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Turkish Pre-Service Primary Teachers' Decisions on Various Socioscientific Issues: SEE-SEP Model-Analysis

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Abstract

The science curriculum in the Turkish education system includes socioscientific issues (SSI) as a context for developing students' reasoning skills, scientific thinking habits, and decision-making skills from an early age. Conducting activities on real problems with teachers and pre-service teachers based on SSI and making decisions considering different dimensions in SSI can provide a better explanation and transfer of the content dimension of the subject. It was found that SSI studies are conducted with science teachers and pre-service science teachers in Türkiye. In this study, activities with different SSIs were organized with pre-service primary teachers, and the decisions of pre-service primary teachers on various socioscientific issues were evaluated considering different dimensions (sociology/culture, environment, economy, science, ethics/morality, and policy) using the SEE-SEP model. Nine different SSI scenarios were presented to 60 pre-service primary teachers in the Central Anatolian region of Türkiye, and they were asked to make a decision in dilemma situations and justify it. It was found that hydroelectric power plants (HEPP), mining, and electric vehicles are highly favored by pre-service primary teachers, while GMOs, cloning, and the establishment of industrial zones are not highly favoured, and they are undecided about biotechnology. It is concluded that the pre-service primary teachers' decisions to support various SSI are mainly economic and scientific, while the environmental and ethical/moral dimensions lead mainly to non-support and indecision.

Keywords: Socioscientific Issue, Decision-Making, SEE-SEP Model, Pre-Service Primary Teachers

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Introduction

Schools should reflect the dynamic interactions between science and society by focusing on the conceptual issues that science explains and its relationship to social, political, economic, and moral dimensions (Sadler and Fowler, 2006). Students are expected to understand science and be involved in the decision-making process by weighing the benefits and risks of scientific issues that are important to society (Dawson and Venville, 2009). Thus, essential steps are taken in scientific literacy and educating individuals in the future. Real-life problems lead students to decision-making processes because they contain dilemmas that involve both social and scientific factors. Real-life problems at the center of science and social life and containing dilemmas are called socioscientific issues (SSI). Socioscientific issues are complex, open-ended, often controversial, and dilemmatic questions for which there is no clear answer (Sadler, 2003), generally involve observations and require individual or societal decisions at the frontiers of scientific knowledge (Kolstø, 2006). While these questions affect society by being scientific, moral, and ethical, they contain essential contradictions that can have conceptual, methodological, and social implications for human life (Lee, Abd-El-Khalick and Choi, 2006; Sadler and Donnelly, 2006; Topcu, 2010).

Social and political issues at local, national, and global levels are considered in the context of real-life when creating SSI, including cost-benefit analyses in which the risk factor plays an important role, requiring sustainable development, and including values and moral considerations (Grace and Ratchliffe, 2002). While social, ethical, religious, environmental, economic, and legal issues that affect individuals or society are frequently discussed in the public sphere and social media, they are also on the agenda with SSI. Examples of SSIs include COVID-19 vaccine, climate change, vaccines, nuclear energy, and biotechnology developments (Dawson and Venville, 2009). Social, moral, and ethical issues should be addressed at every stage of science education because students need to have the basic infrastructure and skills necessary to make informed judgments and decisions about the developments they encounter in the media or daily life (Gray and Bryce, 2006). In this context, socioscientific-based instruction makes science topics uninteresting to students and can be described as dull, more exciting, and enjoyable (Dolan, Nichols, and Zeidler, 2009). Based on this regard, the focus of this study was to identify the dimensions that influence the decisions of pre-service primary teachers who will train students in the Turkish education system with the SEE-SEP model. Explanations on the SEE-SEP Model will be presented in the following section.

Inclusion of Socioscientific Issues in The Classroom

People often face real-world problems that do not have a clear solution and require reflection and decision-making (Zeidler and Sadler, 2007). Since SSIs are expected to appeal to many disciplines such as biology, chemistry, medicine, physics, and environmental science due to their

structure, and their impact will be seen across a broad spectrum, these topics should be highlighted and discussed (Chang-Rundgren and Rundgren, 2010). This is because SSIs can enable students to ask questions about scientific and social problems, participate in discussions, engage in argumentation and decision-making processes, and solve the problem (Presley et al., 2013; Sari and Wiyarsi, 2021). Using SSI, students can formulate their arguments from different perspectives such as social, environmental, and economic issues (Patronis, Potari, and Spiliotopoulou, 1999). In this way, an attempt is made to develop their knowledge and understanding of scientific concepts and involve them in decision-making activities (Karisan and Cebesoy, 2021).

Incorporating SSI into the instructional process helps students understand the relationship of science to their daily lives, and develop their engagement and attitudes toward science (Bulte, Westbroek, de Jong, and Pilot, 2006). Teaching through SSI uses controversial science topics to engage them in the discussion, debate, and two-way dialog (Nichols and Zeidler, 2009). Opportunities are created for students to decide how to act, analyze scientific knowledge to justify it, and use critical thinking skills to synthesize (Dawson and Venville, 2009). In this way, not only is content knowledge applied to an original topic, but students' critical thinking, decision-making, and science communication skills are developed (Albe, 2008; Maloney, 2007). Teachers' use of SSI in the instructional process allows global issues to be brought into the classroom environment and for students to develop character and values as global citizens (Lindahl, Folkesson and Zeidler, 2019). Using SSIs as context can help students become more engaged in learning and better prepared to make informed decisions after school (Christenson, Chang-Rundgren and Höglund, 2012). It was deemed important to include SSI in the instructional process at most education levels when assessed from these perspectives. It was emphasized that it helps students develop skills on decision-making, analysis, synthesis, evaluation, and understanding of their relationships to various domains (Zeidler, 2001).

SEE-SEP Model

While individuals form their arguments about SSI, various dimensions form the core of these views (Chang and Chiu 2008). Dimensions such as values, ethical issues, or the environment can be evaluated from different perspectives on SSI. Therefore, SSI has interdisciplinary, multidimensional, and multi-perspectival characteristics. Chang-Rundgren and Rundgren introduced the “SEE-SEP model” in 2010 by describing the multidimensional structure of SSI with a model. The SEE-SEP model provides a systematic and holistic way to examine the dimensions of judgments and decisions about SSI (Chang-Rundgren and Rundgren 2010). The model is described in six dimensions Sociology/Culture-S, Environment-E, Economy-E, Science-S, Ethics/Morality-E, and Policy-P. These six dimensions are interrelated and inseparable from their three aspects (roots): personal experience, values, and knowledge.

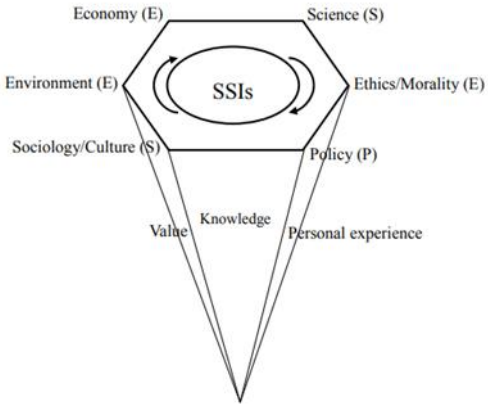

Figure 1. The SEE-SEP model of SSI (Chang-Rundgren, & Rundgren, 2010)

Figure 1 shows that the SEE-SEP model has six different dimensions. Chang-Rundgren and Rundgren (2010) briefly explain these dimensions as follows. Economy; When deciding on the SSI, economic conditions are considered, and concepts such as economic prosperity are emphasized. Environment; In the views related to the SSI, the environment is integrated and the positive-negative effects of the environment are emphasized. Sociology/culture is concerned with individuals' experiences in the society in which they live and the impact of their culture on SSI decisions. Scientific knowledge on various topics, including science, chemistry, biology, medicine, or technology influences thought processes and thus, SSI -based decisions. Ethics/morality has more to do with the emotional aspect, and each SSI makes decisions based on their values, religious beliefs, or moral views. Policy means that individuals consider the law or government policy and are influenced by this situation in their decisions about SSI. These six dimensions are associated with concepts, theories, laws, or evidence that relate to the aspect of belief. Value involves attitudes and refers to the affective domain of people. They tend to make decisions about SSIs based on their preferences. However, to the extent that SSIs are associated with people's daily lives, people will be able to discuss and present their own experiences with SSIs using personal experiences.

The SEE-SEP model helps explore how individuals reason in SSI. The model also allows researchers to reveal the multidimensional nature of SSI by showing the interaction of science, environment, ethics, sociology, economics, and policy with the three aspects of knowledge, value, and personal experience (Karisan and Cebesoy, 2021). Using the SEE-SEP model, we can focus on the content of the ideas students put forward, the sources they use in their justifications, knowledge, values, and experiences by connecting six themes (Christenson, Chang-Rundgren, and Zeidler, 2014). In addition, students' decisions may be based on one or more topic areas simultaneously while interacting with aspects of values, knowledge, and personal experiences. Furthermore, the topic areas and aspects students refer to in their decisions may vary depending on the content of the SSI (Chang-Rundgren and Rundgren, 2010).

Aim of Study

Science education programs based on the vision of producing scientifically literate individuals in the Turkish education system include SSI as an essential context for developing students' reasoning skills, habits of scientific thinking, and decision-making abilities (Ministry of Education [MoNE], 2013; 2018). Therefore, it should be essential to conduct real-world problems with teachers and pre-service primary teachers based on SSI. The fact that teachers and pre-service teachers consider different dimensions in the SSI they encounter can provide a better explanation and teaching of the content dimension of the subject. In addition, it allows students to evaluate events and issues from different aspects rather than transferring them from a single perspective. Dawson and Venville (2020) argue that SSI should be used to enhance professional development in teacher education, and it should go beyond the teacher by making the content interesting. Zohar (2007), on the other hand, saw it as an opportunity for teachers to engage in the teaching process where SSI is discussed prior to service and transfer the knowledge and experience they gain to their future students. When examining studies in the relevant literature, it was found that SSI studies are conducted in Türkiye with science teachers and pre-service teachers (Ates and Saracoglu, 2016, Aydın and Kaptan, 2014, Eş and Varol, 2019, Demiral and Türkmenoğlu, 2018, Gürbüzkol and Bakırcı, 2020, Öztürk and Erabdan, 2019, Türksever, Karışan and Türkoğlu, 2020). However, in this country, it was considered necessary by the researchers to organize activities with pre-service primary teachers who will cover socioscientific issues for the first time in the subjects of life science, science, and social studies in the future, and focus on the need to consider social, moral, and ethical issues in students' decision-making processes. The most effective way to achieve this is to organize events based on SSI with pre-service primary teachers and gain experience by perceiving the reasons for their decisions in SSIs. Based on this importance, an attempt was made to determine the dimensions influencing pre-service primary teachers' decisions in SSI using the SEE-SEP model.

The aim of this study is to evaluate pre-service primary teachers' decisions on different socioscientific issues from different dimensions (sociology/culture, environment, economics, science, ethics/morality, and policy). To this end, answers were sought to the following questions:

1-What decisions do pre-service primary teachers make about different socioscientific issues?

2-What dimensions influence pre-service primary teachers' decisions on different socioscientific issues?

Method

Research Design

A qualitative research model is defined as research in which qualitative data collection methods such as observation, interview, and document analysis are used, and a qualitative process is followed to uncover the events realistically and holistically in a natural setting (Yıldırım and Şimşek, 2013). In this study, a case study, one of the qualitative research designs, was used because the decisions of pre-service primary teachers related to the socioscientific issues were studied in depth. A case study is defined as the intensive study of a complex event or situation (Stake, 1995; Glesne, 2012) and its holistic analysis within its limitations (Yıldırım and Şimşek, 2013). In this study, the decisions of pre-service primary teachers in different SSI are described as a case and analysed in-depth using the SEE-SEP model.

The Participants of the Research

The study was conducted with 60 pre-service primary teachers in their final year of study at a state college in Central Anatolia in the 2019-2020 academic year. The study participants were identified and included in the study using criterion sampling based on the criteria that they had taken courses in different subjects such as science education, life skills education, and social studies education, that the researchers were easily accessible to the participants, that they were willing to participate in the study, and that they were senior students.

Data Collection Tools

In this study, which assesses pre-service primary teachers' decisions on the social studies topic based on different dimensions, open-ended questionnaires were used in which different SSIs are presented in scenarios. In these SSI forms, there are a total of nine different SSI scenarios: Nuclear Power Plant, Stem Cells, Hydroelectric Power Plant (HEPP), Establishment of Industrial Zones, Mining, Electric Vehicles, Biotechnological Developments, GMO, and Cloning. According to Khishfe (2012), students who have prior knowledge of a topic are more likely to participate in class, and structure their arguments more accurately. Therefore, when creating the open-ended question forms, the researchers scripted the SSIs, and prior information on these topics was included in the form. Real-life situations were used in the scenarios where pre-service primary teachers can question SSI, make arguments, situations that can lead to a dilemma, and require decisions. Then, field experts were asked to evaluate the scenarios in terms of relevance, clarity, content validity, and language expression, and the SSI forms were finalized.

The SSI forms consist of two parts. The first part contains the real situation (scenario) with the basic information and dilemma situations about SSI, while the second part asks the pre-service

primary teachers to decide about this SSI and justify their decision. In order to check the comprehensibility of the SSI form, a pilot study was conducted with a different pre-service teacher group. In order to check the comprehensibility of the scenarios, a pilot study was conducted with a different pre-service teacher group. After this pilot application, it was concluded that a period of 15 minutes was sufficient. For each SSI form, 15 minutes were provided, and the pre-service primary teachers were asked to record their decision and reasons in writing voluntarily. Since there are nine different SSI forms, data were collected at three different time points. The dilemmas presented in the SSI forms are summarized below:

Table 1. Information on the Prepared Scenarios

SSI Form	Content
Nuclear Power Plant	Nuclear energy and production methods, nuclear power plants, waste, environmental, and economic considerations.
Stem Cell	Stem cell technology and the production of artificial organs using this technology, and its evaluation in terms of health and ethics.
HEPP	Hydroelectric power, hydroelectric power plants (HEPP), environmental impact, economic considerations.
Establishment of an Industrial Zone	Ecological, cultural, and economic considerations for establishing an industrial zone.
Mines	The opening of new mines and their environmental, cultural, and economic impact on the region.
Electric Vehicles	Comparison of electric and gasoline vehicles in operation, use, performance, environmental impact, and economic considerations.
Biotechnological Advances	The re-emergence of endangered plant species through biotechnological developments, their economic and environmental impacts.
GMO	Production of GMO crops, their impact on nutrition processes and consumption, and their economic and environmental impacts.
Cloning	Areas where cloning is used and the procreation of children without sexual reproduction, ethical and moral discussions

Data Analysis

In examining the decisions and rationales of the pre-service primary teachers, it was found that they justified their decisions in SSI. These justified decisions were analysed using content and descriptive analyses based on the SEE-SEP model. Content analysis is a systematic, replicable technique in which some words of a text are summarized with smaller content categories, and the coding is based on specific rules (Büyüköztürk, Çakmak, Akgün, Karadeniz, and Demirel, 2012). On the other hand, descriptive analysis focuses on engaging with studies on a particular topic and evaluating trends and research findings in a descriptive dimension as systematic studies (Çalık and Sözbilir, 2014).

Based on the responses of pre-service primary teachers, their decisions about various SSIs were examined first. The reasoned decisions in the forms of SSI were read individually, and the line-by-line analysis approach described by Patton (2014) was used in coding the data. A word, phrase, or sentence formed a unit for data analysis. At this stage, researchers undertook open coding and created

categories within a logical filter by comparing similar and different aspects. Then, considering the SEE-SEP model, they determined which dimensions affected pre-service primary teachers' decisions and presented them in categories.

Reliability and Ethics of the Research

The researchers coded the SSI forms separately to ensure the reliability of the coding. After coding, the code lists were compared, and the researchers agreed on the codes that did not match by recoding them together. To ensure the transferability of the research findings, the results were presented in an explanatory manner with figures and tables. The results were presented to the reader with direct quotes to increase the consistency of the research, and their connections with other findings are presented by interpreting the results. Details of how the data were collected, recorded, and analysed were presented to the reader to ensure the confirmability of the research. The pre-service teachers were given pseudonyms such as T1, T2, T3, … and the reasoned decisions they made were reproduced in the results section with direct quotes - and in a way that the reader can understand the sentence structures.

Results

The results of this study, in which the decisions of pre-service primary teachers on various social science topics were assessed from different perspectives (sociology/culture, environment, economics, science, ethics/morality, and policy), are presented below according to the sub-objectives.

Decisions of Pre-Service Primary Teachers on Various Socioscientific Issues

The various SSI -related decisions of the pre-service primary teachers were analysed along with their reasons and summarized in Table 2 according to their support/non-support for the dilemma situations in the scenario.

Table 2. All SSI-Related Decisions of Pre-Service Primary Teachers

Different SSI	Support	%	Non-Support	%	Undecided	%	Total
Nuclear Power Plant	31	52.5%	21	35.5%	7	12%	59
Stem Cell	25	59.5%	9	21.5%	8	19%	42
HEPP	46	79%	10	17%	2	4%	58
Establishment of an Industrial Zone	21	49%	21	49%	1	2%	43
Mines	41	72%	13	22%	3	6%	57
Electric Vehicles	29	%66	7	16%	8	18%	44
Biotechnological Advances	15	50%	6	20%	9	30%	30
GMO	16	28%	35	62%	6	10%	57
Cloning	15	29%	30	58%	7	13%	52

When examining the overall decisions of pre-service primary teachers on SSI, the most supported SSI is HEPP (79%) and mining (72%), followed by electric vehicles (66%), stem cells (59.5%), nuclear power plant (52.5%), and biotechnology (50%).

GMO (62%), cloning (58%), and industrial zone (49%), which have the highest percentage among SSI not supported by pre-service primary teachers, draw attention.

When examining the SSI subjects on which pre-service primary teachers were undecided, it appeared that the subject with the highest percentage was biotechnology (30%), while they avoided commenting on this topic (n=30).

Dimensions Influencing Pre-service Primary Teachers' Decisions on Various Socioscientific Issues

The extent to which pre-service primary teachers' decisions on various socioscientific issues are influenced was analysed based on the SEE-SEP model, and the dimensions of pre-service primary teachers' reasoned decisions on each SSI are presented in subtitles.

Dimensions of pre-service primary teachers' reasoned decisions on the nuclear power plant

The dimensions of reasoned decisions made by pre-service primary teachers on the nuclear power plant SSI form were identified and presented in Figure 2.

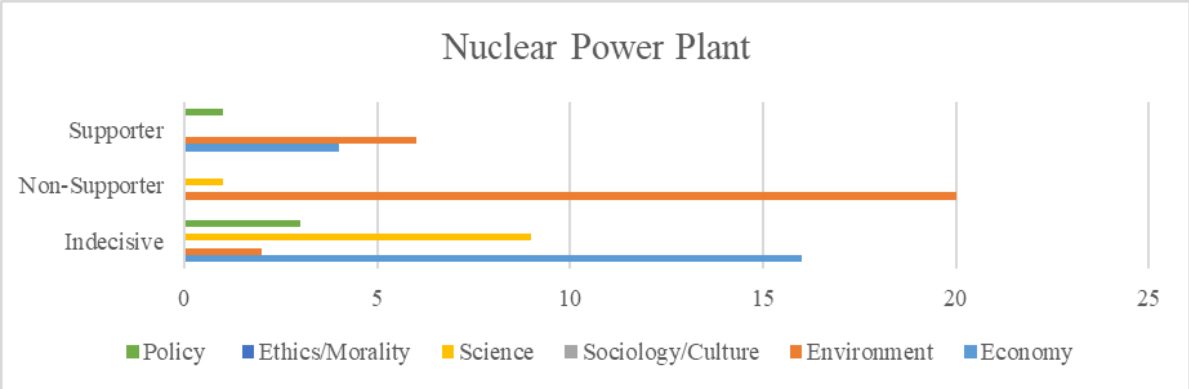

Figure 2. Dimensions of pre-service primary teachers' decisions on the nuclear power plant

When examining the decisions of the pre-service primary teachers about the nuclear power plant (Table 2), it is found that 52.5% of the respondents support the nuclear power plant, 35.5% do not support it, and 12% are undecided. When examining the reasons for these decisions, the "economy" dimension was the most compelling reason for the support decisions, followed by the "science" dimension (Figure 2). It can be seen that pre-service teachers who do not support the nuclear power plant consider the "Environment" dimension and that the "Environment" dimension is most effective in their indecision.

The following are some examples of the reasoned decisions made by pre-service primary teachers on the "Nuclear Power Plant SSI " scenario.

> *T_{18} (Supporting-Economy): "I support the idea of establishing NPPs. Because as a country, we should not lag behind other countries. We need to strengthen our economy as a country that sells energy, not buys it. I already know that the areas to be established are not prone to earthquakes, and I think disaster scenarios are unnecessary."*

T_{29} (Supporting -Science): "I support nuclear energy. Because I think that in a world that is developing day by day in every way, of course, new scientific studies and projects should be included. One of these studies is nuclear power plants, because the problems that arise will certainly be solved with the developing technology."

T_{49} (Non-Supporter-Environment): "I am not a supporter of nuclear power plants because it is an undeniable fact that these power plants are beneficial in terms of their function, we cannot deny that, but I find it negative because their possible damage to the environment will affect the health and life of living beings. Instead, we should rely on natural resources."

Dimensions of pre-service primary teachers' decisions on stem cells

The dimensions of pre-service primary teachers' reasoned decisions on the Stem Cells SSI form were identified and presented in Figure 3.

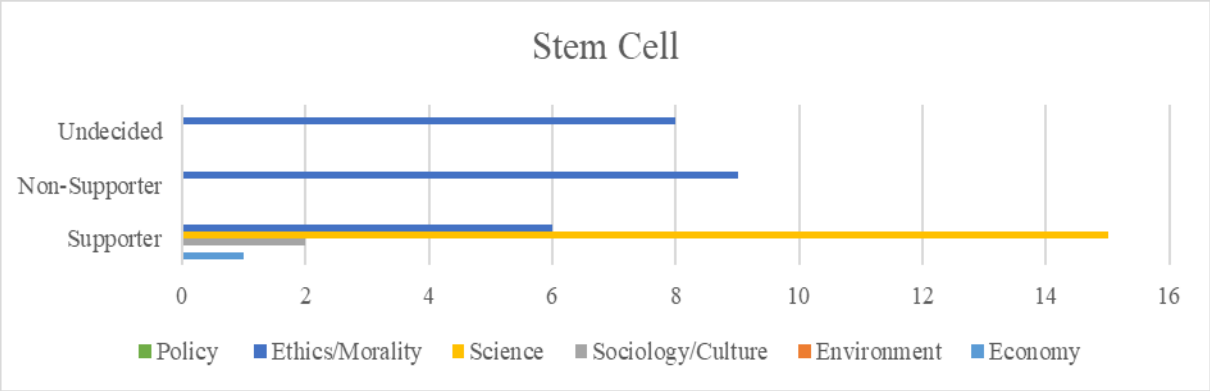

Figure 3. Dimensions of pre-service primary teachers' decisions on stem cells

When examining pre-service primary teachers' decisions about stem cells (Table 2), it is found that 59.5% of respondents favor stem cells, 21.5% do not favor them, and 19% are undecided. When the reasons for these decisions are examined, the dimension of "science" as a reason for support decisions has had the most significant impact on candidate decision making. It can be seen that prospective teachers who do not support the stem cell issue consider the "ethics/morals" dimension and that the only effective dimension in their indecision is "ethics/morals."

The following are some examples of the reasoned decisions of pre-service primary teachers' regarding the stem cell scenario SSI.

T_{23} (Non-Supporter-Ethics/Morality): "I do not support stem cell therapy because it is unethical. It seems unreasonable to me to kill a living human being who has a new disease that God has given. It is a sin; you should not risk saving the other person."

T_{29} (Supporter -Science): "I support stem cell therapy. There are risks in every aspect of life, and there are treatment options, but science and technology have advanced to the point where even these forms of treatment are evolving. With stem cells being an evolving treatment, there will be a solution to diseases like diabetes, Parkinson's, and cancer."

Dimensions of pre-service primary teachers' decisions on HEPP

The dimensions of reasoned decisions reported by the pre-service primary teachers on the HEPP SSI form were identified and presented in Figure 4.

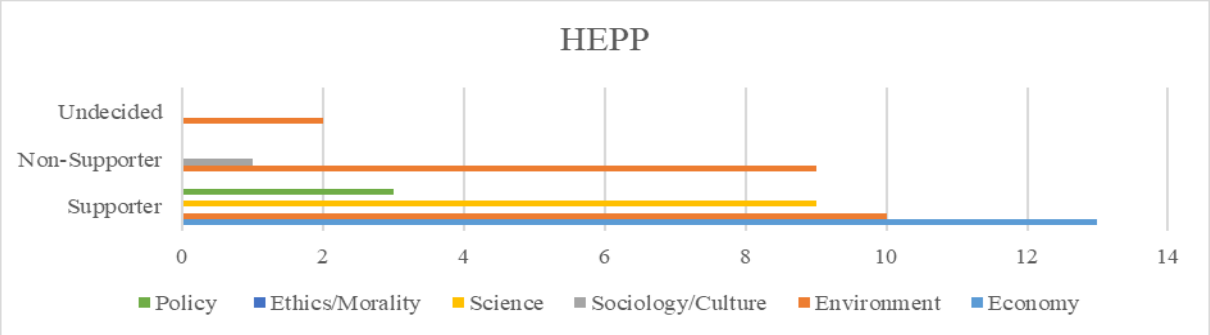

Figure 4. Dimensions of pre-service primary teachers' decisions on HEPP

When examining pre-service primary teachers' decisions about HEPP (Table 2), it is found that 79% of the respondents are supportive of HEPP, 17% do not support, and 2% are undecided. When the reasons for these decisions are examined, the "economics" dimension was the most effective reason for the supportive decisions, while the "environment" and "science" dimensions were influential in the pre-service teachers' decision-making. It can be seen that the pre-service teachers who do not support HEPP consider the "Environment" dimension and that the only effective dimension is "Environment" when they are still undecided.

The following are some examples of the reasoned decisions made by pre-service primary teachers on the HEPP SSI scenario.

T_{18} (Supporter-Economy): "I am supportive because dams are beneficial to our country. Using electricity and water from these dams reduces economic dependence on foreign countries."

T_5 (Supporter -Environment): "I support the project on the condition that it is controlled. For example, if no trees are cut down, no living creatures are harmed, and agricultural activities are not interrupted, I can support the construction of a HEPP."

T_7 (Supporter -Science): "Today, science and technology are being used, and technology is powered by electricity. I support the use of HEPP because our time today is technology and electricity-driven."

T_6 (Non-Supporter - Environment): "I do not support the death of fish and other creatures, and the destruction of forests if there is no solution. Because to say I do support that is to say I support the destruction of the environment and global warming."

Dimensions of pre-service primary teachers' decisions on establishing an industrial zone

The dimensions of pre-service primary teachers' reasoned decisions about establishing an industrial park were identified on the SSI form and shown in Figure 5.

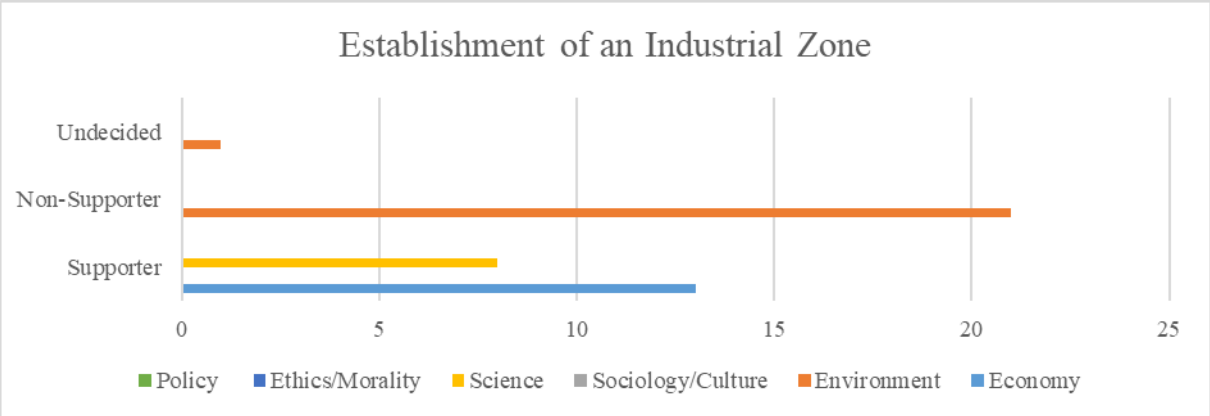

Figure 5. Dimensions of pre-service primary teachers' decisions on establishing an industrial zone

When examining pre-service primary teachers' decisions about establishing an industrial district (Table 2), it was identified that 49% are supportive, 49% are not supportive, and 2% are undecided. When the reasons for these decisions are examined, the "business" dimension was the most effective reason for the supportive decisions, while the "science" dimension was effective in the pre-service teachers' decision-making. It can be seen that pre-service teachers who do not support the industrial zone issue consider the "environment" dimension and that the only effective dimension in their indecision is the "environment" dimension.

The following are some examples of the reasoned decisions made by the pre-service primary teachers for the scenario of establishing an industrial zone SSI.

> *T_{23} (Non-Supporter-Environment): "I am not in favour of the industrial zone because it causes great harm to the environment and natural structure. Also, it causes global warming, which will be a disaster not only for us but for all living beings entrusted to us."*

> *T_{24} (Supporter -Economy): "I support the establishment of an industrial zone. But the necessary precautions should be taken for this establishment. Its establishment is more important for the country's development from an economic point of view, and only the necessary precautions should be taken."*

> *T_{25} (Supporter -Economy): "I support the industrial zone because if there is no industry, we will be dependent on foreign countries, which is not good for our country because our economy will be greatly affected. The collapse of the economy means the collapse of a country."*

> *T_{27} (Supporter -Science): "I support industrial zones; their impact on global warming is indeed serious, but this can be minimized by using evolving science and technological tools. Our age is the age of science, and we need to keep up with it."*

Dimensions of pre-service teachers' decisions on mining

The dimensions of pre-service primary teachers' reasoned decisions about mines were identified on the SSI form and shown in Figure 6.

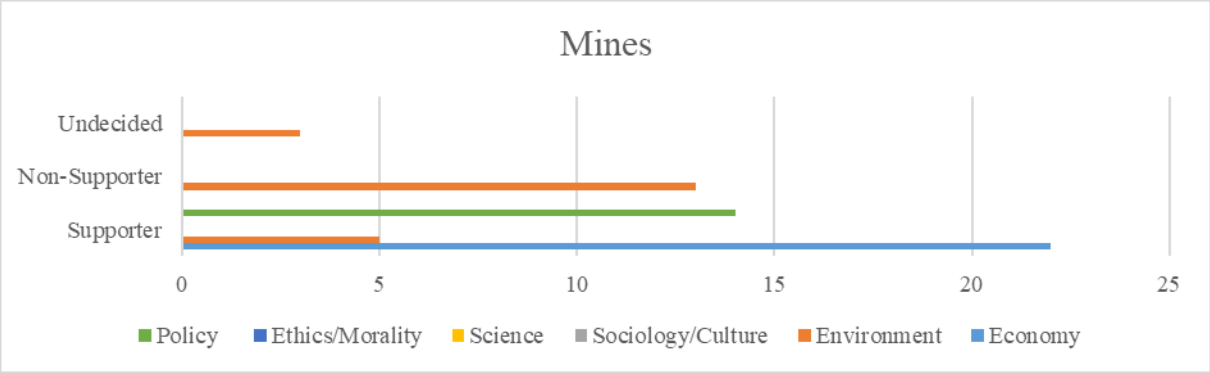

Figure 6. Dimensions of pre-service teachers' decisions on mining

When examining the decisions of the pre-service primary teachers about mining (Table 2), it is found that 72% of the respondents are supportive of mining, 22% are not, and 6% are undecided. When the reasons for these decisions are examined, the "Economy" dimension was the most effective reason for the supportive decisions, while the "Policy" dimension was effective in the pre-service teachers' decision-making. It can be seen that the pre-service teachers who do not support mining consider the "Environment" dimension and that the only effective dimension in their indecision is the "Environment" dimension.

Below are some examples of the reasoned decisions that pre-service primary teachers made about the mining scenario SSI.

T_9 (Supporter-Economy): "I support the establishment of a mine by taking the necessary precautions. Because mining is an excellent development in its economy, it has many uses.

T_{10} (Supporter-Policy): "I support the establishment of a mine. Because the established mines are important for Türkiye, for our policy, it will bring important results, both in terms of processing and employment for the workers who will work in the factory."

T_2 (Non-Supporter-Environment): "I do not support mines. The number of people who have lost their lives in accidents is high, and the necessary measures are not taken in mines. Besides, the consumption of mines means disturbing the balance of nature and leaving a bad world for future generations."

Dimensions of pre-service primary teachers' decisions on electric vehicles

The dimensions of reasoned decisions given by the pre-service primary teachers on the Electric Vehicles form SSI were identified and shown in Figure 7.

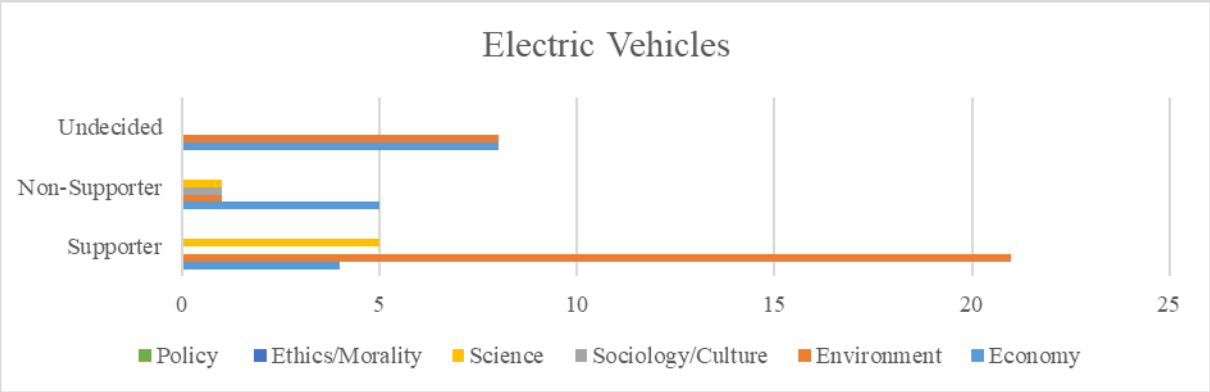

Figure 7. Dimensions of pre-service primary teachers' decisions on electric vehicles

When examining pre-service primary teachers' decisions about electric vehicles (Table 2), it was found that 66% of the respondents were supportive of electric vehicles, 16% were opposed to electric vehicles, and 18% were undecided. When the reasons for these decisions were examined, the "environment" dimension was the most effective reason for supportive decisions, while the "science" and "economy" dimensions were effective in the pre-service teachers' decision-making. It can be seen that the pre-service teachers who do not support the electric vehicle issue consider the "economy" dimension and both the "environment and economy" dimensions in their indecision.

The following are some examples of the reasoned decisions of pre-service primary teachers on the electric vehicle scenario SSI.

> *T_1 (Supporter-Environment): "I support electric vehicles. Because I think electric vehicles are more environmentally friendly than gasoline vehicles. Although they are more expensive financially, it is more important that they do less harm to the environment."*
>
> *T_{16} (Undecided-Environment-Economy): "I am undecided because if it breaks down, there is no one to fix it, battery replacement is expensive, it will hurt my economy, but on the other hand, if I think I am not polluting, I am."*
>
> *T_{21} (Non-Supporter - Economy): "There are not enough charging stations in Türkiye. " If I want to drive a long distance, we will probably be stuck on the road. Also, the vehicles are costly compared to gasoline-powered vehicles, and I would not prefer a device that is so expensive and impractical to use."*

Dimensions of pre-service primary teachers' decisions on biotechnological developments

The dimensions of pre-service primary teachers' reasoned decisions about biotechnological developments SSI were identified and presented in Figure 8.

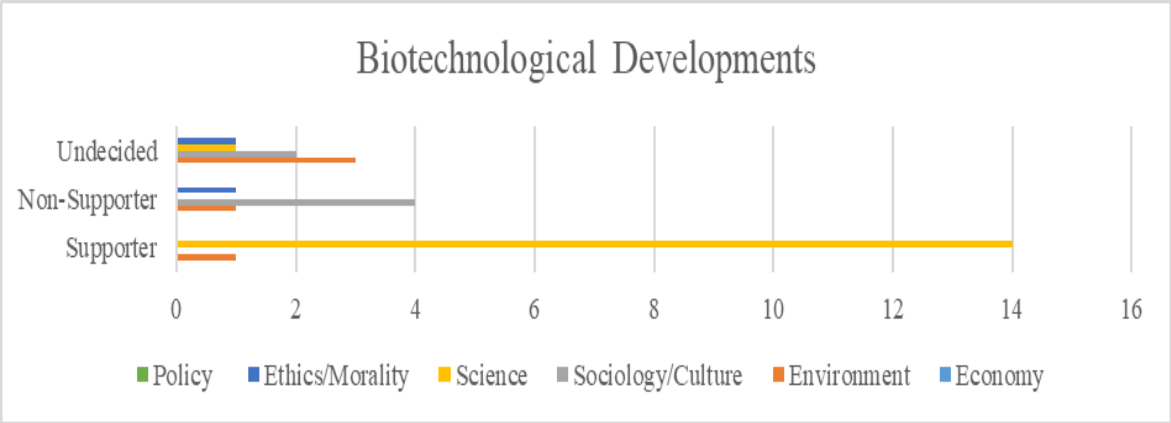

Figure 8. Dimensions of pre-service primary teachers' decisions on biotechnological developments

When examining pre-service primary teachers' decisions about biotechnological developments (Table 2), it was found that 37.5% of the respondents supported biotechnological developments, 56% did not support them, and 6.5% were undecided. When these decisions are examined, the science dimension was the most effective reason for the pre-service teachers' decision to support teaching. It can be seen that the pre-service teachers who do not support the subject of biotechnology and are undecided consider the dimension of "Ethics/Morality."

The following are some examples of the reasoned decisions of pre-service primary teachers on biotechnology developments SSI.

T_8 (Non-Supporter-Environment): "I am against it because biotechnological developments harm living beings first and then the environment, and then solutions for this harm are created as if this is a good thing."

T_{10} (Supporter-Science): "I am in favor because science and technology will be indispensable for the next centuries. Thanks to these innovations, life can be extended."

T_{22} (Undecided-Sociology/Culture): "I am undecided because it is both useful and harmful. I think it disrupts the cultural structure; in that sense, it is harmful. However, it is also useful because it makes the superhuman."

T_{26} (Supporter-Science): "Biotechnological developments are useful. For example, gene therapy for cancer also effectively reduces genetic diseases, which is useful because it enables such scientific developments. Of course, there are disadvantages, but the advantages outweigh them."

Dimensions of pre-service primary teachers' decisions on GMOs

The dimensions of reasoned decisions reported by the pre-service primary teachers on the GMO SSI form were identified and presented in Figure 9.

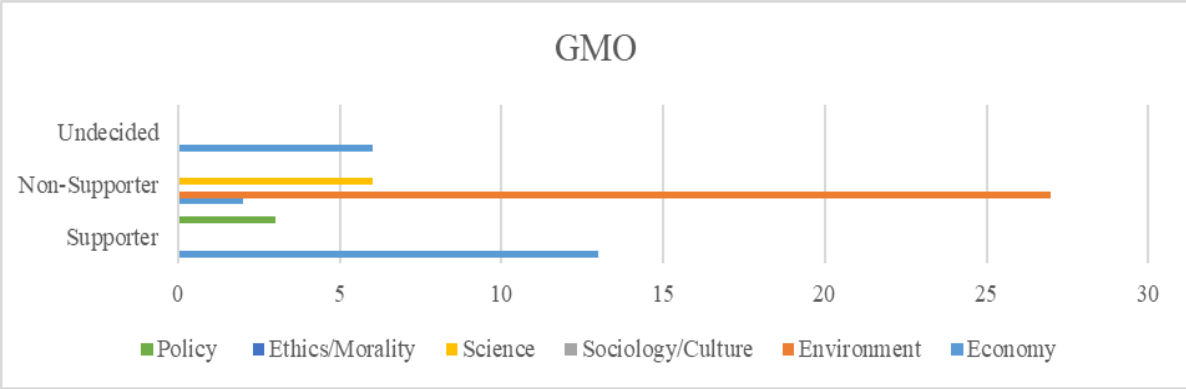

Figure 9. Dimensions of pre-service primary teachers' decisions on GMOs

In examining pre-service primary teachers' decisions about GMOs (Table 2), it was found that 28% of the respondents supported GMOs, 62% did not, and 10% were undecided. When the reasons for these decisions were examined, the "economics" dimension was the most effective reason for the supportive decisions, while the "Policy" dimension was influential in the pre-service teachers' decision-making. It can be seen that pre-service teachers who do not support the GMO issue give more consideration to the "Environment" dimension. On the other hand, undecided pre-service teachers considered the "Economy" dimension.

Below are some examples of the reasoned choices of pre-service primary teachers for the scenario GMO SSI.

T25 (Supporter-Economy): "Considering our country's economy, the economic contribution will be high in terms of money going abroad and money left over when we produce it."

T19 (Supporter-Policy): "I support GMO products; they should also be produced in our country. It will gain political power if we produce them ourselves instead of importing them from abroad."

T15 (Non-Supporter-Environment): "I do not support. Because I am a fan of natural life, and GMO products harm living things, and they damage the balance of nature..."

T52 (Supporter-Economy): "I support GMOs when they are used in appropriate areas. In other words, their use in agriculture will benefit both employment and production. However, if GMO products are offered for sale, consumption should be left to society."

Dimensions of pre-service primary teachers' decisions on cloning

The dimensions of reasoned decisions given by the pre-service primary teachers on the cloning form SSI were identified and presented in Figure 10.

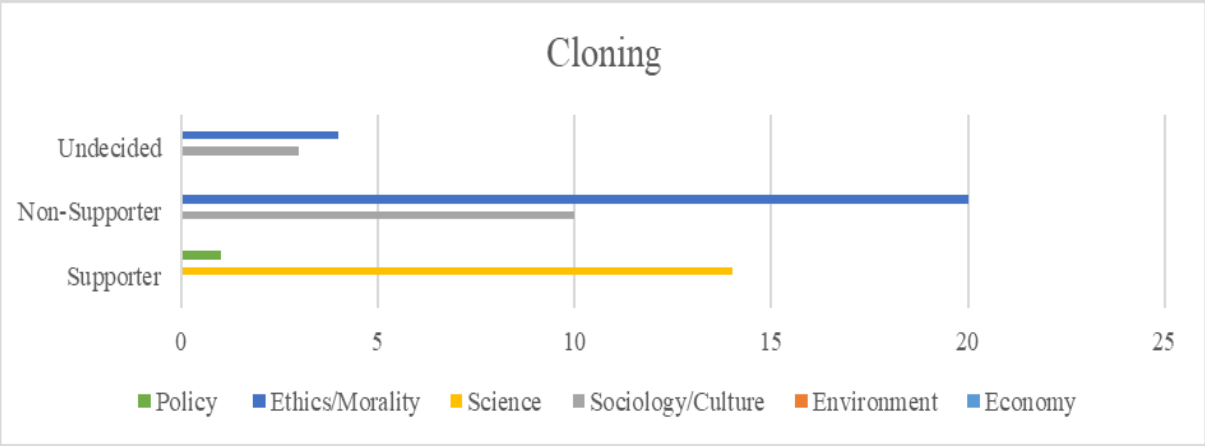

Figure 10. Dimensions of pre-service primary teachers' decisions on cloning

When examining pre-service primary teachers' decisions about cloning (Table 2), it was found that 29% were supportive of cloning, 58% were not, and 13% were undecided. Looking at the reasons for these decisions, it can be seen that the "science" dimension was effective in the pre-service teachers' decision-making with the highest reasons for the endorsement decisions. The pre-service teachers who do not support the issue of cloning and are undecided pay more attention to the "Ethics/Morality" dimension and then decide according to the "Sociology/Culture" dimension.

Below are some examples of the reasoned decisions that pre-service primary teachers made regarding the cloning scenario SSI.

T3 (Non-Supporter-Ethics/Morals): "I do not support it because I think it is negative. Instead of cloning plants, people should plant seeds. Instead of cloning endangered animals, they should protect them. Human cloning is unethical, and it is not appropriate for people to use cloned living beings for their interests. Because they are also a living being."

T18 (Supporter-Science): "I think the studies on cloning should be continued, and human cloning should also be carried out. From the point of view of the need for organ transplants and military needs, we should benefit from science."

T9 (Non-Supporter-Sociology/Culture): "I am not a supporter of cloning. There may be positive aspects, but I think the negative aspects outweigh the positive. In particular, human cloning may lead to the emergence of a slave class, and, the crime rate will increase."

T45 (Non-Supporter-Ethics/Morality): "I do not support cloning because it is morally and ethically inappropriate. Because it seems very cruel to me to kill another living being in order to save the life of another living being through an organ transplant."

Discussion, Conclusion and Recommendations

In this study, the decisions of pre-service primary teachers on various socioscientific issues were assessed on various dimensions based on the SEE-SEP model. In examining the decisions of pre-service primary teachers about different SSIs were examined, it was found that HEPP, mining, and electric vehicles were highly supported. GMOs, cloning, and industrial zoning were found to lack high support, and pre-service primary teachers were undecided on biotechnology. Similar to this study, studies conducted with Turkish pre-service teachers found that pre-service teachers are not against HEPPs and support the establishment of HEPPs (Bodur and Şenyuva, 2013, Öztürk and Yenilmez Türkoğlu, 2018, Yangın, Geçit and Delihasan, 2012). Atasoy (2018) found that pre-service teachers made more ecologically oriented arguments in their statements about HEPPs, and they wanted the continuity of HEPPs because they did not want to depend on foreign sources for energy. Aydın and Silik (2020) pointed out in their study that primary school teachers facilitate our lives and create the need for energy, considering factors such as the economy and environment. In different studies, it was found that Turkish pre-service teachers have negative attitudes towards GMOs (Öztürk and Yenilmez Türkoğlu, 2018; Kilinc and Sönmez 2012; Gürbüzoğlu and Yalmancı, 2016). In the study conducted by Kıvanç and Arı (2019), it was found that pre-service teachers have negative attitudes towards gene transfer studies that can be performed on humans and animals. Uysal, Cebesoy, and Karışan (2018) concluded that pre-service teachers' attitudes toward various SSIs such as gene transfer and cloning change in the context of the subject studied. However, biotechnology developments have recently been discussed more frequently in moral issues and technology. Genetic engineering has been associated with disrespect for human dignity and even accused of being moral and inhumane (Tauscher, 2015). The concern generated by this situation may have caused pre-service primary teachers to be undecided about biotechnology.

With Türkiye's developing economic model, various SSIs are highlighted and frequently discussed in the media (the nuclear power plant under construction, the domestic electric vehicle project, the increasing demand for raw materials, etc.). Various media (TV, newspapers, social networks, popular science publications, etc.) publicly discuss SSIs in scientific findings, ethical and moral values, and various examples. Therefore, it can be assumed that the context of knowledge, values, and experiences has come to the forefront in the reasoned decisions of pre-service primary teachers because SSIs are frequently discussed in the media. This is because the media has an impact on various SSI by highlighting aspects such as the environment and society (Türköz and Öztürk, 2020). It is ensured that individuals gain awareness of the socioscientific issues through popular media tools (newspaper, scientific journal, internet, etc.) and make decisions by understanding, interpreting, and critically evaluating it correctly (Öztürk and Erabdan, 2018). SSIs are inherently open, unresolved, contradictory, and dilemmatic topics. Because of these structures, individuals are

evaluated in different ways of thinking (Levinson, 2006). Thomas and Durant (1987) argued that SSI serves as a context for acquiring scientific literacy. By structuring the process in terms of information, presenting evidence, and defending ideas for or against, an individual's ideas become effective and can change or diversify different people's opinions (Çınar, 2013). Thus, discussing SSI situations develops individuals' decision-making ability as citizens and prepares the ground for the decisions made to be the product of the common mind (Karakaya, 2015). In his study, Sadler (2009) stated that studies on SSI have motivational contexts for learning and provide ample evidence for reviewing learning activities. Dawson and Venville (2020) pointed the importance of SSI and emphasized that teachers should focus on teaching their students how to use evidence to justify decisions from the earliest grades. In this way, they argued, students would acquire fundamental skills that significantly increase their usefulness during school and life. Aldağ (2006), on the other hand, stated that the main point is not that students take different positions, but that they try to consider different ideas, evaluate them, and make decisions to solve the problem. Chang and Chiu (2008) stated that SSI -based scenarios organized gain importance in identifying the reasons behind students' decisions, ideas, and beliefs. In a related evaluation, these activities with pre-service primary teachers formed the basis for using SSI in a classroom context. The decisions made on different SSIs provided pre-service primary teachers with an experience and opportunity to evaluate real-life problems from different aspects and make decisions rather than looking at them from a single perspective.

It was concluded that the pre-service primary teachers' decisions to support various SSI are mainly economic and scientific, while the environmental and ethical/moral dimensions mainly lead them to be unsupported and undecided. SSI has a multifaceted structure with moral, ethical, social, political, and economic characteristics. Sometimes they are problems that are difficult to get out of, difficult to decide, and cannot be solved alone. Christenson et al. (2012) discovered that values were the most frequently used support (67%) in SSI, while information was less frequently used (27%). Bossér (2018) found that the dilemma and complexities of SSI prepare individuals to engage in discussion and decision-making processes. Sadler and Zeidler (2004) found that students' ethical and moral thoughts influenced their reasoning skills in the SSI scenario they presented, but they found that students trusted the science faculty in decision-making. Thus, we can say that pre-service primary teachers have placed the information context at the forefront of their reasoned decisions. In addition, applications such as in vitro fertilization, cloning, the use of stem and embryo cells in biotechnological studies, the presence of contents in products derived from GMOs that are not consistent with the cultural, religious, and moral values of society, or the early diagnosis of genetic diseases and abortion by terminating the life of the embryo are practices in this field brings ethical debates. For this reason, it is only natural that the results obtained in biotechnological research influence and debate the ethical and moral values of society (Öztaş, Yel and Öztaş, 2005). At the same time, the fact that the majority of the country is Muslim and the SSIs being at the centre of

religious debates, have effectively contributed to reasoned decisions in the ethical and moral dimensions. Thus, we can say that pre-service primary teachers have placed the value context at the forefront of their reasoned decisions to disagree and be undecided. Topçu (2008) concluded that pre-service teachers are influenced by personal experiences, social considerations, technology, and ethical and moral considerations when making decisions about SSI. Evren-Yapıcıoğlu and Kaptan (2018) concluded in their research that the decision about SSI is influenced by many factors, such as the individual's age, religious judgments, field knowledge, environment, and economic situation. Wu and Tsai (2007) concluded in their study that there is a relationship between the use of multiple modes of reasoning (socially oriented, economically oriented, environmentally oriented, and science or technology-oriented) and students' reasoning skills, thereby improving decision making in SSI and encouraging students to use more than one mode of reasoning. They suggested that perspective thinking should be encouraged. This research shows that pre-service primary teachers' SSI can view and justify their decisions differently.

On the other hand, this research could enable pre-service primary teachers to make decisions by considering different dimensions in SSI to explain better and communicate the content dimension of the topic. Evaluating the professional position in the future has allowed students to evaluate events and facts from different aspects rather than transferring them from a single perspective. Since SSI inherently requires thinking about different views, aspects, dimensions, and disciplines, it should not be evaluated in a single perspective or dimension (Akkaş, 2018). This multifaceted decision-making structure provides meaningful learning opportunities. In this way, SSI has a positive effect on increasing students' motivation and attitude (Rahayu, Setyaningsih, Astarina, and Fathi, 2018). Ke, Sadler, Zangori, and Friedrichsen (2021) found that students like it not because it focuses on one subject but because they use SSI in non-science dimensions and engage in meaningful learning activities. Considering these factors, it is necessary to include SSI in teacher education and training to develop decision-making processes in teaching. Teachers are the ones who first introduce students to SSI in the Turkish education system. Opportunities can be created not only for science teachers and prospective teachers but also for pre-service primary teachers to engage in hands-on classroom activities supported by various methods and techniques related to SSI. Thus, a contribution can improve pre-service teachers' decision-making and discussion skills by allowing them to see and evaluate different perspectives and approach the topic holistically.

Conflict of Interest

No potential conflict of interest was declared by the authors.

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Credit Author Statement

Author 1: Conceptualization, Writing- Original draft preparation, Supervision, Writing- Reviewing and Editing

Author 2: Methodology, Visualization, Investigation, Writing- Reviewing and Editing.

Ethical Statement

Pre-service primary teachers, who were selected voluntarily, were informed in detail about the whole process before the study. It was explained that pre-service primary teachers could withdraw from the study at any time. Pre-service primary teachers also stated that they did not suffer any academic or psychological harm at the end of the study. The authors declare that no unethical action was taken in this study, that the responsibility belongs to the author/authors in all cases that may arise from an ethical violation, and that the informed consent/consent form is signed by the participants.

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