem cell studies, genome project, global warming, alternative fuels, climate change and nuclear energy.

References

Aikenhead, G. S. (1985). Collective decision making in the social context of science. *Science Education*, *69*(4), 453-475.

American Association for the Advancement of Science [AAAS] (1989). *Science for all Americans. Project 2061*. New York: Oxford University Press. Retrieved December 18, 2018 http://www.project2061.org/publications/sfaa/online/intro.htm

Applebaum, S., Zeidler, D. L., & Chiodo, K. L. (2010). Using socioscientific issues as contexts for teaching concepts and content. *Exemplary science for resolving societal challenges*, 147-171.

Bell, R. L., & Lederman, N. G. (2003). Understandings of the nature of science and decision-making on science and technology based issues. *Science Education*, *87*(3), 352–377.

Bossér, U., Lundin, M., Lindahl, M., & Linder, C. (2015). Challenges faced by teachers implementing socioscientific issues as core elements in their classroom practices. *European Journal of Science and*

Mathematics Education, 3(2), 159-176.

Brown, S. R. (1980). *Political Subjectivity: Applications of Q Methodology in Political Science*, Yale University Press, New Haven, CT.

Brown, S. R. (1993). A primer on Q methodology. *Operant Subjectivity, 16* (3/4), 91–138.

Brown, S. R. (1996). Q methodology and qualitative research. *Qualitative Health Research, 6*(4), 561-567.

Brown, S. R. (2004). Q methodology, In *The SAGE Encyclopedia of Social Science Research Methods*, Lewis-Beck, M. S., Bryman, A., & Liao, T. F., Eds., Vol. 3, Sage, Thousand Oaks, CA, pp. 887–888.

Brown, S. R., Durning, D. W., & Selden, S. (1999). Q methodology, In *Handbook of Research Methods in Public Administration*, Miller, G. J. & Whicker, M. L., Eds., Marcel Dekker, New York, pp. 599–637.

Brown, S. R. & Ungs, T.D. (1970). Representativeness and the study of political behavior: An application of the Q technique to reactions to the Kent State incident. *Social Science Quarterly, 51,* 514-526.

Burek, K. (2012). *The impact of socioscientific issues based curriculum involving environmental outdoor education for fourth grade students.* Graduate School Theses and Dissertations. University of South Florida.

Chang Rundgren, S. N., & Rundgren, C. J. (2010). SEE-SEP: From a separate to a holistic view of socioscientific issues. *Asia-Pacific Forum on Science Learning & Teaching, 11*(1), 1-24.

Chang, S. N., & Chiu, M. H. (2008). Lakatos' scientific research programmes as a framework for analysing informal argumentation about socio- scientific issues. *International Journal of Science Education, 30*(13), 1753-1773.

Christenson, N., Chang Rundgren, S. N., & Höglund, H. O. (2012). Using the SEE-SEP model to analyze upper secondary students' use of supporting reasons in arguing socioscientific issues. *Journal of Science Education and Technology, 21*(3), 342-352.

Christenson, N., Chang Rundgren, S. N., & Zeidler, D. L. (2014). The relationship of discipline background to upper secondary students' argumentation on socioscientific issues. *Research in Science Education, 44*(4), 581-601.

Dryzek, J. S. & Holmes, L. T. (2002). *Post-communist Democratization*. Cambridge University Press, Cambridge, UK.

Durning, D. W., & Brown, S. R. (2007). Q methodology and decision-making. In G. Morçöl (Ed.), *Handbook of Decision-making* (pp. 537-563). Boca Raton, FL: CRC Press.

Eggert, S., & Bögeholz, S. (2010). Students' use of decision- making strategies with regard to socioscientific issues: An application of the Rasch partial credit model. *Science Education, 94*(2), 230-258.

Eggert, S., Ostermeyer, F., Hasselhorn, M., & Bogeholz, S. (2013). Socioscientific decision making in the science classroom: The effect of embedded metacognitive instructions on students' learning outcomes. *Education Research International, 2013*, 1-12.

Ekborg, M., Ottander, C., Silfver, E., & Simon, S. (2013). Teachers' experience of working with socioscientific issues: a large scale and in-depth study. *Research in Science Education, 43*(2), 599-617.

Eriksson, M., & Rundgren, C. J. (2012). Vargfrågan-Gymnasieelevers argumentation kring ett sociovetenskapligt dilemma [The wolf issue-upper secondary students' argumentation about a socioscientific issue]. *Nordic Studies in Science Education, 8*(1), 43-58.

Eş, H., & Öztürk, N. (2021). An activity for transferring the multidimensional structure of SSI to middle school

science courses: I discover myself in the decision-making process with SEE-STEP!. *Research in Science Education, 51,* 889-910., https://doi.org/10.1007/s11165-019-09865-1.

Eş, H., Işık Mercan, S., & Ayas, C. (2016). A new socioscientific issue for Turkey: Life with nuclear. *Turkish Journal of Education, 5*(2), 47-59.

Fang, S-C., Hsu, Y-S., & Lin, S-S. (2019). Conceptualizing socioscientific decision making from a review of research in science education. *International Journal of Science and Mathematics Education, 17*, 427-448.

Fleming, R. (1986a). Adolescent reasoning in socio-scientific issues, part I: Social cognition. *Journal of Research in Science Teaching, 23*(8), 677-687.

Fleming, R. (1986b). Adolescent reasoning in socio-scientific issues, part II: Nonsocial cognition. *Journal of Research in Science Teaching, 23*(8), 689- 698.

Grace, M.M., & Ratcliffe, M. (2002) The science and values that young people draw upon to make decisions about biological conservation issues. *International Journal of Science Education, 24*, 1157-1169.

Heath, P. A., White, A. L., Berlin, D. F., & Park, J. C. (1987). Decision making: Influence of features and presentation mode upon generation of alternatives. *Journal of Research in Science Teaching, 24*(9), 821-833.

Hodson, D. (2003). Time for action: Science education for an alternative future. *International journal of science education, 25*(6), 645-670.

Hofer, B. K. (2000). Dimensionality and disciplinary differences in personal epistemology. *Contemporary Educational Psychology, 25*, 378-405.

Hurd, P. D. (1958). Science literacy: Its meaning for American schools. *Educational leadership, 16*(1), 13-16.

Jiménez-Aleixandre M.P., & Pereiro-Muñoz C. (2002) Knowledge producers or knowledge consumers? Argumentation and decision-making about environmental management. *International Journal of Science Education,* 24, 1171-1190.

King, P. M., & Kitchener, K. S. (2004). Reflective judgment: Theory and research on the development of epistemic assumptions through adulthood. *Educational Psychology, 39,* 5–18.

Koçak, M. (2010). *The application of Q methodology to generate a functional typology of terrorist organizations in Turkey.* Unpublished doctoral dissertation, Kent State University.

Kolstø, S. D. (2001). To trust or not to trust, pupils' ways of judging information encountered in a socioscientific issue. *International Journal of Science Education, 23,* 877–901.

Kolstø, S. D. (2006). Patterns in students' argumentation confronted with a risk-focused socioscientific issue. *International Journal of Science Education, 28*(14), 1689-1716.

Lee, Y. C. (2007). Developing decision-making skills for socioscientific issues. *Journal of Biological Education, 41*(4), 170-177.

McKeown, B. F. & Thomas, D. B. (1988). *Q Methodology*, Sage, Newbury Park, CA.

McKeown, B. (2001). Loss of meaning in Likert scaling: A note on the Q methodological alternative. *Operant Subjectivity*, *24*(4), 201-206.

Ministry of National Education [MoNE] (2018). *Fen bilimleri dersi öğretim programı (ilkokul ve ortaokul 3, 4, 5, 6, 7 ve 8. sınıflar)* [Science Curriculum (Grades 3,4,5,6,7 and 8)]. Ministry of National Education Publications, Ankara.

National Research Council [NRC]. (1996). *National science education standards*. Washington DC: National

Academies Press.

Patronis, T., Potari, D., & Spiliotopoulou, V. (1999). Students' argumentation in decision-making on a socioscientific issue: implications for teaching. *International Journal of Science Education*, *21*(7), 745-754.

Presley, M. L., Sickel, A. J., Muslu, N., Merle- Johnson, D., Witzig, S. B., Izci, K., & Sadler, T. D. (2013). A framework for socio- scientific issues based education. *Science Educator*, *22*, 26-32.

Ratcliffe, M., & Grace, M. (2003). *Science education for citizenship: teaching socioscientific issues*. Maidenhead, UK: Open University Press.

Robbins, P. (2005). Q methodology, In *Encyclopedia of Social Measurement*, Kempf-Leonard, K., Ed., Vol. 3, Elsevier, San Diego.

Rundgren, C. J., Eriksson, M., & Chang Rundgren, S. N. (2016). Investigating the intertwinement of knowledge, value, and experience of upper secondary students' argumentation concerning socioscientific issues. *Science & Education, 25*(9-10), 1049-1071.

Sadler, T. D. (2003). *Informal reasoning regarding socioscientific issues: The influence of morality and content knowledge*. Unpublished doctoral dissertation, University of South Florida.

Sadler, T. D. (2004a). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching, 41*(5), 513-536.

Sadler, T. D. (2004b). Moral and ethical dimensions of socioscientific decision-making as integral components of scientific literacy. *Science Educator, 13*(1), 39-48.

Sadler, T. D., Barab, S. A., & Scott, B. (2007). What do students gain by engaging in socioscientific inquiry? *Research in Science Education*, *37*(4), 371-391.

Sadler, T. D., & Donnelly, L. A. (2006). Socioscientific argumentation: The effects of content knowledge and morality. *International Journal of Science Education, 28*(12), 1463-1488.

Sadler, T. D., & Zeidler, D. L. (2004). The morality of socioscientific issues: Construal and resolution of genetic engineering dilemmas. *Science Education*, *88*, 4-27.

Sadler, T. D. & Zeidler, D. L. (2005). Patterns of informal reasoning in the context of socioscientific decision-making. *Journal of Science Teacher Education*, *17*, 217- 241.

Stainton Rogers, R. (1995). Q methodology. J. A. Smith, R. Harré ve L. van Langenhove (Ed.). In *Rethinking methods in psychology*, (pp. 178-192). London: Sage Publications.

Stefanova, Y., Minevska, M., & Evtimova, S. (2010). Scientific literacy: Problems of science education in Bulgarian school. *Problems of Education in the 21st Century*, *19*, 113-118.

Stephenson, W. (1953). *The Study of Behavior: Q-technique and its Methodology*, University of Chicago Press, Chicago, 1953.

Tytler, R., Duggan, S., & Gott, R. (2001). Dimensions of evidence, the public understanding of science and science education. *International Journal of Science Education, 23*, 815–832.

Watts, S. & Stenner, P. (2005). Doing Q methodology: Theory, method and interpretation. *Qualitative Research in Psychology, 2*(1), 67-91.

Watts, S. & Stenner, P. (2012). *Doing Q methodological research: Theory, method & interpretation.* London: Sage Publications.

Webler, T., Danielson, S., & Tuler, S. (2009). *Using Q method to reveal social perspectives in environmental*

research. Greenfield, MA: Social and Environmental Research Institute.

Van Exel, J. & De Graaf, G. (2005). *Q methodology: A sneak preview*. Retrieved 15 October 2019 from https://bit.ly/2n9ruW6

Yager, R. E. (1996). History of science/technology/society as reform in the United States. In R.E. Yager (Ed.), *Science/Technology/Society as Reform in Science Education* (pp. 3-15). Albany: State University of New York Press.

Yang, F. Y., & Anderson, O. R. (2003). Senior high school students' preference and reasoning modes about nuclear energy use. *International Journal of Science Education, 25*, 221–244.

Yıldırım, İ. (2017). Students' perceptions about gamification of education: A Q-method analysis. *Education and Science, 42*(191), 235-246.

Young, J. M., & Shepardson, D. P. (2018). Using Q methodology to investigate undergraduate students' attitudes toward the geosciences. *Science Education*, *102*(1), 195-214.

Zeidler, D. L., Sadler, D. T., Simmons, M. L., & Howes, E. V. (2005). Beyond STS: A research-based framework for socioscientific issues education. *Science Education, 89*, 357-377.

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.

Zoller, U. (1982). Decision-making in future science and technology curriculum. *European Journal of Science Education*, *4*(1), 11-27.

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