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Investigating preservice science teachers' argument quality through SSI-based instruction: The role of context

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ABSTRACT Socioscientific (SSI)-based instruction has gained popularity in science education research as the number of controversial topics has increased daily. This study has two objectives: first, it aims to explore the quality of arguments made by pre-service science teachers (PSTs) through various SSI contexts. Second, it explores whether the context influences participants' argument quality. For these purposes, a case study was designed with 13 senior (fourth grade) PSTs enrolling in a state university in Türkiye. Data were collected through participants' reports. The results revealed that participants mostly articulated arguments along with supporting evidence (including backing, warrant, or grounds) without considering different perspectives (i.e., counter-arguments) and refuting evidence (i.e., rebuttal) in various SSI contexts. In terms of the SSI context, genetically modified organisms and artificial meat consumption contexts were the ones where participants were able to generate more arguments compared to other SSI contexts. Recommendations for teacher education programs in terms of enhancing the quality of arguments and the role of various SSI contexts in improving participants' argumentation processes were provided.

Keywords: *Argument quality, Context, Pre-service science teachers, Socioscientific issues (SSI), SSI-based instruction*

Fen bilgisi öğretmen adaylarının argüman kalitelerinin SBK temelli öğretim yoluyla incelenmesi: Bağlamın rolü

ÖZ Sosyobilimsel (SBK) temelli öğretim, tartışmalı konuların sayısının gün geçtikçe artmasıyla fen eğitimi araştırmalarında popülerlik kazanmıştır. Buradan yola bu çalışmanın iki amacı vardır: Araştırmanın ilk amacı, fen bilgisi öğretmen adaylarının çeşitli SBK bağlamlarında ürettikleri argümanların kalitesini incelemektir. Araştırmanın diğer amacı ise bağlamın katılımcıların argüman kalitesini etkileyip etkilemediğini araştırmaktadır. Bu amaçlar doğrultusunda, Türkiye'de bir devlet üniversitesinde öğrenim gören 13 son sınıf fen bilgisi öğretmen adayı ile bir durum çalışması tasarlanmıştır. Veriler, katılımcıların yazılı raporları aracılığıyla toplanmıştır. Sonuçlar, katılımcıların çoğunlukla farklı SBK bağlamlarında farklı bakış açılarını (örn. karşı argümanlar) ve bu bakış açılarına yönelik çürütücü kanıtları (örn. çürütme) dikkate almadan destekleyici kanıtlarla (destek, gerekçe veya dayanak kullanarak) birlikte argümanlar ifade ettiklerini ortaya koymuştur. SBK bağlamı açısından, GDO ve yapay et tüketimi bağlamları, incelenen diğer SBK bağlamlarına kıyasla katılımcıların daha fazla argüman üretebildikleri bağlamlar olduğu belirlenmiştir. Argümanların kalitesinin artırılması ve farklı SBE bağlamlarının katılımcıların argümantasyon sürecini geliştirmedeki rolü açısından öğretmen eğitimi programları için öneriler sunulmuştur.

Anahtar Sözcükler: *Argüman kalitesi, Bağlam, Fen bilgisi öğretmen adayları, Sosyobilimsel konular (SBK), SBK temelli öğretim*

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INTRODUCTION

While controversial issues that are connected to science and society (known as socioscientific issues, SSI) have created an important venue for science education research for over two decades, the COVID-19 period has ensured its place in science education research. While genetic engineering-related issues such as cloning, genetic testing, or climate change have long been addressed in SSI research (Sadler & Zeidler, 2005), the COVID-19 period was a game changer for SSI research. Issues such as mandatory COVID-19 vaccination, use of disposable gloves and masks, plastic pollution created by disposable plastics like gloves and masks, and reduced weather pollution due to mandatory lockdowns have been introduced as new controversies (Çetinkaya & Sarıbaş, 2023; Forsythe & Chan, 2021; Krell et al., 2024; Powell, 2023). Individuals need to make informed decisions while dealing with these controversies by considering the different aspects involved. Many stakeholders as well as participants' own values and experiences are involved in this decision-making process (Chang Rundgren & Rundgren, 2010). However, developing informed decision-making skills is not an easy task. SSI education can nurture individuals' informed decision-making skills by employing personally relevant, contentious, and ill-structured problems that demand the application of scientific, and evidence-based reasoning (Zeidler, 2014). Students often get involved in argumentation while making decisions on SSI (Wu & Tsai, 2007). Thus, argumentation is an important and central theme in SSI research (Dawson & Carson, 2020; Sadler, 2004; Sadler & Donnelly, 2006; Wu & Tsai, 2007; Zeidler et al., 2019).

SSI and Argumentation

Enhancing learners' argumentation skills has long been subject to both international and national policy documents. For instance, argumentation is assumed to be an essential component of K-12 in the United States (National Research Council [NRC], 2012), and evidence-based reasoning is listed as one of the eight scientific and engineering practices (NGSS Lead States, 2013). In a similar manner, the 2018 Turkish primary and middle school science curriculum supports developing appropriate learning environments where students feel free to share their opinions, create arguments, and provide different justifications for their arguments in addition to postulating counterarguments for their peers' assertions (Ministry of National Education [MoNE], 2018). The latest science curriculum takes a similar stand as well (MoNE, 2024).

The basis of argumentation is the construction of an argument. An argument includes a claim along with evidence that can be written, oral, or thought along with data (Dawson & Carson, 2020). Toulmin's Argumentation Pattern (TAP) was proposed by Toulmin (1958), which defined different components of an argument. According to TAP, a *claim* is an assertion; *data* is relevant evidence; while a *warrant* links a claim to data. *Qualifiers* are situations under which a claim or set of data is supported; *rebuttals* are situations in which a claim or set of data is not supported; and *backing* presents the underlying theory or presumptions that support the data and warrants (Toulmin, 2003). TAP is the most popular and widely used structured framework for assessing the quality of arguments and the development of argument generation skills (Chinn, 2006; Christenson & Walan, 2022).

Research in science education relies on two types of argumentation: scientific argumentation (scientific topics without immediate social ramifications) and socioscientific argumentation (issues that situate science in a social context emphasizing ethics, political discourse, and individual decision-making) (Erduran & Jiménez-Aleixandre, 2008; Sparks et al., 2022). As SSI focuses on issues that are open-ended, ill-structured, and subject to debate (Sadler, 2004), SSI is closely linked to argumentation. In this manner, SSI creates an ideal context for argumentation (Zeidler & Sadler, 2007). The SSI framework involves participants in thinking and reasoning processes through the use of discourse practices like argumentation, debate, discussion, and other forms of discourse (Zeidler et al., 2019). Consequently, argumentation has been a central theme in SSI education (Dawson & Carson, 2020; Sadler, 2004; Sadler & Donnelly, 2006; Wu & Tsai, 2007; Zeidler et al., 2019). Following this, enhancing students' argumentation skills has gained popularity in science education research (Aziz & Johari, 2023; Capkinoglu et al., 2020; Dawson & Carson, 2017, 2020). Discussing and creating arguments are

assumed to be effective in enhancing students' reasoning processes (Zeidler & Kahn, 2014). Thus, many scholars adopted SSI-based instruction to nurture students' argumentation skills. The results were promising: the results revealed students' argumentation and reasoning quality were enhanced (e.g., Aziz & Johari, 2023; Capkinoglu et al., 2020; Dawson & Carson, 2020; Jafari & Meisert, 2021; Karpudewan & Roth, 2018; Khishfe, 2022; Kinslow et al., 2019). For instance, exploring students' argumentation skills about climate change in a disadvantaged school, Dawson and Carson (2020) revealed that SSI-based argumentation in climate change can improve students' argumentation skills, respectively. In another study, Kinslow et al. (2019) implemented an SSI field-based environmental education curriculum in a high school setting and reported that the implementation enhanced students' socioscientific reasoning skills. In a more recent study, Bächtold et al. (2023) explored students' written argumentation skills on SSI during a debate-based intervention. They revealed that students whose initial argumentation levels were low tended to justify their arguments more frequently at the end of the intervention.

Aims and Research Questions

As the main implementers of SSI-based teaching on argumentation, teachers' teaching practices have critical importance. Thus, they need to gain skills for nurturing their students' argumentation skills in science classes. This can be achieved by professional development programs for in-service science teachers and by undergraduate courses for preservice science teachers (PSTs). Similar efforts to enhance PSTs' argumentation skills were found in the relevant literature (Atabey & Arslan, 2020; Christenson & Walan, 2022; Capkinoglu et al., 2021; Karisan & Topcu, 2016; Krell et al., 2024; Kutluca & Aydin, 2017; Martín-Gámez & Erduran, 2018). For instance, Atabey and Arslan (2020) implemented cooperative SSI-based teaching and reported that cooperative SSI-based intervention enhanced teachers' argumentation quality. In another study, Capkinoglu et al. (2021) revealed that explicit instruction on components of arguments improved PSTs' awareness of components of argumentation. Supporting this finding, Martín-Gámez and Erduran (2018) reported that pre-service teachers had difficulty constructing arguments and providing more convincing supportive evidence without being given an explicit argumentation education. Indeed, Christenson and Walan (2022) argued for the importance of training in socioscientific argumentation in teacher education programs. All the above-mentioned studies highlight the importance of giving explicit argumentation education during undergraduate education. However, the role of SSI-based instruction in nurturing preservice teachers' argumentation skills remains elusive. Han-Tosunoglu and Ozer (2022) indicated that most studies focusing on SSI were conducted with students, which was further confirmed by our recent literature review. Furthermore, Zhao et al. (2023) highlight the necessity and urgency of systematic courses to enhance PSTs' argumentation skills. Hence, further studies focusing on enhancing PSTs' argumentation skills by adopting SSI-based instruction are needed: To pin this existing gap in the literature, in this study, we focused on developing PSTs' argumentation skills by providing a semester-long SSI-based instruction by using various SSI contexts. Consequently, our first research question explored:

1. What is the quality of arguments articulated by pre-service teachers across various SSI topics?

In addition, we explored the role of various contexts in enhancing argumentation quality as many studies explored a single SSI context (e.g., climate change by Dawson & Carson, 2020, and by Karisan & Topcu, 2016; nuclear energy by Ozturk & Yilmaz-Tüzün, 2017; vaccination by Çetinkaya & Sarıbaş, 2023; and by Krell et al., 2024; energy by Martín-Gámez & Erduran, 2018; plastic pollution by Aziz & Johari, 2023; water- and fat-repellent substances in everyday products by Rietz et al., 2021; biodiversity by Jafari & Meisert, 2021; animal testing by Garrecht et al., 2021; nuclear power plant by Öztürk & Yenilmez Türkoğlu, 2024). However, there has been an effort to explore the role of various SSI contexts in argumentation quality lately (e.g., Capkinoglu et al., 2020, 2021; Ercan Yalman, 2023; Sparks et al., 2022). In such a study, Capkinoglu et al. (2021) explored 7th-grade middle school students' argumentation quality in local SSI such as artificial lakes, hydroelectric power plants, chicken coops, and base stations. Ercan Yalman (2023) used 12 different SSI contexts (e.g., nuclear energy, animal testing, space pollution, and acid rain). The results revealed mixed findings. While Ercan Yalman (2023)

reported that the context did not significantly influence the argumentation quality, Capkinoglu et al. (2020) revealed that power plants were challenging for students to construct arguments along with supporting evidence. Moreover, Garrecht et al.'s (2021) study added complexity to already existing mixed results, as the issue of familiarity can enhance students' argumentation quality. Thus, the role of SSI context in argumentation quality still points to an existing gap in research. To address this gap, our second research question explored:

2. Does the context of SSI affect the quality of pre-service science teachers' arguments?

METHOD

This study adopted a case-study approach. Merriam (2014) defined a case study as a comprehensive description and analysis of a bounded system that is composed of one specific program or one specific classroom of learners. The main characteristics that make a case study unique are being particularistic (focusing on a particular situation), descriptive (providing a thick description of the particular situation), and heuristic (clarifying the reader's comprehension of the situation) (Merriam, 2014). This method was selected as the researchers were interested in a particular situation. In this manner, PSTs enrolling in an elective course constitute a particular classroom of learners. Moreover, a detailed description of the content of the course was provided to provide the details of the course (descriptive nature). Lastly, by using various SSI topics, it was tried to clarify the reader's comprehension of the situation.

Sample

The sample of this study comprised 13 preservice science teachers (eight females and three males) enrolling in a non-compulsory course entitled 'Science and Technology related Problems'. The elective course was provided in the 7th semester of the science teacher education program in a state university that was found in the Western region of Türkiye. The participants enrolling in the study accomplished several required courses about the education profession (i.e., education psychology, sociology, and philosophy) and the teaching profession (i.e., instructional principles and methods or instructional technologies) in addition to core science courses (i.e., chemistry, biology, physics, geology, and mathematics). The participants had not attended any courses focusing on SSI-based instruction or controversial issues beforehand. The participants were informed about the content of the course in the first week of the semester, and they were voluntarily enrolled in the course. Participants came from a middle-class socioeconomic background. They were between 21 and 23 years old.

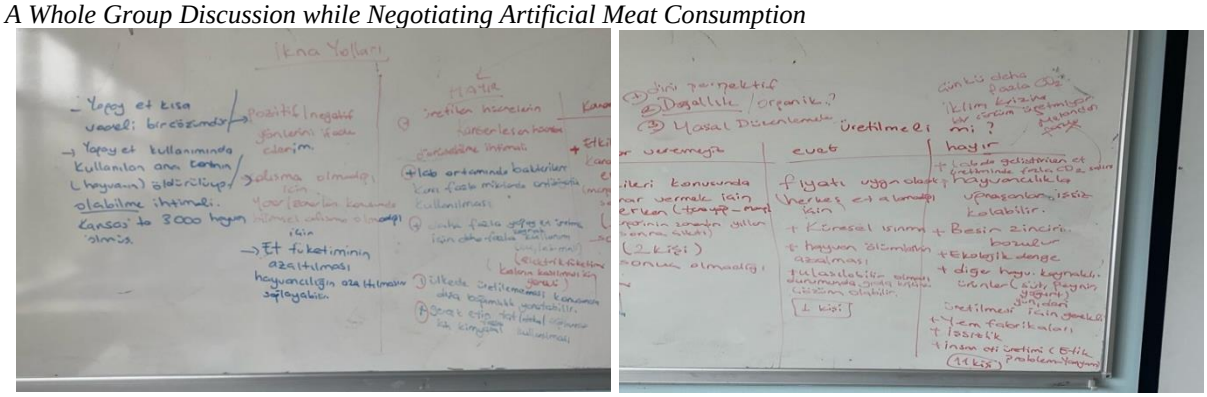
The Course Design and Data Collection

This study was carried out in the non-compulsory course entitled 'Science and Technology related Problems' which was vacant in the 7th semester of the undergraduate science teacher education program. This course is designed to enhance participants' understanding of scientific and technological developments and to weigh the positive/negative impacts of these innovations on human life and risks to human health (Higher Education Council [HEC], 2018). It was a two-hour class (e.g., approximately 100 minutes) and ran for 13 weeks, excluding exam weeks.

The first five weeks included the theoretical part of the study. The first author presented SSI, its definition, and its characteristics in the first week. The second week is devoted to increasing participants' understanding of the role of SSI in the science program and how the current science program aims to develop students' reasoning and decision-making skills using SSI. Together with the instructor, the participants reviewed the science curriculum objectives from grade 5 to grade 8 in terms of finding appropriate SSI objectives. In the third week, decision-making factors (e.g., environmental, economic, social, ethical) and reasoning modes (e.g., rationalistic, emotive, and intuitive) were presented. In the last two weeks (week 4 and week 5), argumentation, Toulmin's argumentation model, Watson's

argumentation model, and why argumentation is an important construct in SSI were discussed. In the second part of the course, participants were actively faced with various SSI topics (8 weeks). Each SSI topic was covered for two weeks: each week a new topic was introduced, and the participants were handled with a booklet explaining the main SSI topic being discussed. Then, a series of prompts asked them to clarify their positions, their supportive arguments, counterarguments, and/or rebuttals. The participants prepared written reports in the following week, and then, the whole class discussion was held to reveal different perspectives (Figure 1). Participants had a chance to get immersed in the topic during these two weeks (2 x 100 minutes).

Figure 1.
A Whole Group Discussion while Negotiating Artificial Meat Consumption



All the SSI topics covered in this study were chosen as they were aligned with the primary science curriculum objectives. For instance, topic 1 (Cystic Fibrosis and Huntington's Disease) was related to the inheritance patterns covered in the 8th-grade science course (F8.2.2. dominant and recessive genes, crossover, and F8.2.5. genetic engineering and biotechnology applications). It also included a controversy (abortion) that was directly linked to society. In a similar manner, topic 2 (artificial meat consumption) was selected as it is a recent biotechnology application and it is directly related to the 8th grade science curriculum (F.8.2.5. biotechnology applications and environmental impact of biotechnology applications). The objectives covered in the curriculum ('F.8.2.5.2. Discusses the dilemmas created by the biotechnological applications, and pros and cons of these applications for humanity' and 'F.8.2.5.3. Makes predictions about the future applications of genetic engineering and biotechnology' (MoNE, 2018, p. 49)) were directly related to this topic and the rest of the topics covered in this study. A summary of each SSI topic is provided below:

Topic 1: Genetically Inherited Diseases (Cystic Fibrosis and Huntington's Disease)

This topic consisted of two different genetically inherited diseases. While Cystic Fibrosis (CF) is autosomal recessive, Huntington's Disease (HD) is autosomal dominant. A brief overview of each disease (i.e., symptoms, life span, and treatment options) was provided each week. In the first week, a couple whose father was diagnosed with HD was presented. This fictional couple discovered that they were going to have a baby. Should they abort the fetus? Why?

The second week included a different couple's story whose both had brothers diagnosed with CF couple had brothers who had CF in their family. This couple also discovered that the wife was expecting. Should they abort the fetus? Why?

Topic 2: Artificial Meat Consumption

A brief overview of artificial meat consumption is provided (how artificial meat is produced, the stages of production, the pros and cons of artificial meat consumption, and the research about artificial meat in different countries). Then the following questions were asked:

What do you think about the consumption of artificial meat?

Do you personally want to consume artificial meat? Why?

Topic 3: Pesticide Use

First, a few questions about their prior experience in growing vegetables or trees, shopping habits, and their preferences while buying vegetables and fruits were asked. Then, their opinions about whether the food they bought might contain any pesticide residuals were sought.

Is it possible to do farming without pesticide use? How is it possible and what are the possible consequences of using pesticides while farming?

Topic 4: Organic Farming

The definition and the conditions of organic farming were presented briefly. The participants were asked whether they considered buying products grown by organic farming, paying more for these products grown by organic farming, or how they would identify a product as 'organic'.

Topic 5: Genetically Modified Organisms (GMOs)

A brief overview of how genetically modified organisms (GMOs) work was provided. Then, a success story was presented about genetically modified eggplants having higher productivity rates and requiring less pesticide use during farming. After this brief information, the participants discussed: What do you think about growing genetically modified agricultural products?

After participants were asked about their decisions on each SSI topic, there were additional questions to explain why they felt that way and how they would persuade someone who disagreed.

The Researchers' Role

The first author was the course instructor in this study, while the second author provided feedback during the course. During the discussion sessions, the researcher tried to be neutral to all different perspectives and decisions and did not try to direct the discussions or participants' decisions on an SSI topic. In addition, she created a safe environment where the participants could express their opinions without being judged or identified as wrong.

Data Analysis

A rubric for assessing the quality of participants' argumentation was created based on the TAP components: If the participant's decision only included a claim without any accompanying evidence or justification, then, it was coded Level-1. If participants provided supportive or counter-arguments for their claims, it was coded Level-2. For Level 3, participants' claims should include both supportive and counter-arguments together. If there were rebuttals along with claim, supportive, and counter-arguments, then, this was coded as Level-4 (see Table 1 for criteria along with sample excerpts). In this manner, it was possible to observe the change in participants' argumentation quality during the place-based SSI instruction.

Table 1.
The Coding Rubric Used for Data Analysis

Level	Score	Criteria	Description
Level 1	1	Claim	Participant presents a claim (a position or a decision) but does not offer any elaboration for his/her position (do not include backing, i.e., data, warrant)
Level 2	2	Argument **or** counter-argument	Participant presents a claim which includes explanation, evidence, and rationale for his/her position (includes backing, grounds, warrant)
Level 3	3	Argument **and** counter-argument	Participant presents a claim which includes explanation, evidence, and rationale for his/her position (includes backing, i.e., data, warrant). In addition, s/he provides alternative claims to his/her claim with accompanying evidence.
Level 4	4	Argument, counter-argument and rebuttal	Participants address a counterargument and provide rejection for a valid reason that supports counterarguments and supporting evidence.

Participants' written responses were first qualitatively analyzed and then, transferred to numerical form to explore the differences among various SSI topics.

Credibility and Trustworthiness of the Study

The credibility of a qualitative study can be assured by using various triangulation methods (Guion, 2002; Stahl & King, 2020). One such triangulation technique is investigator triangulation: In this approach, multiple researchers are employed to conduct a comparative analysis of individual findings. Each member of the research team evaluates the data and then convenes to discuss and examine the data analysis collectively (Stahl & King, 2020). Following this, the two researchers individually coded the first five participants' written responses in three SSI topics (pesticide use, organic farming, and GDOs) by using the coding sheet created together for the current study. Then, the researchers gathered to discuss their coding in two parallel sessions. In the first session, the researchers discussed the similarities and differences in coding sheets. After agreeing on the coding, the rest of the data were coded accordingly. In the second session, the coded data were reviewed and full agreement was achieved among the researchers. The inter-coder reliability which indicates the degree of agreement between two or more qualitative coders was calculated (Miles & Huberman, 1994). According to Lombard et al. (2002), the basis for this was the percent agreement, derived by dividing the total number of agreements and disagreements by the number of agreements. While this ratio was found to be 67% in the first session, it was found as 100% in the last session.

Prolonged engagement was also used to ensure credibility. Prolonged engagement requires staying at the research site for at least the duration of a research (e.g., a whole semester) (Stahl & King, 2020). The present study lasted for a semester and the first researcher engaged in the site and with the participants during the semester to become familiar with the context. Lastly, a thick description which refers to presenting a detailed description of the context was confirmed by providing a rich description of course content and the role of the researchers.

Ethical Issues

The Scientific Research and Publication Ethics Committee for Science and Engineering of Uşak University approved the present study with the decision number 2022-23/06. All the participants were informed about the content of the course in the first week of the semester and signed an informed consent form to receive their voluntary participation request. They were informed that they could withdraw at any time during the study. They were assured that their answers and responses would be kept confidential without revealing their true identity under any circumstances. Each participant was assigned a code (e.g., PST-1) to ensure the confidentiality of their identity. Square bracelets ([]) were used to complete the meaning or explain the reasoning pattern (i.e., claim, backing, grounds, counter-argument, or rebuttal) by the researchers.

FINDINGS

The quality of arguments made by PSTs across various SSI topics was explored first. Findings related to participants' reasoning for each SSI topic were presented below:

Participants' Reasoning Quality Across Various SSI Topics

Genetically Inherited Diseases

Participants' reasoning in genetically inherited diseases namely, Cystic Fibrosis and Huntington's disease were examined. Table 2 shows that the arguments presented by PSTs regarding Huntington's disease are predominantly found at Level 2 (f=6) showing that they generated arguments along with supportive evidence. Only one participant (PST 7) was able to generate higher-level arguments (i.e., Level 4) that included claims, supportive evidence, counter-arguments along rebuttal. Different patterns in argument quality other than Level 2 and Level 4 were not observed.

Table 2.
Participants' Excerpts from Different Reasoning Levels in Huntington's Disease

Argument quality	Frequency	Participant ID	Sample excerpt
Level 2	6	PST 4	"Lale [the fictitious character] should not think at all during this time [referring to abortion] *[claim]*. Because 25 years is a long time, even someone might not be able to take care of their own needs *[grounds]*. Therefore, since she has already realized this situation, she should have an abortion immediately *[warrant]*."
Level 4	1	PST 7	"Lale should not have an abortion *[claim]*. This is because the disease begins to show its symptoms approximately halfway through a person's life. The first half of human life is like a golden age. It is worth living. The fact that it [referring to HD's disease] shows symptoms after a certain age, makes the period before that a peaceful life *[grounds]*. It does not constitute an obstacle *[warrant]*. Technology and science are developing more and more every day. Perhaps they will find a cure to this disease about 25 years after the child is born and prolong life *[backing]*. Some might argue that it is unethical to bring a child into the world knowing they may develop a serious illness *[counter argument]*. However, the potential for a fulfilling and peaceful early life, combined with the hope for future medical advancements, outweighs this concern. The couple should consult with experts and make rational decisions *[rebuttal]*."

While PST 4 who supported abortion was only able to propose an argument (the fictitious character should get an abortion) along with supporting evidence (someone might not be able to take care of their own needs), PST 7 who did not support abortion was able to produce counterarguments (consulting with experts for rational decisions) along with rebuttals (science and technology are developing so new cures might be found meantime).

In a similar manner, participants mostly produced arguments at Level 2 (f=4) and Level 4 (f=4) in the Cystic Fibrosis case. Sample excerpts were provided in Table 3. Any participant only provided a claim (Level 1) or provided an argument with supportive evidence and a counter-argument (Level 3) was found.

Table 3.
Participants' Excerpts from Different Reasoning Levels in Cystic Fibrosis

Argument quality	Frequency	Participant ID	Sample excerpt
Level 2	4	PST 4	"I do not think they should abort the embryo just on the off chance *[claim]*. Since they do not know whether the baby will be born healthy or not *[grounds]*, they should first test the embryo to see whether it is healthy *[warrant]*. They should decide based on the test result."
Level 4	4	PST 10	"Making decisions when the health of the fetus is in question is more challenging. Yes, I was against abortion *[claim]* because I thought it was a sin, but the baby will suffer from the moment it is born. It is very difficult for parents to turn a blind eye *[ground]*. It is unbearable to think that your child would suffer in front of your eyes and could die at any moment. I oppose abortion, even though there is no cure for it at the moment, but I think it can be cured with the advancement of gene therapy *[backing]*. Yes, it hurts to know that your child is suffering, but the parents will also feel regret when that baby is killed *[rebuttal]*. Even though it is a very difficult decision, I think the baby should not be aborted."

While PST 4 only presented a claim (they should not abort the fetus), and its reasoning (they should get genetic testing), PST 10 supported her claim (they should not abort the fetus), with the possibility of new treatment options with the advancement of gene therapy. She also provided a counter-argument (parent might get an abortion) although not stated directly because of the suffering of their child. She offered a rebuttal as to why they should not by indicating they also feel regret when they abort the fetus.

Pesticide Use

The second SSI context was pesticide use. Table 4 shows participants' reasoning showing different reasoning quality levels along with sample excerpts. According to Table 4, PSTs mostly articulated arguments at Level 2 (f=5) which included claims and supportive evidence. Higher-level arguments (Level 3 and Level 4) were less frequent (f=1, and f=2 respectively).

Table 4.
Participants' Excerpts from Different Reasoning Levels in Pesticide Use

Argument quality	Frequency	Participant ID	Sample excerpt
Level 1	2	PST 11	"I think pesticides are more harmful. I prefer not to use pesticides in agriculture *[claim]*."
Level 2	5	PST 8	"It should be continued to use pesticides in agriculture *[claim]*. Many pesticides are used for plant protection purposes. Pesticides help protect animals from parasites and fleas. They prevent illnesses that may be caused by moldy and spoiled foods. They also prevent the growth of harmful, invasive weeds and protect nature and trees *[grounds]*."
Level 3	1	PST 5	"As far as I know, there are different types of pesticides. In the US the use of DDT pesticide is banned because it can kill not only insects and fungi but also other living things *[backing]*. DDT is also banned in Türkiye *[backing]*. Pesticides are available against insects, weeds, and fungi. When using pesticides, it is first necessary to pay attention to the dose and to choose them according to what they are to be used against *[claim]*. Since most chemical pesticides do not have a selective effect on the target organism, they can cause disease or death to living organisms other than the target organisms. They are known to cause poisoning, toxins, shortness of breath, and developmental delay *[backing]*. However, we must acknowledge that pesticides are necessary for high agricultural yields in addition to controlling pests that can otherwise devastate crops *[counter argument]."*

Table 4. (Continued)
Participants' Excerpts from Different Reasoning Levels in Pesticide Use

Argument quality	Frequency	Participant ID	Sample excerpt
Level 4	2	PST 2	"I think the use of pesticides has less impact on humans, animals, and the environment *[claim]*, because of the use of pesticides in agriculture, that is, if the pesticide is used with attention to the dose of the drug *[backing]*, the pesticide does not harm the plant and the soil much *[grounds]*. When we wash the pesticide-used products thoroughly in running water and eat them, even if it does not completely clean the pesticide, it minimizes the amount *[qualifier]*. Someone might believe that pesticides are harmful to humans, animals, and the environment *[counter argument]*. However, by taking the precautions I mentioned [referring to the use with attention to the dose and washing procedure], their impact on humans, animals, and the environment can be minimized *[rebuttal]."*

Organic Farming

One of the SSI contexts being used was organic farming. Table 5 shows participants' different levels of reasoning in organic farming. According to Table 5, participants' arguments about organic farming were mostly found at Level 1 (f=3) and Level 2 (f=5) implying that participants were able to provide arguments (Level 1) and support their arguments (Level 2). Whereas, higher levels (articulating counter-arguments and rebuttals) were less frequent. While no participant was able to provide counter argument (Level 3), two participants were able to provide counterarguments and rebuttals.

Table 5.
Participants' Excerpts from Different Reasoning Levels in Organic Farming

Argument quality	Frequency	Participant ID	Sample excerpt
Level 1	3	PST 6	"I make sure that the products I buy are organic *[claim]*. I try to buy mostly from village vendors."
Level 2	5	PST 3	"I prefer to buy organic products *[claim]*. Organic ones are healthier and tastier in terms of vitamins (nutritional value) [the expression in parentheses was added by the student]. People like it when they eat it. The smell is different. My grandparents say that the smell and taste of the products bought from the market have changed. They especially prefer to buy from places that they think sell organic products *[grounds]*."
Level 4	2	PST 1	"I pay attention most of the time, but not always [buying organic products]. Whether in the market or the grocery store, the word "organic" alone is not meaningful *[claim]*. Contrary to popular belief, the distorted shape, size, or color of a fruit or vegetable does not prove that it is organic *[counter argument]*. The only way to understand that it is organic is the certificate that the product has *[warrant]*. Traceability, which is the most important feature of organic farming activities, is conveyed to the consumer through technical information in organic product certificates *[backing]*. If a product is organic, the label contains information such as the first planting and harvest date of that product. But of course, the most important thing is the presence of the organic farming logo on the packaged product. First of all, the code and logo of the control and certification body that inspects the product should also be included *[rebuttal]*."

As shown in the excerpts, PST 6 only asserted a claim while PST 3 provided grounds why she preferred to buy organic products indicating their nutritional value, smell, and taste. The higher level of argument was provided by PST 1. She asserted a claim (buying organic products), she also indicated how to

identify a product as 'organic' by providing evidence. Moreover, she included a counter-argument that the distorted shape, size, or color would not indicate whether a product is organic or not while also providing rebuttals on how to label a product as 'organic' by standardized certification processes.

Genetically Modified Organisms (GMOs)

GMOs were another context that was used. While participants mostly articulated arguments at Level 2 (f=7), they also produced higher levels of arguments at Level 3 and Level 4 (f=4 for each) Sample excerpts along with frequencies at each level are provided in Table 6.

Table 6.
Participants' Excerpts from Different Reasoning Levels in Pesticide Use

Argument quality	Frequency	Participant ID	Sample excerpt
Level 2	7	PST 13	"I do not want GMOs to enter my country *[claim]*. Using GMO products is forbidden in my country. But there may be GMOs in products that are imported *[grounds]*. Who wants to use something that is already harmful? I want the products we use or grow to be organic [claim]. We used to be able to get by without GMO products; we can get by without GMO products now. The long-term consequences of GMOs are irreversible *[backing]*."
Level 3	4	PST 10	"I prefer to grow GMO crops *[claim]*. GMOs and pesticides are harmful to human health. However, I have read that there is no information or evidence about the exact harm of GMO crops *[grounds]*. I think there is a greater risk of consuming chemicals by using pesticides. In addition, pesticides disrupt the ecological balance by harming birds, fish, and other organisms *[grounds]*. However, GMOs might have genetic modifications that could have unforeseen consequences *[counter-argument]."*
Level 4	4	PST 4	"I think GMO agricultural products should be cultivated *[claim]*. Otherwise, as long as pesticides are used, air soil, water, and environmental pollution occur. As a result, acid rain occurs and thus environmental pollution occurs. When these insecticides are used, the person applying them may be poisoned *[grounds]*. When GMO agricultural products are grown, at least, the pollution I have mentioned can be minimized *[backing]*. For example, water pollution may not occur. Therefore, I think that using GMO products instead of using pesticides today will be a solution to both economic and environmental problems *[backing]*. However, some people argue that GMOs could have unknown health effects and negatively impact biodiversity *[counter argument]*. While these concerns are valid and warrant further research, the immediate benefits of reducing pesticide use and minimizing environmental pollution make GMOs a preferable option. Moreover, stringent regulations and ongoing scientific evaluations can help mitigate potential risks associated with GMOs *[rebuttal]*."

Artificial Meat Consumption

The last context used was artificial meat consumption. Table 7 presents different levels of arguments articulated by the PSTs. The arguments put forth by PSTs were predominantly found at Level 1 (f=6) and Level 2 (f=7). In addition, while some of their explanations were found at Level 1 and Level 2, they also articulated higher-level arguments (f=3 at Level 3 and f= 2 at Level 4 respectively).

Table 7.
Participants' Excerpts from Different Reasoning Levels in Artificial Meat Consumption

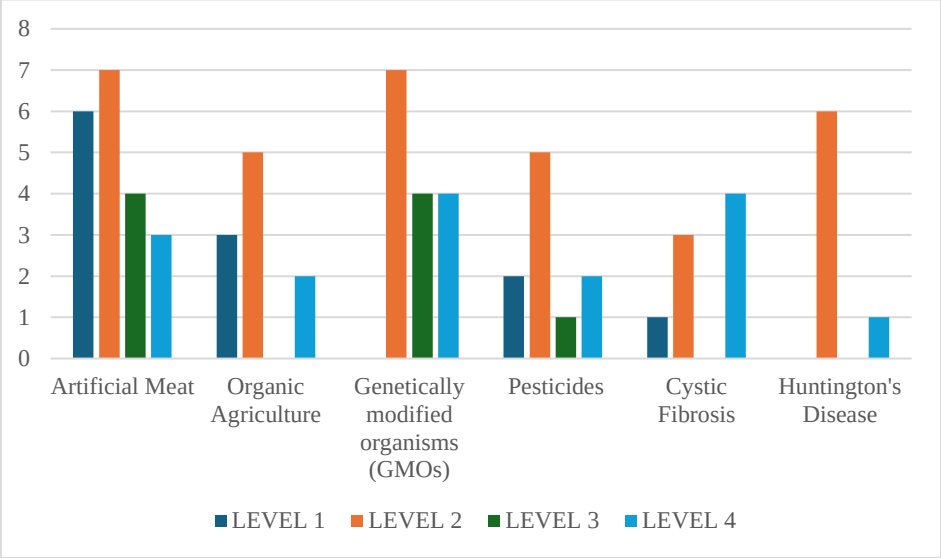
Argument quality	Frequency	Participant ID	Sample excerpt
Level 1	6	PST 9	"I think artificial meat production can be beneficial for the environment."
Level 2	7	PST 1	"No, I don't want to consume artificial meat *[claim]*. Because right now they have only developed artificial meat, but it has not been sold in the world yet. So, it has not been consumed by people yet *[ground]*. This means there is no experiment, no scientific study on how artificial meat will affect human health *[warrant]*. Maybe it can cause serious diseases, maybe it can end human life. This research [referring to the one on artificial meat] may have been carried out to reduce the population by affecting reproductive hormones *[backing]."*
Level 3	3	PST 10	"I do not want to consume artificial meat *[claim]*. I don't think it would be possible for just one cell to replace natural meat *[grounds]*. I think that too many chemicals are used just to give it that flavor and color and that these chemicals are very harmful to health [warrant]. I cannot take such a risk because it is possible to cause cancer while making it possible to eat meat *[backing]*. In agriculture, even the excreta of animals is used to increase yields, but it is a fact that the gases [referring to methane gas] that are claimed to be released into nature are also produced by humans. Only 18% of the greenhouse gas is caused by animal production *[counter argument]."*
Level 4	4	PST 8	"I think that artificial meat production should not take place *[claim]*. Artificial meat has various side effects as well as advantages. The stem cells used in the production of artificial meat can predispose to cancer formation. Too much meat is produced from these cells. This means that the cells multiply excessively *[ground]*. Therefore, it is said to be a risky method. Many people make a living from animal husbandry. If artificial meat becomes widespread, there is a risk that the personnel working in meat factories will be unemployed as they will no longer be needed *[warrant]*. Artificial meat production may lead to cheaper meat prices. This would make eating meat accessible to everyone - regardless of income level [counter argument]. It sounds like good news, but if this happens, the obesity rate is likely to increase *[rebuttal]."*

The Role of Context in Argumentation Quality

The second research question guided this study was whether the context of SSI affects the quality of PSTs' arguments. Figure 2 presents how participants' argumentation quality varied across various SSI contexts.

Figure 2 shows that although the SSI context differs, PSTs' arguments were mostly found at Level 2 (claim and supporting evidence including warrant, backing, or grounds). Participants mostly articulated arguments at Level 2 for GMOs and artificial meat contexts. In addition, participants were able to generate arguments for each argument level in the artificial meat consumption context. In terms of creating counter-arguments along with claims and supporting evidence (labeled as Level 3), it was observed that GMOs and artificial meat consumption were the most used SSI contexts while Huntington's disease and Cystic Fibrosis contexts were found to be the least. Another interesting finding revealed was while they were able to provide higher-level arguments which include counter-arguments and rebuttals (labeled as Level 4), arguments only including supporting evidence and counter-arguments (labeled as Level 3) were rarely found in their written reports. While participants were able to articulate higher-level arguments including counter-arguments and rebuttals in GMOs and Cystic fibrosis cases, there was only one participant who was able to articulate a higher-level argument in Huntington's disease.

Figure 2.
PSTs' Argument Quality Across Various SSI Contexts



DISCUSSION

The present study explored the quality of arguments articulated by PSTs and whether different SSI contexts influenced participants' argument quality. For these purposes, a semester-long SSI-based instruction was implemented. Our findings revealed that regardless of context, PSTs mostly articulated arguments along with supporting evidence (including backing, warrant, or grounds) without considering different perspectives (i.e., counter-arguments) and refuting evidence (i.e., rebuttal) for these perspectives in various SSI contexts. This finding was consistent throughout the course. This finding was partially supported by the literature exploring students' argumentation quality in various SSI contexts. Confirming our findings, Wu and Tsai (2007) reported that participants were able to make evidence-based decisions while less than 40% were able to construct counter-arguments and rebuttals. However, Wu and Tsai's (2007) study did not include any intervention. Intervention studies usually reported that SSI-based instruction improved participants' argumentation quality (Atabey & Arslan, 2020; Aziz & Johari, 2023; Bächtold et al., 2023; Dawson & Carson, 2020; Zohar & Nemet, 2002). For instance, Aziz and Johari (2023) reported that there were significant increases in students' supportive arguments, counter-arguments, and rebuttals in the post-test when compared to the pre-test. Although the present study did not assess participants' argumentation quality before and after SSI-based instruction, we still expected an increase in the number of high-level arguments (labeled as Level 3 and Level 4) throughout the course. While there were very few high-level arguments in genetically inherited diseases that were discussed at the beginning of the course, the number of high-level arguments (labeled as Level 3 and Level 4) increased in GMOs and artificial meat consumption that were discussed through the end of the course even though it was not a linear increase. This nonlinear increase supports the literature reporting that students' argumentation skills can be enhanced through deliberate instruction (e.g., Aziz & Johari, 2023; Bächtold et al., 2023; Dawson & Carson, 2020; Dawson & Venville, 2022). Indeed, Capkinoglu et al. (2021) indicated that explicit argumentation education improved PSTs' awareness of argument elements (e.g., claim, backing, warrant, etc.). Supporting this, SSI-based instruction including argumentation education adopted in this study helped participants to make decisions and justify their decisions by using argument elements such as warrant, backing, or grounds. Moreover, Dawson and Venville (2022) also found that SSI-based instruction assisted students to make decisions and justify their decisions along with supporting evidence. However,) providing SSI-based instruction to PSTs, Ercan Yalman (2023) reported that the participating teacher candidates were often unable to construct comprehensive arguments including all argument components such as claim, evidence, and rebuttal. This study further confirmed our findings.

The reason why some participants were able to generate high-level arguments in some SSI contexts (e.g., artificial meat consumption or GMOs) might be related to the SSI context being discussed. In line with this, issue familiarity (Garrecht et al., 2021) and personal relevance (Dawson & Venville, 2022; Sparks et al., 2022) were important factors influencing the diversity of discipline-related arguments. If participants feel engaged in the SSI context being discussed, then, they might produce more nuanced and high-level arguments. Exploring the role of issue familiarity, Garrecht et al. (2021) investigated students' arguments in animal testing. They reported that issues such as animal testing might constitute an effective context that engages students with complex SSIs without requiring more than basic familiarity. In a similar manner, Dawson and Venville (2022) reported that personal relevance facilitated students' ability to construct more nuanced arguments. Indeed, PSTs in our study might feel personal relevance in contexts such as GMOs and artificial meat consumption and these issues might be more familiar to them to produce more nuanced arguments including counter-arguments and rebuttals.

Confirming that, our second research question exploring the role of SSI context revealed that participants were able to generate more arguments in some SSI contexts compared to others. Most studies found in the literature used a single SSI topic for exploring participants' argument quality (e.g., climate change, vaccination, or plastic pollution (see, Aziz & Johari, 2023; Dawson & Carson, 2020; Çetinkaya & Sarıbaş, 2023; Krell et al., 2024). However, lately, there has been an effort to adopt multiple SSI contexts to explore the participants' argument quality. In such a study, Cenk and Ercan Yalman (2022) explored senior PSTs' argumentation skills in various SSI contexts (e.g., climate change, GMOs, nuclear energy, organ donation, stem cells, alternative medicine, space pollution, euthanasia, and vaccination). They reported that participating PSTs were able to generate more arguments in biotechnology and health-related SSIs including climate change, GMOs, nuclear energy, stem cells, and alternative medicine while they were able to produce arguments at lower levels in SSI contexts such as euthanasia, space pollution, and vaccination. While this study partially confirms our findings about the role of the SSI context being discussed, it differs as there was no explicit SSI-based instruction including argumentation education like in this study. In another study, Ercan Yalman (2023) explored whether the role context affects PSTs' argument quality and reported that only the nuclear energy context noticeably influenced participants' argument quality. However, other SSI contexts being explored (e.g., animal testing, climate change, space pollution, biotechnology, and endangered species) were not found to be influencing the argument quality of participants. The reason why the nuclear energy context was more meaningful to the participating teacher candidates might be related to where the participants were located. As the study was conducted in Mersin where one of the first nuclear energy power plants of Türkiye is being constructed, the participants might be more familiar with the context being discussed as issue familiarity (Garrecht et al., 2021) and personal relevance (Dawson & Venville, 2022; Sparks et al., 2022) were reported as influencing factors in producing more nuanced arguments.

CONCLUSION, LIMITATIONS, AND IMPLICATIONS

This study explored how SSI-based instruction influenced preservice teachers' argument quality and whether their argument quality differed in various SSI contexts. While the results showed that participating PSTs were able to produce arguments including claim, warrant, backing, and/or grounds, higher level arguments including counter-arguments and rebuttals were less even though their numbers increased throughout the course. This, in fact, is an important finding which can show directions for future research. SSI-based implementations are quite new in teacher training programs. Chen and Xiao (2021) highlighted the necessity of explicit guidance and support for teachers to implement SSI-based instruction. Improving teachers' practices can be achieved through teacher education programs. There was a consistent call for including argumentation (Capkinoglu et al., 2021) and socioscientific argumentation (Krell et al., 2024) in teacher education programs in SSI research. However, the literature also reported that PSTs had difficulty in producing high-level arguments including counter-arguments and rebuttals (Capkinoglu et al., 2021; Martín-Gámez & Erduran, 2018; Zhao et al., 2023). Consequently, the number of courses including SSI-based instruction might be increased. Indeed, Zhao

et al. (2023) called incorporation of a more balanced argumentation education in teacher education programs. Incorporating argumentation in SSI-based instruction can be a way to achieve this.

The present study also has limitations which can provide suggestions for future research. First, we did not assess the effectiveness of SSI-based instruction by using an experimental design including a control group and make statistical comparisons between the treatment and control groups. Thus, future studies might adopt a control group to compare the effectiveness of SSI-based instruction. Moreover, we did not conduct any pre- and post-test comparisons. Some comparisons in participants' argumentation skills between pre-and post-test assignments might also help understand the effectiveness of SSI-based instruction. Lastly, we only included participants' written reports in our analyses. Future research focusing on classroom debate might help understand how participants produce counter-arguments for persuading others.

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TÜRKÇE GENİŞLETİLMİŞ ÖZET

Sosyobilimsel konular (SBK) uzun yıllardır fen eğitimi araştırmalarına yön vermektedir. Klonlama, genetik testler veya iklim değişikliği gibi geleneksel SBK'lerin yanı sıra COVID-19 pandemisi, zorunlu COVID-19 aşısı, tek kullanımlık maske ve eldiven kullanımı ve bunların yarattığı plastik kirliliği gibi yeni ikilemler getirmiştir. Bireylerin bu ikilemlerle ilgili kararlar verirken farklı paydaşların görüşlerini de dikkate almalıdır. Ancak karar verme becerilerinin geliştirilmesi sanıldığı kadar kolay değildir. SBK eğitimi, tartışmalı ve iyi yapılandırılmamış problemleri kullanarak, bilimsel ve kanıta dayalı muhakeme becerilerinin uygulanması yoluyla bireylerin karar verme becerilerini geliştirebilir (Zeidler, 2014).

2018 ve 2024 yıllarında değişen fen bilimleri öğretim programları da öğrencilerin çeşitli SBK'de bilinçli karar verme becerilerinin geliştirilmesini sıklıkla vurgulamaktadır (MEB, 2018, 2024). Bu bağlamda yenilenen fen bilimleri öğretim programları, öğrencilerin fikirlerini rahatça ifade edebilecekleri, argüman oluşturabilecekleri, argümanlarını farklı gerekçelerle destekleyebilecekleri ve arkadaşlarının iddialarını çürütmek için karşı argümanlar geliştirebilecekleri uygun öğrenme ortamlarının geliştirilmesini desteklemektedir (MEB, 2018). Nitekim, SBK açık uçlu, iyi yapılandırılmamış ve tartışmaya açık konulara odaklandığından (Sadler, 2004), SBK argümantasyonla yakından ilişkilidir. Bu nedenle SBK, argümantasyon için ideal bir bağlam oluşturur (Zeidler ve Sadler, 2007). SBK; tartışma, münazara ve argümantasyon gibi söylem uygulamalarının kullanımı yoluyla katılımcıları düşünme ve muhakeme süreçlerine dâhil eder (Zeidler vd., 2019).

Öğretmenlerin, öğrencilerinin çeşitli SBK'deki argümantasyon becerilerini geliştirebilmeleri için kendilerinin SBK temelli argümantasyon yöntemini uygulama becerilerine sahip olması gerekmektedir. Bu halihazırda okullarda öğretmenlik yapan öğretmenler için hizmet içi eğitimler yoluyla gerçekleştirilebilirken, öğretmen yetiştirme programlarında da öğretmen adaylarının bu becerilerinin geliştirilmesi önem kazanmaktadır. SBK alan yazını, öğretmen adaylarının eğitim verilmediği takdirde argüman oluşturma ve argümanlarını destekleme becerilerinin zayıf olduğunu rapor etmektedir (Capkinoglu vd., 2021; Martín-Gámez ve Erduran, 2018; Zhao vd., 2023). Bu bağlamda öğretmen adaylarına sağlanan eğitimlerin öğretmen adaylarının argümanları oluşturan iddia, veri, destek ve gerekçe gibi bileşenleri tanıma konusundaki farkındalıklarını arttırdığını ve daha nitelikli argümanlar oluşturmalarına yardımcı olduğunu rapor etmektedir (Atabey ve Arslan, 2020; Capkinoglu vd., 2021). Aynı zamanda alan yazında, öğretmen adaylarının argüman becerilerinin geliştirilmesini yönelik bir çağrı da bulunmaktadır (Christenson ve Walan, 2022; Zhao vd., 2023). Buradan yola çıkılarak araştırmanının ilk problemi şu şekilde belirlenmiştir:
1. Fen bilgisi öğretmen adayları tarafından çeşitli SBK'de üretilen argümanların kalitesi nedir?

İlgili alan yazın incelendiğinde, öğretmen adaylarının argüman kalitesinin genellikle tek bir bağlamda (örneğin; hayvan deneyleri ya da nükleer santral kurulması gibi) incelendiği görülmektedir (bkz. Aziz ve Johari, 2023; Dawson ve Carson, 2020; Garrecht vd., 2021; Öztürk ve Yenilmez Türkoğlu, 2024). Ancak farklı SBK bağlamlarının öğretmen adaylarının argüman kalitelerine etkisini inceleyen çalışma sayısı oldukça azdır (Cenk ve Ercan Yalman, 2022; Ercan Yalman, 2023). Bu çalışmaların bir kısmında (örn, Cenk ve Ercan Yalman, 2022) ise herhangi bir uygulama mevcut değildir. Dolayısıyla, bu çalışmanın araştırma sorusu şu şekilde belirlenmiştir:
2. Farklı SBK bağlamlarının fen bilgisi öğretmen adaylarının argüman kalitesini nasıl etkiler?

Bu çalışmada belirlenen araştırma sorularına cevap aramak için örnek olay yöntemi tercih edilmiştir. Çalışmaya Ege bölgesinde bulunan bir devlet üniversitesinde öğrenim görmekte olan 13 dördüncü sınıf fen bilgisi öğretmen adayı katılmıştır. Çalışma "Fen ve Teknoloji Kaynaklı Sorunlar" dersi kapsamında 13 hafta boyunca yürütülmüştür. Araştırmanın gerçekleştirilebilmesi için ilgili üniversitenin Etik Kurulundan izin ve araştırmaya katılan öğrencilerden bilgilendirilmiş onam formu alınmıştır.

Çalışmaya çerçevesinde 13 haftalık bir SBK temelli öğretim programı hazırlanmıştır. İlk altı hafta; SBK tanımı, fen bilimleri öğretim programındaki SBK kazanımları, SBK'de karar verme ve argümantasyon

yöntemleri ele alınırken kalan sekiz hafta boyunca farklı SBK bağlamları (genetik hastalıklar-Huntington hastalığı ve Kistik Fibroz, böcek öldürücü kullanımı, organik tarım, GDO'lu organizmalar, yapay et tüketimi) konularında hazırlanan senaryolar sınıf ortamında tartışılmış ve öğrenciler konu ile ilgili birer rapor hazırlamıştır. Veriler, katılımcıların yazılı olarak hazırladıkları ve konu ile ilgili aldıkları kararlarını, gerekçelerini ve varsa karşı argüman ve çürütücülerini yazdıkları raporlar yoluyla toplanmıştır. Her bir öğrencinin yazılı argümanları, hazırlanan argüman değerlendirme rubriği ile değerlendirilmiştir.

İlk araştırma sorusu kapsamında, elde edilen bulgular, fen bilgisi öğretmen adaylarının farklı SBK bağlamlarında farklı bakış açılarını (örn. karşı argümanlar) ve bu bakış açılarına yönelik çürütücü kanıtları dikkate almadan çoğunlukla destekleyici kanıtlarla (destek, gerekçe veya dayanak dahil) birlikte argümanlar ifade ettiklerini ortaya koymuştur. Bu bulgu, farklı SBK bağlamlarında öğrencilerin argümantasyon kalitesini araştıran alan yazın tarafından kısmen desteklenmiştir: Örneğin, Wu ve Tsai (2007), katılımcıların %40'ından azının karşı argüman ve çürütme oluşturabildiğini ve çoğunun kanıta dayalı kararlar verebildiğini rapor etmiştir. SBK temelli öğretim uygulamalarının ise genellikle katılımcıların argüman kalitelerini geliştirdiği rapor edilmiştir (Atabey ve Arslan, 2020; Aziz ve Johari, 2023; Bächtold vd., 2023; Dawson ve Carson, 2020; Zohar ve Nemet, 2002). Örneğin, Aziz ve Johari (2023) SBK temelli öğretim sonunda, öğrencilerin destekleyici argümanlarında, karşı argümanlarında ve çürütmelerinde ön teste kıyasla son testte önemli artışlar olduğunu sonucuna ulaşmıştır. Her ne kadar bu çalışmada katılımcıların argümantasyon kalitesi uygulama öncesi ve sonrası değerlendirilmemiş olsa da yüksek seviyeli argümanların (Seviye 3 ve Seviye 4 olarak etiketlenen) sayısında bir artış olmasını beklenmiştir. İlk tartışılan genetik geçişli hastalıklarda çok az sayıda üst düzey argüman varken, sonraki konularda (özellikle GDO'lar ve yapay et tüketiminde) doğrusal bir artış olmasa da üst düzey argümanların (Seviye 3 ve Seviye 4 olarak etiketlenen) sayısı arttığı görülmektedir. Doğrusal olmayan bu artış, öğrencilerin argümantasyon becerilerinin SBK temelli öğretim yoluyla geliştirilebileceğini rapor eden alan yazını desteklemektedir (örneğin, Aziz ve Johari, 2023; Bächtold vd., 2023; Dawson ve Venville, 2022; Dawson ve Carson, 2020).

Bazı katılımcıların bazı SBK bağlamlarında (yapay et tüketimi veya GDO'lar) üst düzey argümanlar üretebilmesinin nedeni, ele alınan SBK bağlamıyla ilgili olabilir. Buda bizim ikinci araştırma sorumuza cevap oluşturmaktadır. Nitekim, konuya aşinalık (Garrecht vd., 2021) ve kişisel ilgi (Dawson ve Venville, 2022; Sparks vd., 2022), argümanların çeşitliliğini ve derinliğini (karşı argüman ve çürütücülerle, argümanları destekleme) etkileyen önemli faktörlerdir. Katılımcılar, tartışılan SBK bağlamıyla ilgili hissederlerse, daha incelikli ve üst düzey argümanlar üretebilirler. Bu durum da bizim farklı SBK bağlamlarının katılımcıların farklı seviyelerde argüman oluşturmasında etkili olduğu bulgularımızla örtüşmektedir. Alan yazındaki pek çok çalışma, tek bir konu bağlamında katılımcıların argümann kalitelerini incelemiştir (örneğin, iklim değişikliği, aşılama veya plastik kirliliği (bkz. Aziz ve Johari, 2023; Dawson ve Carson, 2020; Çetinkaya ve Sarıbaş, 2023; Krell vd., 2024). Ancak son zamanlarda, katılımcıların farklı SBK bağlamlarında ürettikleri argümanları inceleyen çalışmalar görülmektedir (Cenk ve Ercan Yalman, 2022; Ercan Yalman, 2023). Örnegin Cenk ve Ercan Yalman (2022), iklim değişikliği, GDO'lar, nükleer enerji, kök hücreler ve alternatif tıp gibi biyoteknoloji ve sağlıkla ilgili SBK'lerde katılımcıların daha fazla argüman üretebildiklerini, ancak ötenazi, uzay kirliliği ve aşılama gibi bağlamlarda ise daha düşük düzeyde argüman üretebildiklerini rapor etmiştir. Bu çalışma, tartışılan SBK bağlamının rolüne ilişkin bulgularımızı kısmen doğrulamakla birlikte, bu çalışmada olduğu gibi argümantasyon destekli bir SBK temelli öğretimin olmaması nedeniyle farklılık göstermektedir. Bir başka çalışmada ise Ercan Yalman (2023) farklı bağlamlardan sadece nükleer enerji bağlamının katılımcıların argüman kalitesini belirgin şekilde etkilediğini belirlemiştir. Bununla birlikte, araştırılan diğer SBK bağlamlarının (ör. hayvan deneyleri, iklim değişikliği, uzay kirliliği, biyoteknoloji ve nesli tükenmekte olan türler) katılımcıların argüman kalitesini etkilemediği görülmüştür. Belirtilen çalışma, Türkiye'nin ilk nükleer enerji santrallerinden birinin inşa edildiği Mersin'de gerçekleştirildiğinden, katılımcılar tartışılan bağlama daha aşina olabilirler çünkü konuya aşinalık Garrecht vd., 2021) ve kişisel ilgi (Dawson ve Venville, 2022; Sparks vd., 2022) daha nicelikli argümanlar üretmede etkili faktörler olarak karşımıza çıkmaktadır.