Id: 1866220

Participatory Educational Research (PER)
Vol.13(4), pp. 151-172, July 2026
Available online at http://www.perjournal.com
ISSN: 2148-6123
http://dx.doi.org/10.17275/per.26.53.13.4

# Beyond the Classroom: Exploring the Impact of Technology-, Culture-, and Daily Routine-Based Socioscientific Issues on Pre-service Primary Teachers' Decisions and Argumentation

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**Article history**

**Received:**
18.01.2026

**Received in revised form:**
19.02.2026

**Accepted:**
24.03.2026

**Key words:**
socioscientific issues; technology-based SSIs; culture-based SSIs; daily routine–based SSIs; decision-making; argumentation quality

This study investigates pre-service primary teachers' (PPTs') decision-making processes, the factors influencing these decisions, and the extent to which they can defend their decisions in a qualified manner within the context of culture-based socioscientific issues (SSIs), and daily routine–based SSIs, in addition to technology-based SSIs. Hydroelectric power plants were chosen for a technology-based SSI, tying cloth to trees as a culture-based SSI, and using facial cleansing gels as a daily routine–based SSI. This study used a qualitative descriptive design, which is suitable for describing phenomena in relatively new or underexplored areas, allowing the integration of qualitative interpretations with simple quantitative indicators such as frequencies of factors influencing decisions. In the context of this design, data were collected through written forms in which 25 PPTs explained and defended their decisions regarding SSI scenarios developed by the researchers. The data were analyzed inductively to identify factors influencing PPTs' decisions and deductively to examine argumentation qualities. The findings indicate that PPTs were able to make clear decisions in technology-based SSI but showed indecision in culture-based and daily routine–based SSIs. Supportive decisions were frequently observed for technology and daily routine–based SSIs, whereas culture-based SSIs often resulted in decisions favoring discontinuation of the tradition. Additionally, the factors influencing decisions and the quality of justifications varied depending on the SSI context, particularly in cultural and daily routine–based issues. These results suggest that culture and daily routine–based SSIs should be incorporated more frequently to develop individuals' decision-making and argumentation skills.

## Introduction

Whitehead (1967) argued that life cannot be postponed until students are fully prepared; yet, more than half a century later, efforts to reorganize education to equip students with relevant knowledge and skills still persist (Narayanti et al., 2024). In science education,

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this has prompted reflection on its core aims, with scientific literacy emphasizing individuals' ability to apply scientific processes and principles to everyday issues and decision-making (National Research Council, 1995).

SSIs offer valuable opportunities to bring important science-based issues encountered in daily life into classroom settings and to develop students' abilities to make decisions and to justify and defend those decisions (Foulk et al., 2020; Gutierez, 2015; Lee, 2007). Genetically modified organisms (Khishfe, 2024), global warming (dos Santos, 2014), and cloning (Arslan & Durak, 2024) are among the various SSIs addressed in the literature to promote informed decision-making and scientific argumentation.

Some SSIs in the literature originate from tensions between scientific knowledge and technology. For example, Nida and Eilk (2018) argued that the issue of genetically modified rice includes both scientific and technological dimensions. Sadler and Zeidler (2005) defined cloning, stem cells, and genetically modified foods as biotechnological advancements. These types of topics, closely related to both science and technology, are considered technology-based SSIs (Ladachart & Ladachart 2021).

SSIs can arise not only from technological developments but also from various contextual sources. For example, some SSIs in the literature are seen to originate from dilemmas between cultural beliefs and scientific knowledge. For example, Ladachart and Ladachart (2021) described the tradition in which Thai people float containers made of banana leaves or polystyrene foam on rivers to express gratitude to the water goddess and apologize for using and polluting the river as a culture-based SSIs. Similarly, Dewi et al. (2025) categorized snail skewers, a local culinary tradition in East Java, as a culture-based SSIs, addressing this issue in the context of thermo-chemistry.

On the other hand, some SSIs in the literature stem from dilemmas in individuals' daily routines and their scientific consequences. For instance, Eilks et al. (2018) noted that the use of hazardous chemicals in detergents and cosmetics has been treated as an SSIs in Germany, while Guérin (2019) examined sunscreen use as an SSIs, addressing it as a daily-routine with scientific implications. Accordingly, since SSIs are defined by the dilemmas from which they arise from (e.g., technology- or culture-based), issues such as sunscreen use or cosmetic use are categorized in this study as daily routine–based SSIs.

We situate daily routine–based SSIs within students' everyday lives to help cultivate informed, conscious citizens capable of making decisions. To become informed voters and responsible members of society, students need opportunities to navigate complex issues and see how science connects to daily life (Foulk et al., 2020). A key goal of science education is enabling students to actively engage with SSIs in everyday contexts (Tsai, 2018). Compared to topics that are less directly connected to students' everyday experiences, like nuclear energy or global warming (Shamos, 1995), daily routine–based SSIs are considered more effective for integrating science learning into everyday life, which is a central aim of science education (Ke et al., 2021).

Considering the importance of different SSIs contexts in developing decision-making skills (Sadler & Zeidler, 2005), the current study investigated PPTs' decisions, the factors affecting these decisions, and the quality of their argumentation across three SSIs contexts. Hydroelectric power plants (HPPs) were used as a technology-based SSI, the tradition of tying cloth to trees (TCTT) as a culture-based SSI, and using facial cleansing gel (UFCG) as a

daily routine–based SSI. The problem statement guiding the study was "How do PPTs' decisions, the factors influencing their decisions, and the quality of their argumentation vary across different SSI contexts?" Three research questions based on this problem statement emerged:

(1) How do PPTs' decisions vary across technology-based, culture-based, and daily routine–based SSIs?
Apostrophe/abbreviation inconsistency repeated in research questions.
(2) How do the factors influencing PPTs' decisions vary across technology-based, culture-based, and daily routine–based SSIs?
(3) How does the quality of the argumentation presented by PPTs' for their decisions vary across technology-based, culture-based, and daily routine–based SSIs?

## *Research Background*

### *Technology-Based SSIs (HPPs)*

SSIs encompass societal dilemmas that are conceptually or technologically connected to science (Sadler, 2004). Accordingly, SSIs often involve issues arising from technological developments such as cloning, stem cells, and genetically modified foods (Sadler & Zeidler, 2005). In the literature, topics including fetal tissue transplantation, nuclear energy, and global warming have been identified as technology-based problems within SSIs research (Ladachart & Ladachart, 2021; Zeidler et al., 2005). Therefore, the concept of technology-based SSIs is used in the literature to describe issues arising from dilemmas between technology and science (Ladachart & Ladachart, 2021).

In the current study, the construction of HPPs is used as a technology-based SSI. HPPs convert the kinetic energy of flowing water into electrical energy (Okatan, 2021). This technology offers increased employment, enriched trade, agricultural improvements, and support for the local economy (Yaman & Haşıl, 2018). However, it remains widely debated due to its consequences, including changes in river flow patterns, submergence of cultural and historical sites, coastal erosion, and habitat and vegetation loss (Yaman & Haşıl, 2018). Therefore, HPP technology is used as an SSI in many studies, noting both its advantages and disadvantages (Öztürk & Leblebicioğlu, 2015).

### *Culture-Based SSIs (TCTT)*

Although SSIs are based in science, they cannot be resolved solely through scientific knowledge (Eggert & Bögeholz, 2010). SSIs may present moral problems that conflict with beliefs and involve inconsistent scientific, social, or ethical perspectives (Zeidler et al., 2009), so reasoning or experimentation alone may be insufficient to address these problems (Oulton et al., 2004). Some SSIs arise from conflicts between scientific understanding and cultural beliefs, termed culture-based SSIs (Ladachart & Ladachart, 2021), highlighting the role of culture in shaping students' decisions (Zeidler et al., 2005).

TCTT, examined in this study, is a common tradition in Turkish communities. People tie cloths to sacred trees in hopes of health, protection, peace, or reunion with loved ones. Some believe this practice improves their mood and helps transmit cultural values to future generations. Others argue that excessive cloths damage trees by breaking branches and blocking sunlight, which hinders growth and survival. Due to these opposing effects, individuals must consider cultural beliefs alongside scientific consequences. Conflicting value

judgments make the issue difficult to resolve and open to debate.

*Daily Routine–Based SSIs*

Daily routine–based SSIs originate from everyday life situations, offering strong potential to understand how individuals respond to SSIs within their lived experiences as emphasized by Zeidler et al. (2019). Compared to other SSIs types, their distinctive features can be summarized as follows:

(1) They focus on tensions between everyday routines and their scientific consequences: While culture-based SSIs involve conflicts between cultural beliefs and science, and technology-based SSIs relate to science and technology (Ladachart & Ladachart, 2021), it can be argued that daily routine–based SSIs originate from individuals' everyday routines and their associated scientific consequences.
(2) They focus on how continuing or stopping an action affects individuals' daily routines: In the context of SSIs, a range of outcomes—social, economic, political, (Foulk et al., 2020), cultural (Ladachart & Ladachart, 2021), local (see Atasoy, 2018), and global (see dos Santos, 2014)—can be taken into account. Daily routine–based SSIs are designed to encourage individuals to consider the impact of their decisions on daily routines.
(3) They situate science learning within the context of everyday routine activities: Ke et al. (2021) emphasized that science literacy can be conceptualized through an approach that situates science learning within the context of everyday life. In this framework, the authors argue that SSIs are grounded in daily routines, integrating science learning into daily routine activities as an integral component of science literacy.

*UFCG in the Context of Daily Routine–Based SSIs*

SSIs supports making science learning more relevant to students' lives (Sadler, 2009). The necessity for SSIs to be connected to students' lives can be explained by the statement of Zeidler and Nichols (2009): "Students do not typically think about any topic that is not personal" (p. 50). This statement raises the question, "What is personally relevant to students?" (Zeidler & Nichols, 2009). An answer to this question can be found in the definition of relevance proposed by Stolz et al. (2013), who describe relevance as having an impact on students' present or future lives.

Using issues relevant to students helps raise awareness of how values influence evaluations of choices (Lee, 2007). When personal interests are involved, value judgments may play a role (Acar et al., 2010), highlighting the moral and ethical dimensions underlying SSIs (Sadler & Zeidler, 2005). SSIs directly related to students' daily lives are particularly valuable for examining students' decision-making. Accordingly, the use of daily routine–based issues directly connected to individuals' everyday lives served as a motivating factor for the present study. Given that the participants were PPTs aged 20–23, the use of facial cleansing gels—considered part of their daily routines—was selected as the SSIs context.

Facial cleansing gels are believed to prevent acne, increase self-confidence, and support psychological well-being by maintaining healthy skin. However, microplastics in their contents enter seas, freshwater, and soil, are consumed by animals, and negatively affect growth, reproduction, and development. Individuals must therefore evaluate their daily routines, personal interests, and scientific outcomes. Understanding how people decide whether to maintain these routines, the factors influencing their decisions, and how they

justify them is important for supporting the development of scientifically literate individuals.

*Decision-Making Process and Factors*

Decision-making in SSIs involves negotiating disagreements over conflicting scientific claims and using evidence to evaluate claim reliability and perceived risks (Lee & Grace, 2012). However, SSIs cannot be resolved solely through scientific knowledge (Eggert & Bögeholz, 2010). For decisions such as embryonic stem cell research or clean water protection, science alone cannot determine outcomes (Nielsen, 2013). SSIs therefore require understanding relevant scientific ideas and evaluating social, economic, political, and ethical dimensions (Foulk et al., 2020). Accordingly, addressing SSIs involves considering multiple dimensions, identifying relevant information, and integrating diverse perspectives into decision-making processes (Fang et al., 2019).

Various studies have explored decision-making in SSIs and influencing factors. Lee and Grace (2012) found that in an SSI on preventing avian influenza, students considered science, health, economics, social/cultural factors, environmental hygiene, and practicality when deciding on chicken slaughtering. Christenson et al. (2012) reported that high school students justified decisions in SSI on global warming, nuclear power, consumption, and GMOs using personal experience, values, economy, environment, science, ethics, and society. Topçu et al. (2011) found that PPTs' reasoning about genetic engineering was shaped by personal experiences, social beliefs, moral-ethical considerations, and technological concerns, with differences across contexts. While most SSIs studies focus on health, technology, and the environment, this study contributes by examining decisions and influencing factors in culture-based and daily routine–based SSIs.

*Examining the Quality of Argumentation in Different SSIs Contexts*

Science education aims to help students engage in public discussions and make informed decisions about SSIs affecting their lives (Dawson & Venville, 2010). Well-informed decisions require evaluating evidence, weighing risks and benefits, and considering alternatives (Dawson & Venville, 2010). The process of critically evaluating and verifying views using strong evidence is argumentation (Anisa Widodo et al., 2023).

Since argumentation supports students' scientific literacy (Cavagnetto, 2010), pre-service teachers' ability to construct arguments is fundamental for the future of science teaching (Zhao et al., 2023). Having the knowledge and skills necessary for argumentation will enable teachers to create argumentation-based learning environments and equip students with these competencies (Aglarci Özdemir et al., 2024).

Many studies examine the argumentation quality of pre-service teachers, as it reveals how individuals construct and develop arguments (Aglarci Özdemir et al., 2024). The literature shows that socioscientific argumentation commonly focuses on technological issues such as genetically modified organisms (Khishfe, 2024), environmental issues including global warming (dos Santos, 2014), and health-related issues such as COVID-19 (Saribas & Çetinkaya, 2021). Most studies on argumentation indicate that performance varies by context and that different content influences arguments in distinct ways (Khishfe, 2024; Zhao et al., 2023).

Since most SSIs studies focus on environmental and technological issues, argumentation quality in culture- or daily routine–based SSIs remain largely unexplored. Engagement with

cultural issues, however, is important for developing scientific literacy (Macalalag et al., 2020). Moreover, incorporating SSIs that are relevant to students' everyday lives positively influences affective learning outcomes (Sadler, 2009). Therefore, this study contributes to the literature by examining how PPTs make decisions and the quality of their arguments when cultural beliefs and interests are involved in SSIs.

## Method

In the current study, a qualitative descriptive research method was employed to answer three research questions.

Qualitative descriptive research focuses on providing a straightforward description of phenomena rather than deeply explaining underlying meanings (Ayton, 2023). It is particularly suitable for exploring relatively new or under-researched areas, allowing researchers to develop a basic understanding of the topic (Ayton, 2023). In this study, the approach was used to identify daily routine-based SSIs and to describe PPTs' decisions and argumentation qualities rather than to theoretically explain the complex meaning structures underlying participants' decision-making processes. In this respect, the study differs from qualitative content analysis, which is frequently used in SSIs research. Additionally, unlike qualitative studies commonly used in SSIs research, the qualitative descriptive approach enables data to be supported by both qualitative interpretations and simple quantitative indicators (Seixas et al., 2017), making it suitable for summarizing PPTs' decisions, influencing factors, and argument characteristics through descriptive themes complemented by some quantitative measures.

### *Participants*

The participants were 25 second-year PPTs from a public university in eastern Türkiye, aged 20–23. Of the participants, 21 were female and 4 males. They were undergraduate students in the Department of Primary Education. Graduates of the four-year program are qualified to teach grades 1–4, including science in grades 3 and 4. The PPTs graduating from this department will be responsible for introducing students to SSIs during their primary school years and for supporting the development of their discussion and decision-making skills regarding these issues, a goal emphasized by the Ministry of National Education (2018).

Convenience sampling, one of the types of purposive sampling, was used in selecting the participants. In convenience sampling, there are critical cases that provide particular insights into a problem, as well as convenient cases that involve settings or individuals that the researcher can easily reach and collect data from (Cresswell, 2007). In line with this sampling strategy, participants were asked to join after the study's purpose was shared, resulting in 25 PPTs volunteering to participate.

With respect to the sample size, in qualitative research, sample size varies by purpose and design, with descriptive studies typically involving 5–50 participants (Dworkin, 2012). Data saturation, when no new themes emerge (Mason, 2010), is a key criterion. In this study, recurring codes and diverse data indicated that 25 participants were sufficient.

### *Data Collection Tools*

Data were collected using researcher-developed forms containing scenarios and open-ended questions. The scenarios addressed a technology-based issue (HPPs), a culture-based issue (TCTT), and a daily routine–based issue (UFCG). All scenarios were designed in line with the characteristics of SSIs defined by Oulton et al. (2004): differing views among social groups; variation due to unequal access to information or interpretations; interpretive differences shaped by diverse perspectives and experiences; underlying value differences; the inability of some issues to be resolved solely through rational, logical, or empirical means; and the possibility that some issues may be resolved with new information.

The socioscientific features of the scenarios were guided by Oulton et al.'s (2004) framework, and then questions developed by Sadler and Zeidler (2005) were added to assess argumentation quality and identify factors influencing participants' decisions. The scenarios and questions were then reviewed by two SSI experts. Based on their feedback, revisions were made to balance advantages and disadvantages, remove certain expressions and potentially misleading statistics, and improve grammar. Subsequently, a pilot study with five undergraduate students was conducted, and minor revisions were made to enhance clarity before finalizing the scenarios. All scenarios were presented as supplementary material.

### *Data Collection Process*

After receiving ethical permissions for the study, PPTs were chosen from those who volunteered to participate. All data were collected through written forms (including scenarios and open-ended questions) completed by the volunteer participants. Data were not collected in the classroom environment; the forms were distributed to the PPTs, and they were given one week to complete them. After participants' written responses to one scenario were collected, the other scenario form was distributed. The data collection process took a total of three weeks.

Allowing participants to respond to the scenarios in settings of their own choice may have introduced external influences, such as peer discussions or online sources, potentially affecting the evaluation of their decisions. To address this concern, participants were informed of the study's purpose and encouraged to express their own views, with reassurance that their responses would not be judged as correct or incorrect. This approach was intentionally adopted to allow sufficient time for reflection, minimize pressure, and enable participants to articulate their reasoning more thoughtfully, without time constraints.

### *Data analysis*

#### *Decision-Making and Influencing Factors Analysis*

The responses given by the PPTs regarding their decisions and the factors influencing their decisions were coded using an inductive approach. Two researchers independently analyzed forms from 10 (14% of all data) participants since O'Connor and Joffe (2020) state that, to ensure reliability, approximately 10–25% of the data should be double-coded. Some differences were identified in the coding during analysis. Superstitions and religious codings were merged under "belief;" sustainability, agriculture, and environmental codings under "environment;" and social life and population growth codings under "social life and demographics" to resolve the disagreements. Afterward, all remaining forms were analyzed by the first researcher. As a result of the coding process, 8 codes were obtained for the

cultural scenario and 6 codes were obtained for the scenarios related to HPPs and facial cleansing gels. The number of participants who provided responses corresponding to each code was calculated separately for each of the three scenarios.

*Argumentation Quality Analysis*

Argument quality was evaluated using the "Claim–Evidence–Reasoning-Rebuttal" (CERR) framework developed by McNeill et al. (2006). This framework was developed to support students in expressing their scientific explanations and engaging in argumentation processes (McNeill & Krajcik, 2011).

Although different frameworks are used in the literature to evaluate the quality of arguments, one of the commonly used models is the Toulmin Argumentation Pattern (TAP). However, TAP can be challenging to apply (Erduran et al., 2004). The CERR framework, a simplified version (Lieber & Graulich, 2022), provides a clearer structure for identifying argument components and assessing scientific explanations (Honig et al., 2025) and was therefore used in this study.

In the CERR framework, a claim answers a given question, evidence refers to data supporting the claim, reasoning explains how the evidence supports the claim using scientific principles, and rebuttal involves counter-evidence and justifications rejecting alternative claims (McNeill & Martin, 2013). Each component was scored on a scale from 0 to 2 based on the appropriateness, completeness, and sufficiency of its presentation. A component was evaluated as level 0 if it was not presented or presented incorrectly. Correct but incomplete/inappropriate components were rated as level 1, and correct and complete components were rated as level 2.

All 25 participants completed 3 scenario forms (75 forms total), which were coded for claim, evidence, reasoning, and rebuttal. Minor disagreements occurred in 2 of 12 forms for evidence and reasoning, resulting in an 83% agreement rate. After resolving disagreements, the first researcher analyzed all forms. Frequencies of quality levels for each argument component are presented below.

## Findings

The findings of this study are presented in line with the research questions. Quotations from the PPTs' are coded anonymously as P1 (Participant 1), P2 (Participant 2), etc.

### *Decisions of PPTs in Technology-Based, Culture-Based, and Daily Routine–Based SSIs*

To identify participants' decisions regarding each SSI, frequency values were calculated for each response. These results are presented in Figure 1.

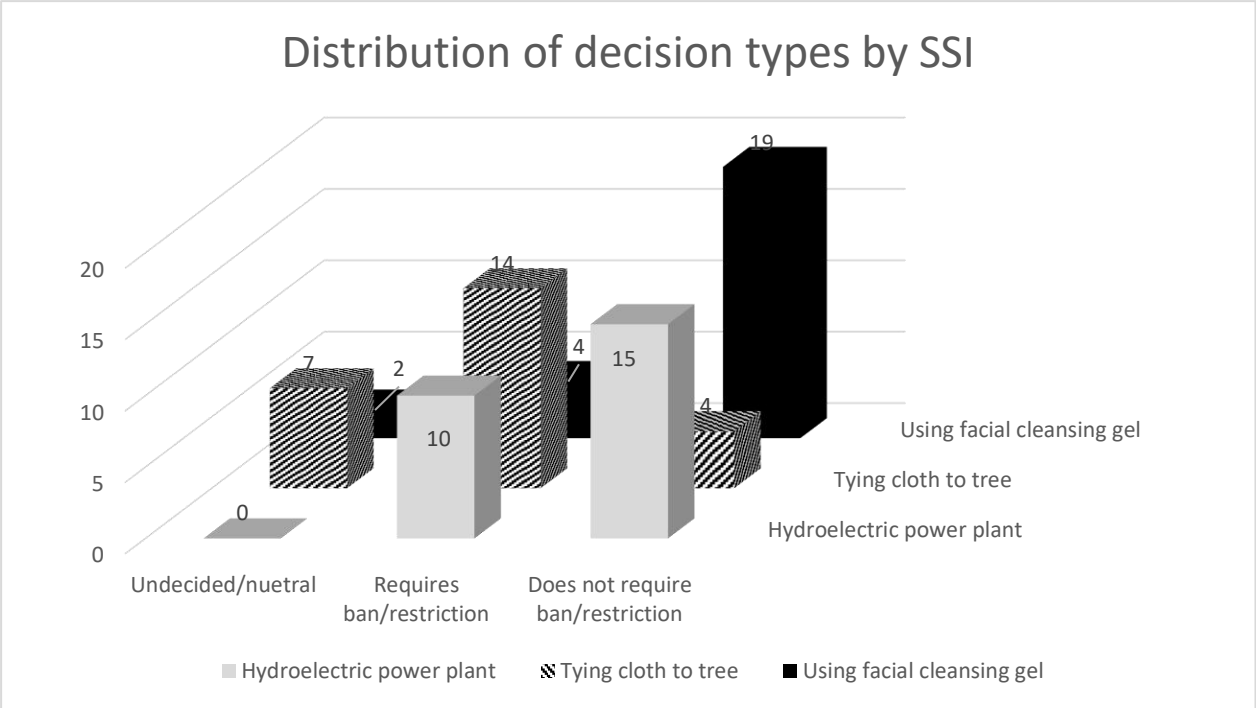


Figure 1. Distribution of decision types by SSI

As shown in Figure 1, 15 of the 25 participants supported the establishment of HPPs, while 10 did not. For the TCTT scenario, 14 participants favored banning or restricting the practice, 4 supported a ban or restriction, and 7 were undecided. Regarding UFCG, 4 participants supported a ban or restriction, 19 opposed it, and 2 were undecided. Example statements regarding decisions on HPPs are as follows:

I support it because HPPs are among the renewable energy sources (P1).

I do not support it because it harms the natural ecosystem and displaces people from their living spaces (P3).

Sample quotations regarding decisions on TCTT are as follows:

This tradition should not continue because it creates a dirty appearance in nature and hinders the growth of trees... I have never tied a cloth before... I don't think I will. I see the tradition of tying cloth to trees as a superstition (P3).

The tradition must continue… I have never tied a cloth to a wishing tree before. I would like to do so. Keeping such traditions alive is important to me (P6).

I am undecided because I think the part that should be preserved is that it helps people feel psychologically relieved. However, the reason I think it should not be preserved is that it is a situation with no proven truth and is not necessarily needed by people (P9).

Sample quotations regarding UFCG are as follows:

It should not be banned or restricted because it helps cleanse my skin from dirt and also makes my skin look healthier and more radiant (P4).

It should be banned/restricted... I didn't know that it harms the ecosystem and me. (P16).

I am undecided. It can be preferred based on personal choice, body structure, and suitability (P22).

### *Factors Influencing Decision-Making on Technology, Culture and Daily Routine–Based SSIs*

The findings regarding the second research question—the factors influencing the decisions of the PPTs—are presented in Figure 2.

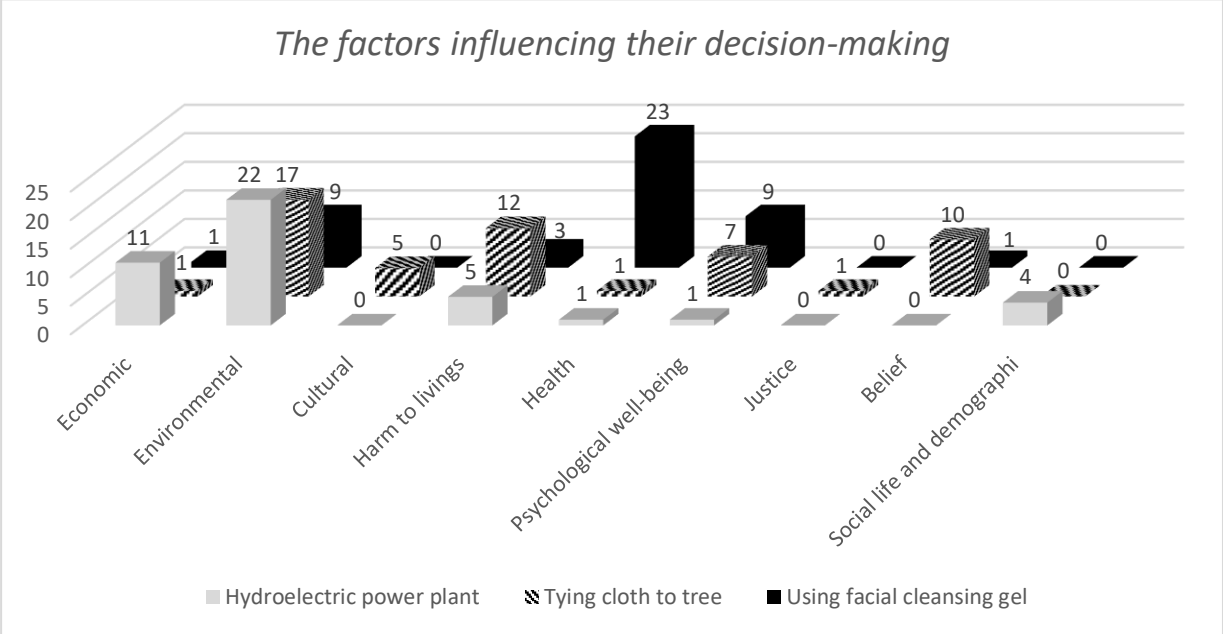


Figure 2. The factors influencing decisions

PPTs' decisions on establishing HPPs were influenced by environmental, economic, harm to living beings, social life and demographics, health, and psychological well-being factors. Decisions regarding the TCTT were shaped by environmental, harm to living beings, belief, psychological well-being, cultural, economic, health, and justice factors. For UFCG, the influencing factors were health, environmental, psychological well-being, harm to living beings, economic, and belief.

Sample quotations regarding the establishment of HPPs are provided below.

HPPs are economically advantageous in the long term due to low operating and maintenance costs. In addition, they contribute to the local economy through employment and infrastructure development. (P21). (Economic)

HPPs are among the renewable energy sources. In this regard, I believe they are environmentally friendly and energy efficient. (P2). (Environmental)

I do not support… By causing harm to the animals and plants living there, they could bring them to the brink of extinction (P3). (Harm to living beings)

First, new resources should be created to meet the needs of the growing world population. As the world population increases, natural resources have started to deplete, making it mandatory to produce new energy sources as alternatives to these resources (P12). (Social life and demographics)

Sample justifications provided by participants for their decisions regarding TCTT are presented below.

The tradition, which is continued for people…to feel happy and peaceful for a short time with this belief, has negative effects on the environment and other living things. (P12). (Environmental)

Traditions and customs form our national identity. ... I think people should not forget their own traditions and customs and should also comply with them for their continuation (P14). (Cultural)

The impact of this tradition on wildlife, where cloth pieces can be dangerous for birds and other small creatures, should be considered (P11). (Harm to living beings)

Because people feel better psychologically and their mood becomes more positive, this makes people happier (P1). (Psychological well-being)

This tradition should not continue because, in our religion, no one should be bowed to except Allah, and help should only be sought from Him…(P16). (Belief)

The participants' justifications regarding UFCG are exemplified below.

It should be banned/restricted... It might have many benefits, but I would say that it should be considered that it negatively affects the food chain. (P6). (Environmental)

There should be no restriction on these face cleansing products to stay healthy and well-groomed. … (P7). (Health)

Face cleansing gels should not be banned because skin cleansing is beneficial for a person psychologically (P8). (Psychological well-being)

***PPTs' Argumentation Quality Regarding Technology, Culture and Daily Routine–Based SSIs***

The findings regarding the quality of participants' argument components are presented in Figure 3.

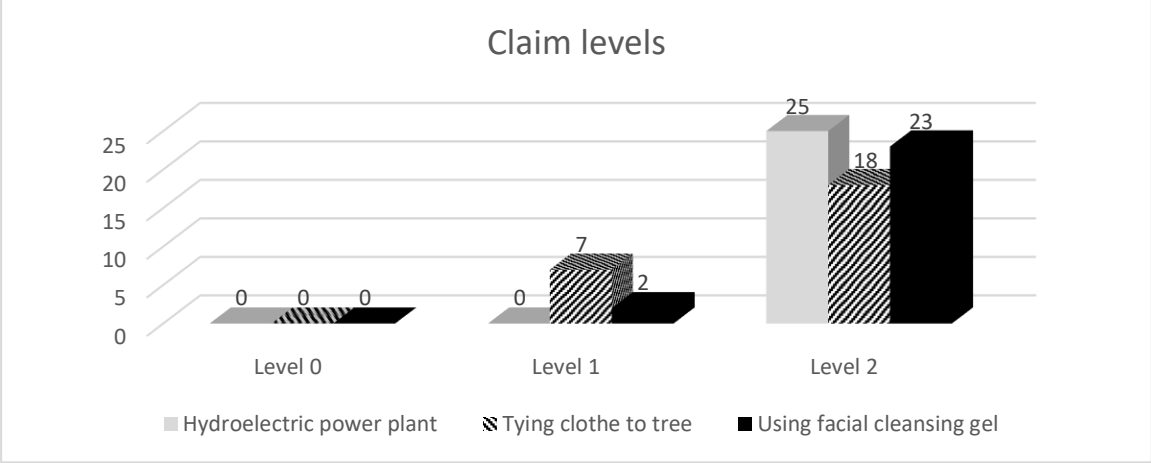


Figure 3. Claim levels

None of the PPTs made claims at the lowest level in any scenario. Level 1 claims appeared only in the TCTT- and UFCG scenarios, most frequently in the TCTT scenario. For the HPP-related SSI, all PPTs produced Level 2 (highest-level) claims, while the fewest Level 2 claims were observed in the TCTT SSI. Findings related to the level of evidence presented are given in Figure 4.

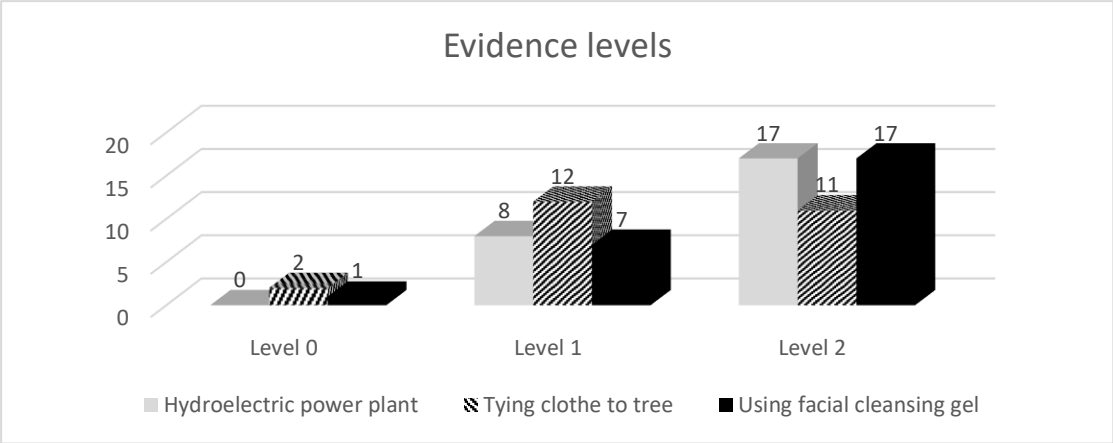


Figure 4. Evidence levels

As shown in Figure 4, Level 0 evidence appeared in the SSI related to TCTT and UFCG. Level 1 evidence was identified in the HPP and UFCG SSI, with the highest number at this level observed for TCTT Level 2 evidence was equally frequent in the HPPs and UFCG SSI while the TCTT had the fewest Level 2 evidence instances . Findings on PPTs' reasoning levels are presented in Figure 5.

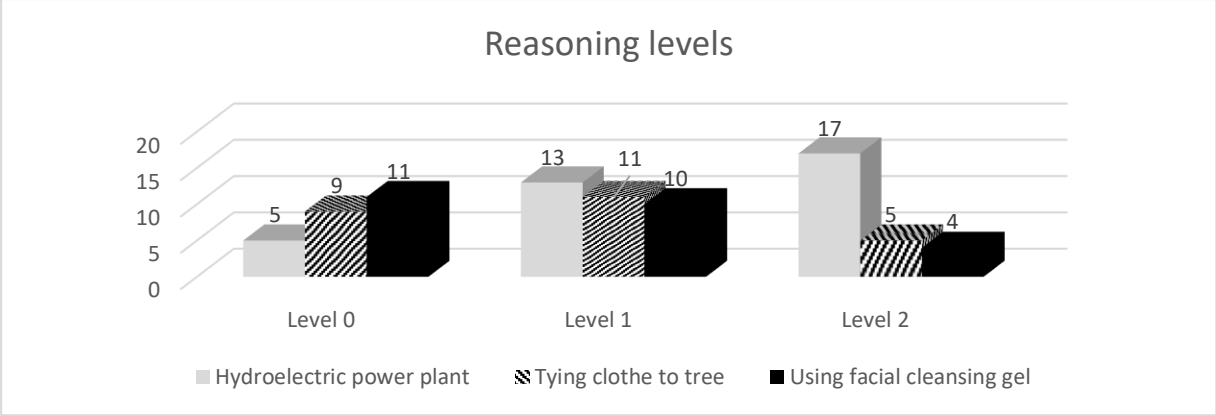


Figure 5. Reasoning levels

Reasoning about TCTT and UFCG at Levels 0, 1, and 2 had similar frequencies. However, in the context of HPPs, a differentiation was observed. The PPTs presented a lower quantity of reasoning at level 0 compared to the other two SSIs; conversely, they provided a higher quantity of reasoning at level 2. The findings related to the level of rebuttal presented by the PPTs are provided in Figure 6.

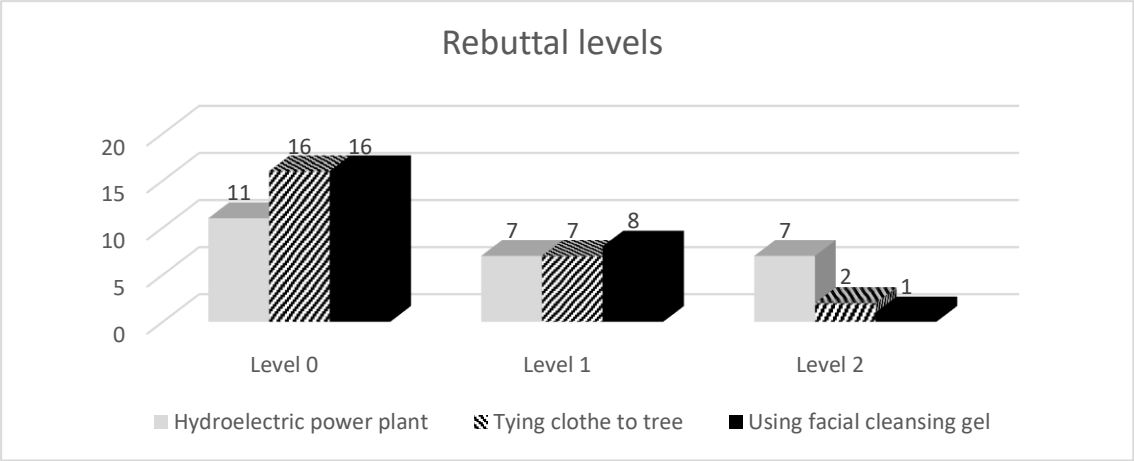


**Figure 6.** Rebuttal levels

Level 0 rebuttals for the TCTT and UFCG are equal , while the fewest rebuttals at this level were presented related to HPPs . At Level 1, similar frequencies were identified for the three SSIs. The majority of level 2 rebuttals were about the HPP scenario (7), while a limited number of rebuttals were identified for the TCTT and UFCG SSIs. Sample quotations for the argument components in the context of the three scenarios are provided in Table 1.

Table 1. Sample quotations from the PPTs indicating the levels of the argument components

| Claim component | 0 | 1 | 2 |
|---|---|---|---|
| Claim | - It can be preferred based on personal preference, the body's structure and suitability (P22). (UFCG) | I'm undecided. The tradition should continue, but in a different way (PS6). (TCTT) | - This tradition should not continue because, in our religion, no one should bow to anyone other than Allah (P16). (TCTT) |
| Evidence | - Responses with no evidence presented | Since the area around my nose is oily, if I don't wash it with facial cleansing products, my pores get clogged and it leads to acne (P10). (UFCG) | Being clean, renewable, and sustainable and not requiring raw material input because its source is water are also among its advantages (P8). (HPPs) |
| Reasoning | - Responses with no reasoning presented | People feel better psychologically, and their mood becomes more positive (P1). (TCTT) | This tradition causes the death of birds, which in turn disrupts the food chain in the ecosystem (P12). (TCTT) |
| Rebuttal | - Responses with no rebuttal presented | Just because rapid production is required, one should not jeopardize their health (P15). (HPPs) | Techniques such as fish passages, artificial ponds, and environmental discharge management … can reduce the negative effects on the ecosystem. An argument I can use against economic costs is that hydroelectric projects can … create job opportunities during the construction and operation phases, contribute to the local economy, and lead to infrastructure improvements (21). (HPPs) |

In addition to frequency distributions, average scores for each CERR component were presented in Table 2.

Table 2. Average scores for each CERR component

| | Average Scores | | | |
|---|---|---|---|---|
| SSI Context | Claim | Evidence | Reasoning | Rebuttal |
| HPPs | 2.00 | 1.68 | 1.88 | 0.84 |
| TCTT | 1.72 | 1.36 | 0.84 | 0.44 |
| UFCG | 1.92 | 1.64 | 0.72 | 0.4 |

As shown in Table 2, PPTs obtained the highest average scores for the claim component across all contexts, with values close to the maximum of 2. Evidence scores are similar across the three scenarios and exceed Level 1. For reasoning, PPTs had the highest average score in the technology-based SSI context, while scores are lower in the culture-based and daily routine–based contexts. Additionally, the lowest average scores across all three SSI contexts are observed in the rebuttal component.

## Discussion

The current study investigated the decisions of PPTs, the factors influencing their decisions, and the quality of their argumentation in technology-based SSI, culture-based SSI, and daily routine–based SSI. Findings are discussed below.

### *Decisions*

Findings showed that supportive decisions were more common in technology- and daily routine–based SSIs, while culture-based SSI more often involved opposition to tradition. Similarly, Bodur and Şenyuva (2013) found more support than opposition to HPPs. This may reflect PPTs' desire to benefit from renewable energy. Supporting this, Cėspedes et al. (2022) reported that university students view HPPs as important for energy independence, and Karasmanaki and Tsantopoulos (2019) found that students support renewable energy and recognize its environmental importance.

One potential reason the participants decided more frequently against the continuation of the tradition in the culture-based SSI is that they question the tradition of wishing trees in terms of their beliefs. Wondering whether this tradition is religiously appropriate may have caused them to base their decisions more on the environmental consequences of the tradition (see Table 1). Ladachart and Ladachart's (2021) study, which revealed that there were more decisions to stop the lantern tradition and that social and environmental factors influenced participants' decisions, supports the findings of the current study.

The higher number of decisions supporting facial cleansing gels reflects participants' reluctance to change routines and focus on personal well-being. Studies show university students often justify nature-related issues anthropocentrically (Kozłowska & Czapla, 2023; Miklós, 2014), supporting the finding that decisions were based on personal interests despite environmental impacts.

The fact that different contexts have a significant impact on decision-making processes and

responses to issues (Ladachart & Ladachart, 2021; Sadler & Zeidler 2005) may have also influenced the decisions made. The variation in the alternative options presented in each SSI context may partly explain this impact. For example, in the SSI related to HPPs, the PPTs had to decide between a technological application and its scientific results, while in the culture-based SSI, they had to decide between cultural values, belief-based factors, and their consequences. In the daily routine–based SSI, they had to decide between their own routines and their consequences.

Another key finding relates to participants' undecided stances. The absence of undecided stance regarding HPPs suggests that participants could more easily make firm decisions on an issue less connected to daily life, likely due to limited cultural and ethical considerations. Similarly, Öztürk and Leblebicioğlu (2015) found that decisions about HPPs were mainly based on scientific/technological and socio-economic perspectives, with minimal moral or ethical influence and no indecision. The lack of religious, ethical, and social pressure may thus have supported decisions favoring HPPs.

PPTs showed greater indecision in the culture-based SSI than in other scenarios, likely due to difficulties in balancing traditional values, personal beliefs, moral/ethical concerns, and social values with scientific outcomes. This finding is supported by Ladachart and Ladachart (2021), who reported indecisive stances regarding the continuation of traditions in cultural contexts. Similarly, in the daily routine–based SSI, participants struggled with decision-making on issues directly affecting their lives, as evaluating routine outcomes may have triggered ethical and moral reasoning, leading to indecision. These results align with Sakmen et al. (2020), who identified indecisive attitudes in an SSI on organ donation, a personally relevant topic.

These findings can be explained through socioscientific decision-making theories, which emphasize that decisions are shaped not only by scientific knowledge but also by emotions, social and moral priorities, and perceptions of SSIs complexity (Sadler, 2004). From this perspective, the participants' decisions appear to reflect the interaction of context, personal relevance, and value-based reasoning. Additionally, SSIs decision making involves evaluating causes, consequences, and the advantages and disadvantages of alternatives (Zohar & Nemet, 2002), suggesting that variations in these factors across contexts may have influenced pre-service teachers' decisions.

These findings have implications for teacher education, as PPTs' decisions vary across SSIs contexts. Programs may benefit from including diverse SSIs with technological, cultural, and daily-life dimensions to promote balanced reasoning and multiple perspectives. Supporting pre-service teachers this way may help them teach students to reason, consider multiple perspectives, and make informed decisions on important scientific issues (Fang et al., 2019).

### *Decision-Making Factors*

Participants considered economic, environmental, harm-related, social life, and demographic factors when making decisions about HPPs. These findings are supported by studies showing that economic, environmental, and social factors shape reasoning in HPP-related SSIs (Namdar et al., 2020; Öztürk & Leblebicioğlu, 2015). In Türkiye, HPPs are widely discussed due to the country's abundant water resources and renewable energy policies, as well as public opposition in affected regions. Frequent media coverage of both governmental initiatives and public responses may have increased PPTs' familiarity with the issue, leading their decisions to be influenced by multiple factors.

Similar to the HPP scenario, PPTs in the culture-based SSI considered environmental, cultural, harm-related, psychological well-being, and belief factors, with cultural and belief factors being prioritized. Consistent with this, Ladachart and Ladachart (2021) reported the use of cultural factors and personal beliefs in culture-based SSIs, while Sadler and Zeidler (2004) highlighted the role of religious beliefs in decision-making. Despite this emphasis, PPTs generally opposed continuing the tradition, suggesting that they questioned its religious validity and chose not to adopt it.

In the context of facial cleansing gels, the PPTs were more influenced by factors of environment, health, and psychological well-being. Two of these three (health and psychological well-being) are based on an anthropocentric perspective. Accordingly, the anthropocentric perspective appeared to influence participants' decisions in situations involving the environment and human health. Helvacı (2021) revealed that the majority of PPTs' educational stories about an environmental issue are written from an anthropocentric perspective, supporting the findings of the current study.

The age of the participants may have been another factor. Many of the PPTs mentioned experiencing acne problems and the difficulties they faced as a result of this issue (see Table 1). This situation can be interpreted as personal experiences affecting decisions and reasoning (Topçu et al., 2011; Sadler & Zeidler, 2005), indicating that experiences have an important effect on decision-making in a daily routine–based SSI.

From a teacher education perspective, context-dependent influencing factors provide important insights, suggesting that engaging PPTs with diverse SSIs contexts may support the development of more comprehensive decision-making skills and encourage them to consider multiple dimensions of complex real-world problems. Exposure to different SSIs contexts may further support the development of the ability to evaluate issues from scientific, ethical, cultural, and societal perspectives. In addition, identifying and explaining the reasoning processes and patterns used by participants when encountering controversial scientific dilemmas may contribute to the design of more effective socioscientific curricula and pedagogical strategies, thereby promoting scientific literacy.

### *Argumentation Quality*

All participants presented Level 2 claims in the HPP scenario, whereas both Level 1 and Level 2 claims emerged in the TCTT and UFCG SSIs, with the highest number of low-level claims related to TCTT. In addition, PPTs' average scores for the claim component in the technology-based SSI were higher than those observed in the other SSIs contexts. These results align with previous findings, where participants made clear decisions in the HPP scenario but were indecisive in others, especially TCTT, limiting high-level claims. Previous studies show participants usually handle claims well (Topçu & Atabey, 2017), considered the easiest argumentation element (McNeill & Martin, 2013), though claim levels still varied by context.

As with claims, participants showed lower evidence levels and average scores in the culture-based SSI. This may be because students relate scenarios to personal experiences (Sadler & Zeidler, 2004), which likely helped them use personal observations as evidence in daily routine SSI. Decision-making factors may also affect evidence use since it is more common to use scientific data related to economic, environmental, health, or social issues than for cultural or belief-based factors. Thus, in culture-based SSIs, participants relied more on personal values and beliefs, possibly because they struggled to identify appropriate evidence (Sadler,

2004) and often based explanations on personal inferences and values rather than evidence (Hogan & Maglienti, 2001).

Other findings showed that participants' reasoning levels and scores were lower than evidence levels and scores, except in the technology-based SSI, consistent with studies (McNeill, 2021) noting difficulties in reasoning (Aydeniz & Gürçay, 2013). Limited prior argumentation experience may explain challenges in linking claims and evidence (Fan et al., 2020). While participants could justify claims in the technology-based SSI, they struggled in other SSIs, possibly because belief, ethical, and cultural values hindered reasoning, as individuals often struggle with moral reflection (Paul & Elder, 2003).

There was, however, a differentiation in favor of the HPP scenario for the rebuttal component, with a relatively high frequency at level 2, and PPTs presented the highest average rebuttal score in the HPP scenario. In culture and daily routine-based SSIs, it is observed that the PPTs' average scores for the rebuttal component are quite low. This may be because opposing ideas are more easily disregarded when the issue is daily routines or cultural values. It is difficult to change people's cultures in a way that contradicts their beliefs (Ladachart & Ladachart, 2021), and issues that most closely align with students' beliefs are more persuasive (Sadler et al., 2004). The participants may have considered their daily personal routines important to their well-being and avoided thinking about different views on this issue. It is reasonable to suggest that students are more inclined to consider different views on issues that are more distal to them.

Overall, these findings indicate that participants' argument quality varies by socioscientific context. In cultural issues, decisions are shaped not only by logic but also by moral values and beliefs (Zeidler et al., 2005), possibly leading individuals to rely more on personal experiences and value-based reasoning. This may limit the use of scientific evidence and constrain more complex arguments. In contrast, technology-related SSIs tend to promote greater use of scientific knowledge and evidence. This suggests that socioscientific argumentation is both contextual and value-driven, not purely cognitive.

The context-dependent nature of argumentation quality suggests that teacher education programs should offer PPTs' argumentation experiences across diverse socioscientific contexts to strengthen evidence-based reasoning. These competencies are essential for enabling them to create argumentation-based learning environments and support their students' development of argumentation skills (Altun & Özsevgeç, 2025).

## Conclusion

This study shows that technology, culture, and daily routine–based SSIs affect decisions, influencing factors, and argumentation quality. PPTs struggled with clear decisions in culture- and daily routine–based SSIs, were more supportive in technology and daily routine contexts, and tended to oppose cultural traditions, suggesting they may reject cultural values seen as inappropriate from a belief or scientific perspective.

Participants also considered different factors across SSIs contexts: economic and environmental in technology-based SSI, cultural and belief in culture-based SSI, and psychological and health in daily routine–based SSI. In addition, the levels and average scores of PPTs' argumentation components varied according to the SSIs content. These findings highlight the importance of using diverse SSIs contexts to support PPTs' argumentation quality and to enable participants to understand and value the relationships between science,

technology, and society.

These findings highlight important pedagogical implications for classroom practice. The higher indecision and lower evidence and reasoning scores of PPTs—especially in culture- and daily routine–based SSIs contexts—suggest limited experience in evaluating such issues through scientific argumentation. This points to the need for learning environments that incorporate SSIs connected to students' everyday lives and cultural contexts. Including these contexts in classroom discussions can help students practice constructing evidence-based arguments while reflecting on the relationship between scientific knowledge, personal values, and ethical perspectives.

On the other hand, the goal is not for students to abandon personal views but to consider alternative perspectives and examine the reasoning behind their beliefs (Sadler et al., 2004). It also helps them become aware of how values influence decisions and consequences (Lee, 2007). Therefore, to leverage culture- and routine-based SSIs for applying scientific ideas in daily life and improving analysis and solution generation (Jumini et al., 2024), these issues should be incorporated into classroom settings.

### *Limitations*

Due to the limited and context-specific sample, the transferability of these findings is restricted. Therefore, the findings should be interpreted as providing descriptive insights rather than broadly generalizable conclusions. Since the data were collected in a natural classroom setting rather than in a fully controlled environment, external factors such as small peer interactions or situational influences might have affected participants' responses.

## Declarations

***Acknowledgments section:*** *Not applicable*

***Declaration of conflicting interest:*** *Authors declare no conflicts of interest.*

***Funding statement:*** *The authors declare that they have not received any financial support for this research from official or private organization.*

***Ethical approval and informed consent statements:*** *This study was approved by the institutional review board of Muş Alparslan University where the research was carried out.*

***Data availability statement:*** *Research data are available from the authors upon reasonable request.*

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