

Article

Relationships Between Preservice Teachers' Interest, Perceived Knowledge, and Argumentation in Socioscientific Issues: Implications for Teaching About the Complexity of Sustainability Challenges

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Abstract: Socioscientific issues are a key aspect of science education, enhancing citizens' understanding of the intricate relationships among global concerns and fostering their engagement in informed decision making on these problems. To this end, teachers must be able to establish connections between scientific content, its application in everyday life, and its impact on social, economic, and environmental dimensions. This study analyzes the factors that influence teachers' ability to address these topics in the classroom. It includes two studies. The first study ($n = 213$) examines prospective science teachers' interest in and perceived knowledge of 14 issues related to the Sustainable Development Goals (SDGs). The second study ($n = 135$) analyzes the types of arguments that participants use to justify their interest. A mixed-method ex post facto design was employed, using ad hoc questionnaires. The results suggest significant differences between interest and perceived knowledge across certain specific topics. Additionally, the topic addressed tends to evoke specific dimensions within arguments, with cultural/social and ecological/environmental aspects being the most prevalent, influencing the connections teachers establish with everyday life contexts. These findings highlight how interest, perceived knowledge, and the topic itself influence the dimensions considered in argument construction when discussing socioscientific issues and may contribute to the development of teacher training programs that foster a deeper understanding of the complex nature of these sustainability-related issues.

Keywords: socioscientific issues; education for sustainability; preservice science teachers; interest; perceived knowledge; types of arguments



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1. Introduction

Socioscientific issues (SSIs) explore the complex relationships among science, technology, and society, as well as their impact on people's daily lives. Owing to their intricate nature, these topics are often contentious and frequently generate conflicts, requiring ethical analysis and the evaluation of moral concerns to reach a satisfactory resolution [1]. When addressing these issues in the classroom with the goal of educating for sustainability, it is essential to not only consider the scientific foundations but to also incorporate all relevant social, economic, and environmental aspects along with their interactions. This makes SSIs

an ideal educational approach for addressing issues related to the United Nations (UN) Sustainable Development Goals (SDGs) as part of the 2030 Agenda [2].

In this context, various reviews on the implementation of SSIs in science education have shown that the most commonly employed topics revolve around sustainability challenges and issues related to the SDGs. Ban and Mahmud [3] used a content analysis method to review articles from SSI education research publications, and their results revealed that SSIs focus mainly on environmental issues. In a similar vein, Högström et al. [4] presented a systematic review of research on SSIs, and the topics identified were mainly the environment and sustainable development and health and technology. In an analysis of the use of SSIs in science lessons, Viehmann et al. [5] developed a scoping review that revealed a focus on environmental, genetic, and health-related concerns.

The use of socioscientific issues in the classroom requires the creation of learning experiences on real-world contexts, which is similar to the Education for Sustainable Development (ESD) approach proposed by UNESCO [6,7] to address the topics outlined in the SDGs. The primary goal of this educational approach is to promote functional scientific literacy, integrating knowledge and skills with moral reasoning so that students can develop the ability to face and make well-informed decisions when addressing current challenges [1]. This aligns with the Education for Sustainable Development model and UNESCO's sustainability competence framework, known as Green Competencies [8]. These competencies include cognitive, affective, and motivational elements that contribute to thinking, planning, and acting sustainably.

Pedagogical strategies based on SSIs, such as discussions and debates on real-world problems, provide effective frameworks for acquiring various complex thinking skills. In recent years, educational research on SSIs has demonstrated positive effects on the development of multiple sustainability-related competencies. The studies conducted by Pratiwi et al. [9] and Solbes et al. [10] revealed that those students who were taught via the SSI scored significantly higher on a critical thinking test than those who were not. Ke et al.'s [11] and Leung et al.'s [12] papers provided evidence that involving students in the development of socioscientific models can promote systems thinking about SSIs. Jones et al. [13] developed a conceptual framework in the context of SSIs to support students' future thinking (it provides elements that allow students to explore how society and its physical and cultural environments could be shaped in the future) that was remarkably successful. In the same vein, Siew and Rahman [14] highlighted the effectiveness of the SSI approach assisted by the future thinking map in nurturing students' future thinking. The positive and significant effects of the use of SSIs in science learning on creative thinking skills have been demonstrated in the research of Satria et al. [15] and Indriani et al. [16]. According to Lee [17] and Garrecht et al. [18], working on SSIs in the classroom can improve decision-making skills, which is considered an important attribute of scientific literacy. Gao et al. [19] concluded that SSI instruction can positively affect students' emotional competence, and qualitative research conducted by Herman [20] noted that SSI instruction had such an impact on students that they came to express emotive reasoning about people and nature. Perspective taking enables an understanding of the diverse cognitive and emotional perspectives of others, and according to Hahn and Zeidler [21], it is fundamental when working on SSIs in the classroom. Newton and Zeidler [22] shed light on how the discourse and argumentation present in SSI application has fostered greater perspective taking.

Other previous studies have highlighted the obstacles that educators must overcome to successfully plan and implement this educational approach. Chen and Xiao [23] analyzed teachers' perceptions of SSI-based teaching through a review of research articles published between 2004 and 2019. Their study identified a wide range of challenges, which they classified into five levels on the basis of the domain in which they arise: teacher,

student, school, community, and policy. The findings revealed that most of the barriers to implementing SSIs are at the teacher level, particularly concerning four aspects:

- Insufficient knowledge of both scientific and social content;
- Lack of instructional competencies for teaching SSIs;
- Feelings of insecurity when addressing these controversies in the classroom;
- Personal interests and beliefs regarding SSIs.

In the case of preservice teachers, although they may perceive themselves as moderately prepared to face the complexity of the relationships between science, technology, society, and the environment, as well as to work with SSI approaches [24], some studies suggest the need for more specific preparation [25,26]. In response to this demand, innovative didactic models based on the use of SSC are being developed, which seem to have a positive effect on the development of teachers' professional competencies [27–30].

Pedagogical strategies based on SSIs have distinct characteristics that differ from those of other teaching strategies; consequently, the challenges faced by teachers are also different. Therefore, it seems essential to design training programs that help develop the specific skills teachers need to successfully implement this educational approach and achieve professional knowledge tailored to the teaching of socioscientific controversies: in other words, pedagogical content knowledge on socioscientific issues [31].

2. Research Objectives

Given the importance of SSIs in fostering a citizenry capable of promoting a sustainable future, the present study explores the ability of future secondary education science teachers to implement these educational strategies in the classroom. Specifically, it delves into two factors that influence this ability: knowledge about SSIs and interest in SSIs [23].

Currently, using SSIs to educate citizens on sustainability requires that teachers have expertise not only in the disciplinary scientific knowledge involved but also in its connections to other school disciplinary domains (e.g., social sciences, economics, politics, and environmental sciences). Previous research has shown that a solid understanding of SSIs enables teachers to develop effective education for sustainability, i.e., teaching the scientific concepts involved while fostering the development of critical thinking, argumentation, informed decision-making skills, and social justice among their students [32,33].

In addition, teachers' lack of interest in certain SSIs can decrease students' motivation, attention, and understanding [34], making students' education difficult for sustainability. According to preceding studies, there is a certain research gap regarding the interest of preservice science teachers in the different topics that can form the core of SSIs.

This manuscript is divided into two studies: the first aimed at determining the self-perceived interest and knowledge of future science teachers in different socioscientific issues related to the SDGs. Gender and academic level were considered as potential influencing factors, as they are commonly included in educational research. While not central to the study's design, their inclusion allows for the exploration of potential differences, contributing to a more comprehensive understanding of individual variation within the sample. The second study aimed to analyze the informal arguments that future teachers used to justify their declared interest in different SSIs. These arguments could originate from the scientific and social dimensions they consider when addressing these complex issues.

3. Materials and Methods of Study 1

3.1. Research Design

An ex post facto design was used in Study 1, with a test–retest administration to increase the reliability of the data about future science teachers' self-perceived interest and knowledge in a variety of socioscientific issues (SSIs). Quantitative techniques were used

for the inferential analyses performed to determine the possible effects on the measures of gender and academic level.

The primary variables in this study were the self-reported interest and perceived knowledge of future science teachers concerning various SSI topics. Additionally, the potential impacts of gender and academic level were considered. Educational and social gender differences may contribute to varying levels of interest and knowledge in specific SSI topics. Furthermore, the limited presence of SSIs in the curriculum could lead to differences in both knowledge and interest as students progress through their undergraduate studies.

3.2. Context and Participants

This study was conducted with preservice students enrolled in the Bachelor's Degree Program in Science Education offered in Ecuador. The program spans nine semesters and is jointly implemented by three higher education institutions. During the first three semesters, students study at the National University of Education (UNAE), located in Azuay Province (central Sierra region), where they receive initial training in pedagogy and didactics. From the fourth to the seventh semesters, they continue their studies at specialized institutions, such as the Amazonian Regional University Ikiam (Napo province, Amazon region) or Yachay Tech (Imbabura province, northern Sierra), which focus on disciplinary content related to the natural sciences. In the final two semesters, students return to the UNAE campus to complete coursework in ethics, philosophy, and professional teacher development.

A total of 213 students (48.8% women, 50.2% men, and 0.9% undisclosed gender) from the first to eighth semesters participated in the present study. Among these participants, 136 were enrolled at UNAE, and 77 were enrolled at Ikiam. The average age was 21.6 years ($SD = 2.7$). With respect to territorial origin, 92.5% of the participants came from households in the Sierra region, 5.1% from the Coastal region, and 2.4% from the Amazon region. In terms of ethnic identification, 62.4% identified as mestizo, and one participant identified as Indigenous. According to Ecuador's Social Registry—a national household classification system based on more than 50 structural indicators—just over 21% of students came from households living in poverty (i.e., with a per capita monthly income less than USD 90).

The combination of participants' geographic mobility across university sites, socioeconomic backgrounds, and ethnic identity suggests a cohort with lived awareness of diverse social, economic, and environmental realities, an experience that may serve as a valuable asset in their future professional placements across these regions, especially when using socioscientific issues in science education.

3.3. Instruments

For this study, a simple questionnaire was designed to allow the participants to self-assess their interest in and knowledge of socioscientific issues (SSIs) via the scale with which students are assessed, ranging from 1 (lowest) to 10 (highest interest or knowledge). A total of 14 different controversial subjects were included, covering a wide range of global and local issues involving natural and artificial resources. Some of the globally controversial subjects were the use of animals in medical experimentation, conflicts arising from coltan extraction for mobile phone manufacturing, and the environmental impact caused by the use of air conditioning equipment. Among the locally relevant controversies are pollution and biodiversity loss caused by livestock farming, health issues and loss of territorial rights due to mining and oil extraction, and water supply problems resulting from severe contamination.

Each controversy was presented in written form in Spanish (the vehicular language in Ecuador at the university), with a length ranging from 57 to 63 words. It was divided into

two information units expressing opposing ideas of approximately 30 words each. One unit presented facts considered desirable or with positive consequences, whereas the other described facts considered negative or harmful. The contrast between both fragments was always expressed via the connector “however”.

The initial version of the questionnaire was provided to three university professors specializing in science education to review the relevance and appropriateness of the items for research purposes, as well as their wording clarity. Their comments and suggestions referred to syntactic expressions and were incorporated to refine and improve the comprehensibility of the instrument’s items.

Finally, two versions of the questionnaire were created. In the first version, seven controversies were presented with the structure positive argument–“however”–negative argument, whereas the other seven followed the inverse structure: negative argument–“however”–positive argument. In the second version of the questionnaire, the presentation order was reversed to prevent order bias among participants. Appendix A provides examples of both the first and second versions.

3.4. Data Collection and Analysis Procedure

To obtain the necessary permissions, an official request was sent to the authorities responsible for the Bachelor’s Degree Program in Science Education at each university involved. Upon approval, data were collected in the classrooms during regular science education lessons. During each data collection session, the first 10 min were dedicated to presenting the study and its academic objective, ensuring complete anonymity for (adult) participants and clarifying that their participation was unrelated to the course and its assessment. After any questions were addressed, the two versions of the questionnaire were randomly distributed among the students. Each student subsequently completed the questionnaire within approximately 15 min.

Three weeks later, the retest session was conducted to deliver the same version of the questionnaire as that in the first administration to each student.

The data collected were organized in a Microsoft Excel spreadsheet and analyzed using SPSS V.28 to perform descriptive and inferential statistics. The descriptive analysis aimed to explore the average interest and knowledge levels regarding each of the proposed topics, particularly using mean values and standard deviations to identify those with the highest and lowest interest among future science teachers. The inferential analyses allowed us to determine the relationship between self-perceived interest and knowledge and sought to determine whether gender and academic level influenced self-perceived interest and knowledge.

4. Results of Study 1

4.1. Interest and Perceived Knowledge in Socioscientific Issues

The participants exhibited a relatively high global average interest in socioscientific issues for the test ($\bar{x} = 7.42$; $SD = 2.09$; with a maximum of 10) as well as for the retest ($\bar{x} = 6.73$; $SD = 2.46$), as detailed in Table 1. The controversies that generated the highest self-perceived interest were the water supply, the use of animals in medical testing, and the use of ICTs. The controversies that generated the least interest were fast fashion, air conditioning equipment, and urbanization.

Regarding perceived knowledge, participants reported a moderate level of knowledge in both administrations ($\bar{x} = 5.14$; $SD = 2.28$) and ($\bar{x} = 5.19$; $SD = 2.41$). As also shown in Table 1, the topics with the highest perceived knowledge were the water supply, the use of ICTs, and the use of animals in medical testing. Conversely, the controversies with the

lowest perceived knowledge were the use of air conditioning equipment, electric cars, and technological development.

Table 1. Future science teachers' self-perceived interest in and knowledge of different SSI topics: mean values and SDs for the first (test) and second administrations (retest).

Topic	Interest Test	SD	Interest Retest	SD	Knowledge Test	SD	Knowledge Retest	SD
Industrialization	7.2	2.0	6.3	2.4	5.0	2.1	4.8	2.3
Electric cars	7.6	2.1	6.8	2.3	4.5	2.4	5.1	2.4
Technological development	7.6	1.9	7.0	2.4	5.5	2.2	5.6	2.3
ICTs	7.9	1.9	7.3	2.4	6.1	2.1	6.0	2.4
Air conditioning equipment	6.6	2.0	6.2	2.4	4.3	2.2	4.6	2.4
Animals in medicine	8.2	1.9	7.5	2.4	5.6	2.3	5.4	2.5
Urbanization	7.0	2.1	6.5	2.4	5.0	2.1	5.0	2.3
Mobile phone manufacturing	7.8	2.1	7.0	2.5	4.6	2.2	5.0	2.4
Livestock farming	7.3	2.3	6.5	2.5	5.5	2.4	5.2	2.4
Water supply	8.3	1.9	7.4	2.5	6.2	2.4	5.8	2.5
Private car use	7.1	2.0	6.6	2.4	5.6	2.4	5.4	2.5
Fast fashion	6.4	2.6	6.1	2.7	4.7	2.6	4.9	2.5
Conservation programs	7.7	2.2	6.7	2.5	4.8	2.3	4.9	2.4
Mining and oil extraction	7.2	2.3	6.3	2.6	4.7	2.3	4.9	2.4
Overall	7.4	2.1	6.7	2.5	5.1	2.3	5.2	2.4

4.2. Effects of Gender on Perceived Interest and Knowledge

Normality tests were conducted to examine the distribution of the two global measures (perceived interest and knowledge averaged for the different SSIs) via the Kolmogorov–Smirnov test. The global perceived interest did not exhibit a normal distribution in the test or the retest ($p < 0.05$ in both). With respect to global perceived knowledge, the test and the retest measures showed normality ($p > 0.05$). Consequently, parametric tests were used for inferential analyses.

The overall test and retest averages showed sufficient stability over time according to Spearman's correlation for perceived interest ($\rho = 0.56$; $p < 0.01$) and according to Pearson's correlation for perceived knowledge ($r = 0.58$; $p < 0.01$). This increases the reliability of participants' responses.

An analysis of the possible influence of gender was conducted via the Mann–Whitney U test for the interest measure and Student's t test for the perceived knowledge measure. The results indicate that men and women showed similar overall interest ($U = 4936.50$; $p > 0.005$) and perceived knowledge ($t = 0.17$; $p > 0.05$), averaging socioscientific issues.

However, some significant differences due to gender emerged in certain specific topics when they were considered one by one. With respect to perceived knowledge, women reported significantly greater perceived knowledge in the fast fashion issue ($M_w = 5.1$; $SD = 2.1$; $M_m = 4.5$; $SD = 2.1$; $t = -2.1$; $p = 0.039$), whereas men reported significantly greater perceived knowledge in the issue of electric cars ($M_w = 4.4$; $SD = 1.8$; $M_m = 5.2$; $SD = 2.1$; $t = 2.9$; $p = 0.004$).

With respect to interest concerns, men showed significantly greater interest in the issue of electric cars ($M_w = 6.9$; $SD = 1.7$; $M_m = 7.5$; $SD = 1.8$; $U = 4452$; $p = 0.012$), whereas women showed significantly greater interest in topics related to the use of ICTs ($M_w = 7.9$;

$SD = 1.7$; $M_m = 7.3$; $SD = 1.9$; $U = 4499.5$; $p = 0.016$) and fast fashion ($M_w = 6.6$; $SD = 2.2$; $M_m = 5.9$; $SD = 2.1$; $U = 4520$; $p = 0.018$).

4.3. Effects of Academic Level on Interest and Perceived Knowledge

The participants' academic level was evaluated via an ordinal variable with values ranging from 1 (first semester) to 8 (eighth semester). The analysis revealed that the overall perceived interest in both the test and the retest did not follow a normal distribution ($p < 0.001$). Consequently, nonparametric tests were used.

Spearman's correlation coefficient revealed a moderate but significant positive correlation between the average interest in SSIs and academic level ($\rho = 0.21$; $p = 0.002$). On the other hand, the average perceived knowledge in the test and retest demonstrated a normal distribution ($p = 0.2$), allowing the use of Pearson's correlation test. The results revealed a nonsignificant, almost null correlation between overall perceived knowledge of socioscientific issues and academic level ($r = -0.01$; $p = 0.884$).

4.4. Relationship Between Interest and Perceived Knowledge in SSIs

The results of the Kolmogorov–Smirnov test revealed that the perceived interest averaged across all the SSIs did not exhibit a normal distribution ($p < 0.05$) in either the test or the retest. On the other hand, regarding overall perceived knowledge, a normal distribution was observed ($p > 0.05$). Since one of the variables did not meet the normality assumption, Spearman's correlation was used.

The results revealed a moderate and significant positive correlation between the two variables ($\rho = 0.498$; $p < 0.001$). This suggests that as the declared interest in socioscientific issues increases, the perceived knowledge of these SSIs tends to increase as well.

5. Discussion of Study 1

The findings indicate that future science teachers show a high level of interest in these topics, which aligns with previous research [35]. This interest is crucial, as it influences the perceived effectiveness of these educational experiences and the likelihood of implementing them in the classroom [26,36]. Notably, these future professionals are particularly concerned with issues essential to maintaining societal well-being and with significant ethical and social implications, such as water supply, advances in medicine, and the use of ICTs. Conversely, they show less interest in topics where personal needs conflict with environmental or social impacts, such as the use of air conditioning systems, urbanization, and fast fashion. This suggests that individual benefits are sometimes prioritized over collective benefits, a phenomenon supported by environmental psychology studies conducted by Steg [37,38], which highlight the influence of egocentric or hedonistic values on environmental decisions.

With respect to perceived knowledge, Ecuadorian preservice teachers presented a moderate to low level of knowledge, which is lower than that reported in other studies involving both in-service and preservice teachers addressing similar issues related to education for sustainability [39–41]. This perception of their knowledge could negatively affect their self-efficacy [42,43] and, by extension, their teaching practices [44,45].

Additionally, we observe that the three topics of greatest interest coincide with the three topics of highest perceived knowledge, and Spearman's correlation analysis reveals a moderate positive correlation. This finding is consistent with the results of Stenseth et al. [46]. They reported a correlation between upper secondary students' level of interest and knowledge in two different contexts.

With respect to gender, although men and women exhibit similar overall interest and perceived knowledge, significant differences emerge in specific topics, such as fast

fashion, the use of ICTs, and electric cars. These differences may be influenced by gender stereotypes associated with social and cultural factors, as observed in other studies [47,48]. Fast fashion may primarily affect women because of their high representation in fashion consumption and the ethical concerns associated with textile production, which could explain their greater interest and knowledge in this topic. On the other hand, men's interest in electric cars could be linked to a greater general interest in automotive technology and technical innovations, areas traditionally associated with greater male participation.

With respect to academic level, the results show a moderate but significant positive correlation between interest and academic level, suggesting that academic training slightly stimulates interest in SSIs. However, the correlation between the knowledge of SSIs and academic level is almost null, which could indicate that these topics are not deeply explored in teacher education programs.

The results of this study motivated the implementation of a second investigation. After assessing the perceived interest and knowledge, the next step was to analyze the arguments that future teachers present to justify their interest in SSIs.

The second study collected and analyzed the informal arguments that future Ecuadorian science teachers used to justify their interest in some SSIs, as declared in Study 1. The results could indicate which dimensions future SSI teachers take into consideration when addressing these issues.

6. Materials and Methods of Study 2

6.1. Research Design

An ex post facto design with a qualitative research method was used.

Neither gender nor academic level were considered in this study, as they did not produce any differences in Study 1 regarding the topics selected for Study 2.

6.2. Context and Participants

A total of 135 students with a Bachelor's Degree in Science Education participated in the study, including 66 men (48.8%) and 69 women (51.1%). Of these, 81 students (60%) were enrolled at UNAE, whereas 54 students (40%) studied at Ikiam. The participants had the same origin and socioeconomic and ethnic characteristics as those in Study 1.

6.3. Instruments

Four topics were selected from the results obtained in Study 1, accounting for high and low levels of declared interest to increase the observed differences in arguments, if any, but also for high and low self-perceived knowledge. In addition, the selection considered two topics related to technology and two related to natural resources. In this way, possible differences in arguments would appear if they were also associated with knowledge or the natural or artificial nature of the topics.

The selected topics are presented in Table 2.

Table 2. Selected topics with high or low levels of declared interest and knowledge in Study 1.

Topic	Interest Level	Knowledge Level
Air conditioning equipment	Low	Low
Mobile phone manufacturing	High	Low
Water supply	High	High
Livestock farming	Low	High

To avoid participant fatigue, the technological or natural resource topics were combined and split into different questionnaires. Hence, one questionnaire included the topics of water supply and air conditioning equipment, and the other included livestock farming and mobile phone manufacturing. Each participant completed only one of the questionnaires. Appendix B shows one of the items in the questionnaires.

6.4. Data Collection and Analysis Procedures

The necessary permissions from the authorities responsible for the Bachelor's Degree Program in Science Education at each university were obtained following the same procedure as in Study 1.

The data collection process was also the same as that in Study 1. Half of each group worked with the questionnaire version containing the topics “water supply” and “air conditioning equipment”, whereas the other half worked with “livestock farming” and “mobile phone manufacturing.”

Given the context of data collection, the absence of participants' prior training on what constitutes a formal argument, and the limited time available for data collection, it seems reasonable to consider that the arguments provided were informal in nature [49].

To analyze the arguments provided, a recurrent coding process was carried out, similar to that used by Baytelman et al. [50]. First, five dimensions were considered for categorizing the arguments: political, economic, moral/ethical, cultural/social, and ecological/environmental. Each dimension was described in terms of its specific and distinctive features, and two judges (two of the researchers) independently categorized a subset of 50 arguments.

The two judges met on several occasions to discuss and adjust the coding criteria and to incorporate some features not considered initially to better describe and differentiate the dimensions of the argument. The initial agreement was not deemed sufficient ($Kappa < 0.60$), so a second subset of 50 arguments was categorized. Finally, substantial agreement was reached ($Kappa = 0.75$) [51]. After this agreement, the defining characteristics of each category were considered sufficiently informative, and one of the researchers proceeded to categorize the remaining arguments. Table 3 shows the final definitions of the dimensions of the arguments.

Table 3. Characteristics of the dimensions of the informal arguments elaborated to justify the personal level of interest in SSIs.

Dimension	Description
Political (PO)	It focuses on issues related to public policies, legislation, governance, and power. It includes discussions on regulation, government rights and responsibilities, and international diplomacy concerning the issue at hand.
Economical (EC)	It addresses financial and economic impacts, including costs and benefits, consumption and production, market analysis, employment effects, and considerations of economic development and resource distribution. This dimension refers to the monetary value of goods and suggests economic improvements for producers (families and livestock farmers), relationships with businesses, consumerism, and capitalism.

Table 3. *Cont.*

Dimension	Description
Moral/ethical (MO)	It relates to issues of justice, rights, responsibilities, and moral considerations. It may include debates on what is ethically right or wrong and fair or unfair, often based on ethical principles and value systems. This dimension discusses what is good or bad concerning certain actions, reflecting on the need to raise awareness about an issue or assess its consequences.
Cultural/social (CU)	It focuses on aspects such as social norms, cultural identity, traditional values, religious beliefs, and the overall impact on society. This includes how certain social groups within a specific area, country, or region (such as families, indigenous communities, small producers, children, or humanity as a whole) are affected. It involves benefits for many people, the generation of conflicts, improved academic training, knowledge acquisition, comfort, and quality of life.
Ecological/environmental (EN)	It refers to the impact on the environment and ecosystems. It includes considerations of sustainability, biodiversity, natural resource conservation, and the effects of climate change. This dimension also covers issues related to the value of biodiversity (humans as living beings), the use of natural resources, and health-related topics.

7. Results of Study 2

7.1. Informal Arguments Elaborated to Justify the Declared Interest in SSIs

A total of 184 informal arguments were collected. Their dimensions were first determined and then categorized according to their features outlined in Table 3 following the procedure described above.

Some examples of the arguments and dimensions identified are shown in Table 4.

Table 4. Examples of informal arguments and dimensions identified.

Topic	Informal Argument	Dimensions
Water supply	“The protection of water sources will help us preserve this resource for a long time. . .	EN
	. . .since, if not properly cared for, it will become the most expensive and most valued element for humanity in the future.”	EC
Livestock farming	“Many families rely on livestock production for their livelihood, and they are already accustomed to this type of work.	EC
	Of course, if we look at it from an environmental perspective, it causes great harm,	EN
	but there is very little information known about this topic.”	CU
	“Since it is one of the means to obtain food, priority should be given to developing sustainable plans according to the needs of the livestock sector, so that producers can limit their land use to only what is necessary for livestock activities.”	MO

Table 4. *Cont.*

Topic	Informal Argument	Dimensions
Mobile phone manufacturing	“The problem with coltan lies in its scarcity and uneven distribution. . .	EC
	. . .yet, on the other hand, mobile phones have revolutionized humanity and driven technological advancement.”	CU
Air conditioning equipment	“These climate control systems bring both benefits and consequences, and people must be aware of and take responsibility for the potential impacts they may cause.”	CU
	“For the comfort of human beings, the planet pays the price.”	MO

7.2. Distribution of the Dimensions Among the Topics

Table 5 presents the frequencies observed for each dimension for each topic. The cultural/social dimension appeared most frequently in the arguments provided ($n = 228$), whereas the political dimension was the least common ($n = 13$). In fact, the latter was not used in two of the four topics addressed.

Table 5. Distribution of the dimensions implied in the arguments among the topics: observed frequencies.

Dimension	Livestock Farming	Mobile Phone Manufacturing	Water Supply	Air Conditioning Equipment	Total
Political	7	6	0	0	13
Economical	39	6	13	3	61
Moral/ethical	15	46	47	27	135
Cultural/social	65	83	45	35	228
Ecological/environmental	72	34	50	56	212
Total	198	175	155	121	649

The ecological/environmental dimension was the most common topic, with the arguments provided in the topics of livestock production, freshwater supply, and air conditioning. In contrast, the cultural/social dimension was the most frequent in the arguments related to mobile phones, as shown in Table 5.

7.3. Relationships Between Dimensions and Topic

To analyze the possible associations between the topics addressed (livestock production, mobile phones, water supply, and air conditioning) and the dimensions involved in the informal arguments used by participants to justify their interest, Pearson’s chi-square test was computed. The results indicated a significant association ($\chi^2(12) = 98.893$; $p < 0.001$), suggesting a statistically significant association between the topic and the dimensions that appear in the arguments used.

When the observed frequencies were compared with the expected ones, the livestock production controversy clearly elicited more economic aspects (39) than expected at random (18.6) and fewer moral/ethical aspects than expected at random (15 vs. 41.2). Compared with the frequencies expected at random, the mobile phone controversy generated more cultural/social aspects (83 vs. 61.5) and fewer economic aspects (6 vs. 16.4). Moreover, in

the air conditioning equipment controversy, the ecological/environmental dimension had a greater presence than expected at random (56 vs. 39.5), and the opposite was obtained in the economic and cultural/social dimensions (35 vs. 42.5). Finally, the water supply controversy frequencies were similar to those expected at random.

8. Discussion of Study 2

This second study analyzes the arguments that future science teachers use to justify their interest in the presented socioscientific issues. The results show that, in general, the arguments primarily address social and cultural aspects, making this the most frequently observed dimension across the four topics.

The thematic analysis reveals that the ecological/environmental dimension is the most frequently used in three of the four topics (livestock production, water supply, and air conditioning equipment), aligning with the growing concern for the planet, as reflected in recent popular consultations conducted by the National Electoral Council [52,53]. In these consultations, the population prioritized environmental conservation over the economic benefits generated by mining activities, demonstrating strong pro-environmental concerns.

The fact that teachers base their interest on social and environmental arguments shows an approach aligned with the dimensions of sustainable development, which form the foundation of the 2030 Agenda and the Sustainable Development Goals [2].

On the other hand, the political dimension appears with the lowest frequency and was not considered by any participant in two of the addressed issues. This lack of reference to the political dimension could be linked to the instability that has affected Ecuador in recent years. Notably, 55% of Ecuadorian youth have little or no interest in political issues [54].

Although all the dimensions are mentioned at a general level, this is not the case for individual topics. The scarce or nonexistent presence of the political dimension, along with the low occurrence of economic arguments in several topics, indicates that a significant portion of preservice teachers do not approach these subjects with the complexity they require. These findings align with those of Krell et al. [55], who reported that many preservice biology teachers tend to use only two or fewer dimensions in their arguments.

The moral/ethical dimension requires special mention. While this dimension appears in multiple arguments, it is important to remember that this study addresses sustainability-related issues through a socioscientific issues approach. In this sense, science teachers should be aware of the need to consistently emphasize the moral dimension in their reasoning [56].

Finally, concerning context, the results show a relationship between context and the predominant dimensions in the arguments provided by future teachers. For example, the topic related to livestock production has a stronger presence of economic and ecological/environmental dimensions, whereas the topic of mobile phone use elicits more cultural/social and moral/ethical arguments than expected. These results are consistent with those of Yalman [57], who identified a relationship between context and the dimensions present in arguments provided by preservice teachers. However, they differ from the findings of Baytelman, Iordanou, and Constantinou [50,58] in university students, who did not observe a relationship between the specific context and the diversity of arguments.

9. Conclusions

This study explores issues that may be relevant to the development of future secondary education science teachers' ability to implement classroom strategies on the basis of socioscientific issues. Considering the results, it is necessary to design teacher training programs that promote a deeper understanding of sustainability-related content and the controversies that arise around these topics. Additionally, it would be advisable to consider gender as a

factor that could influence differences in interest and perceived knowledge in some of these topics. Furthermore, the way future teachers present their informal arguments provides insight into their preparedness to integrate multiple perspectives and how context may influence the frequency of certain aspects being addressed.

The use of socioscientific issues in science education, particularly within the framework of education for sustainability, requires that these topics to be approached from multiple perspectives, highlighting the connections between the different aspects involved. It is reasonable to assume that better content knowledge would facilitate the creation of more comprehensive arguments, leading to a broader understanding of these issues. However, given the specific characteristics of this educational approach and the complexity of present and future societal challenges, it seems necessary to review teacher training curricula to better equip educators with the ability to address these topics with a broader and well-founded perspective. This study may contribute to the design of specific programs that incorporate learning experiences aimed at fostering the acquisition of pedagogical content knowledge in socioscientific issues.

10. Limitations and Future Studies

While these aspects are not considered limitations of the study in a strict sense, it is important to highlight certain contextual and methodological considerations that may inform the interpretation of the findings. First, the study was conducted in Ecuador, which means that the findings reflect the specific socioeconomic, cultural, and educational characteristics of this context. No claims of generalizability are made, as the aim was to explore patterns within this educational setting. Second, although most of the topics addressed in the study focus on global concerns, some are specific to local realities. This reinforces the relevance of the study within the Ecuadorian context, which also implies that the findings may need to be interpreted in light of different regional or national priorities. Finally, the assessment of knowledge was based on participants' self-perception, a common practice in educational research that allows for the exploration of learners' personal understanding and reflections. While this may involve a degree of subjectivity, it is consistent with the interpretive nature of the research design. In light of the present investigation, it would be useful to conduct similar studies to determine the effect of participants' contexts on their interest in addressing different sustainability issues. Furthermore, more in-depth studies are recommended to examine the influence of interest and content knowledge on teachers' pedagogical content knowledge regarding socioscientific issues.

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Informed Consent Statement: Verbal informed consent was obtained from the participants. Verbal consent was obtained rather than written because the research relies solely on anonymous question-

naires, with no clinical interventions or handling of sensitive data. All participants were adults and were fully informed about the study. Their anonymity was guaranteed at all times, and they were explicitly informed that their participation would have no impact on their academic evaluation.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Sample items from the two versions of the questionnaire used in Study 1.

Version 1:

Topic 2										
The use of electric cars reduces air and noise pollution in cities and lowers vehicle maintenance costs, improving the quality of life for citizens. However, electric vehicles are expensive, have limited range, require more polluting natural resources (such as lithium for batteries) in their manufacturing, and the current charging infrastructure is insufficient.										
Less interest/knowledge						More interest/knowledge				
1	2	3	4	5	6	7	8	9	10	
My interest in this topic is. . .										
My knowledge on this topic is. . .										

Version 2:

Topic 2										
Electric cars are expensive, have limited range, require more polluting natural resources (such as lithium for batteries) in their manufacturing, and the current charging infrastructure is insufficient. However, the use of electric vehicles reduces air and noise pollution in cities and lowers vehicle maintenance costs, improving the quality of life for citizens.										
Less interest/knowledge						More interest/knowledge				
1	2	3	4	5	6	7	8	9	10	
My interest in this topic is. . .										
My knowledge on this topic is. . .										

Appendix B

Sample item from the questionnaire used in Study 2.

Topic 1
Mobile phones have revolutionized the way humanity interacts by facilitating communication, access to information, and data management. However, their production requires a scarce mineral called coltan, whose extraction has led to armed conflicts resulting in millions of deaths, child exploitation, and severe environmental damage.
Argument 1:
Argument 2:
Which argument is the most relevant to you

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