

A CASE STUDY ON THE SELF-EFFICACY OF PRE-SERVICE AND IN-SERVICE GREEK TEACHERS REGARDING TEACHING THROUGH THE USE OF SOCIO-SCIENTIFIC ISSUES.

UM ESTUDO DE CASO SOBRE A AUTOEFICÁCIA DE PROFESSORES GREGOS EM FORMAÇÃO E EM SERVIÇO EM RELAÇÃO AO ENSINO ATRAVÉS DO USO DE QUESTÕES SOCIOCIENTÍFICAS

UN ESTUDIO DE CASO SOBRE LA AUTOEFICACIA DE LOS PROFESORES GRIEGOS EN FORMACIÓN Y EN SERVICIO RESPECTO A LA ENSEÑANZA A TRAVÉS DEL USO DE CUESTIONES SOCIOCIENTÍFICAS

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ABSTRACT | In modern societies, science and technology permeate all aspects of life, making it necessary to address socio-scientific issues (SSI) through a framework that connects science and society. Schools play a crucial role in developing students' ability to manage such issues. This case study investigates the views of 12 Greek pre-service and in-service elementary school teachers on incorporating SSIs into their teaching practices. Using semi-structured interviews, the study explores teachers' willingness to engage with SSI, perceived benefits, and barriers such as low self-confidence, curriculum relevance, and community reactions. The findings reveal a strong willingness to integrate SSI despite significant concerns, such as low self-confidence, concerns about curriculum relevance, potential classroom disruptions, and apprehensions about community reactions, particularly from parents and school administrators, highlighting the need for targeted teacher training programs to support effective implementation.

KEYWORDS: Science and society, Socio-scientific issues, Science education, Elementary school teachers, Pre-service teachers.

RESUMO | Nas sociedades modernas, a ciência e a tecnologia permeiam todos os aspetos da vida, tornando necessário abordar as questões sociocientíficas (SSI) através de um enquadramento que ligue a ciência à sociedade. As escolas desempenham um papel crucial no desenvolvimento da capacidade dos alunos para lidar com este tipo de questões. Este estudo de caso investiga as perspetivas de 12 professores gregos do ensino básico, em formação inicial e no exercício da profissão sobre a integração de SSI nas suas práticas pedagógicas. Usando entrevistas semiestruturadas, este estudo explora a disposição dos professores para abordar SSI, os benefícios e os obstáculos percebidos, como a baixa autoconfiança, a relevância curricular e as reações da comunidade. Os resultados revelam uma forte vontade de integrar SSI, apesar de preocupações significativas, tais como a baixa autoconfiança, dúvidas quanto à relevância curricular, possíveis perturbações em sala de aula e receios face às reações da comunidade, sobretudo por parte dos pais e dos responsáveis escolares, realçando a necessidade de programas de formação de professores direcionados para apoiar uma implementação eficaz.

PALAVRAS-CHAVE: Ciência e sociedade, Questões sociocientíficas, Educação em ciências, Professores do ensino básico, Professores em formação inicial.

RESUMEN | En las sociedades modernas, la ciencia y la tecnología impregnan todos los aspectos de la vida, lo que hace necesario abordar las cuestiones sociocientíficas (SSI) mediante un enfoque que conecte la ciencia con la sociedad. Las escuelas desempeñan un papel crucial en el desarrollo de la capacidad del alumnado para enfrentarse a este tipo de cuestiones. Este estudio de caso investiga las perspectivas de 12 docentes griegos de educación primaria, tanto en formación inicial como en ejercicio, sobre la integración de las SSI en sus prácticas pedagógicas. A través de entrevistas semiestructuradas, este estudio explora la disposición del profesorado para abordar las SSI, los beneficios y los obstáculos percibidos, como la baja autoconfianza, la pertinencia curricular y las reacciones de la comunidad. Los resultados revelan una fuerte disposición a integrar las SSI, a pesar de preocupaciones significativas, como la falta de confianza, las dudas sobre su encaje en el currículo, las posibles interrupciones en el aula y el temor a las reacciones de la comunidad, especialmente de las familias y del equipo directivo de los centros. Estos hallazgos destacan la necesidad de programas de formación docente específicos que apoyen una implementación eficaz.

PALABRAS CLAVE: Ciencia y sociedad, Cuestiones sociocientíficas, Educación científica, Profesorado de educación primaria, Profesorado en formación inicial.

1. INTRODUCTION

In modern societies, science and technology are involved in various ways in every aspect of social, economic, and political life. Socio-Scientific Issues (SSIs) cannot be adequately examined through isolated lenses of either science or society. Still, a framework is needed to examine them multifacetedly, highlighting the relationship between society and science. The school, as a fundamental educational institution, can contribute to developing management skills for such issues.

In recent years, the integration of SSIs into education has gained attention as a means to link science and society more closely (Sadler, 2011). Research suggests that the inclusion of SSI in science curricula fosters critical thinking, ethical reasoning, and decision-making skills in students (Ratcliffe & Grace, 2003; Bencze et al., 2012). Studies have shown that engaging students with SSI enhances their ability to analyze complex situations, consider multiple viewpoints, and make informed decisions (Zeidler et al., 2009; Sadler, 2011). Furthermore, teachers play a pivotal role in facilitating discussions around controversial topics, preparing students to engage with real-world issues (Ekborg et al., 2013). Effective teacher training and support are essential for equipping educators with the skills necessary to navigate these discussions and help students develop the competencies needed to address societal challenges (Bryce & Gray, 2004; Özden, 2015).

This research examines the views of six pre-service teachers (students of the Department of Pedagogy and Primary Education at the National and Kapodistrian University of Athens) and six in-service primary school teachers in Greece regarding the use of SSI. The aim is not only to assess these teachers' willingness to incorporate these issues into their teaching but also to highlight the barriers they encounter and explore potential solutions.

The entire sample, without exception, showed a willingness to include SSI in teaching, citing as added benefits the contact of students with a range of, often opposing, points of view, the development of teamwork spirit, argumentation skills, critical thinking and processing and problem-solving. However, they also referred to a variety of inhibiting factors such as how interesting they and the students find an issue, relevance to the curriculum, low self-confidence about their cognitive training, the very nature of SSI as a potential source of disruption in the classroom, the possible reactions of the directly related social group (parents, school management, colleagues) to issues that are particularly controversial, while few also mentioned the absence of teaching time. Finally, the great majority of the participants express the belief that teaching through SSI is suitable only for elder ages, and the last elementary classes, while they also presented a teacher-centered attitude towards the processing of SSIs.

The findings of this research call us to emphasize the need for the creation and implementation of training programs for primary education teachers in order to address the above concerns.

2. LITERATURE REVIEW

The rapid progress of science and the proliferation of technology, phenomena that have affected almost every aspect of human activity, have given rise to and continue to give rise to several interrelated SSI. SSI have been widely recognized as essential components of science

education, promoting the development of critical thinking and ethical reasoning (Sá-Pinto et al., 2022; Bencze et al., 2012). SSI such as climate change, vaccination debates, and genetically modified organisms require students to integrate scientific knowledge with broader social and ethical considerations. Recent studies highlight the importance of embedding SSI into science curricula to help students engage with real-world problems (Ekborg et al., 2013; Ratcliffe & Grace, 2003). However, despite their importance, many teachers face challenges in addressing SSI due to lack of training and relevant teaching resources (Chen & Xiao, 2021). According to Kara (2012), science has long been recognized as a human activity directly related to the social, economic, political, and moral sphere. Citizens are increasingly requested to take a stand on issues based on scientific knowledge or technological capabilities but are overlaid by broader concerns (Hodson 2003 as cited in Sadler 2011).

The existence of SSI is not a simple issue that can be addressed with a scientific and technological solution. SSI constitute a complex context in which the conditions and assumptions underpinning policies and pedagogical practices are reexamined. When it comes to complex socio-ecological and socio-technical phenomena a field of discourse limited to technocratic “answers” fails to connect these issues to the wider economic, political, and ecological contexts (Reis, 2014). SSI not only integrate scientific and social contexts but also serve as a tool to foster scientific literacy by helping students critically engage with scientific knowledge and its implications (Sá-Pinto et al., 2022). Dealing with SSI requires the ability to examine the ethical dimensions of science, critical thinking skills, decision-making, argumentation, and reflective judgment. Those without a basic understanding of the ways in which science and technology interact with the physical and sociopolitical environment are likely to go seriously astray in exercising their rights in a democratic, technologically dependent society (Sadler, 2011).

Based on the definitions provided by Bencze et al. (2012), Kara (2012), Lee et al. (2006), Ratcliffe & Grace (2003), and Sadler (2011), we define SSI in the context of this research as follows: SSI are highly controversial issues that reflect the multifaceted interactions of science, technology, and the broader social context. Thus, they are based on science and potentially have a significant impact on society.

2.1 SSI in Science Education

Education should be oriented towards encouraging students to become active citizens, ready and willing to face, individually and through social actions, issues that affect them, emphasizing the value of SSI analysis for the achievement of this goal (Bencze et al. 2012). According to Albe (2007), (as cited in Espeja et al. 2015), science education should provide opportunities for students to experience science in contexts similar to those they will find outside of school, aiming to achieve scientific literacy for all citizens. SSI allow students to understand the importance of science in everyday life and develop the ability to be critical consumers of scientific information (Kolsto, 2001 as cited in Espeja et al., 2015). According to Lee et al. (2013), exposure to SSIs and active participation in classroom discussions surrounding these topics play a crucial role in fostering students' sense of responsibility and their motivation to engage with these issues in real life. This engagement encourages students to recognize the relevance of SSI to their own lives and inspires them to act in their communities. Additional research suggests that using SSI in education enhances not only scientific understanding but

also critical thinking and decision-making skills, essential for addressing complex issues like evolution and sustainability (Sá-Pinto et al., 2022).

The internalization of information stemming from SSI processing activities is based on understanding the relationships between concepts, the ability to make decisions in times of crisis and draw conclusions, as well as understanding the scope of application of new knowledge, abilities, and skills (Kostromina & Gnedykh, 2015). In SSI processing, scientific knowledge is nothing more than a trigger to promote deeper critical thinking (Ratcliffe & Grace, 2003). SSI-based instruction not only enhances students' understanding of science but also prepares them for active citizenship by engaging them in socio-political and environmental issues (Sá-Pinto et al., 2022).

According to Bencze, Sperling & Carter (2012), despite significant progress in development and research related to educating students about social science topics, practices in schools are often much more modest. Despite the recognized benefits, SSI are not generally included in the science classroom, much less in primary education, in which SSI seem, a priori, to represent a significant challenge for teachers and students (Espeja et al., 2015). SSI processing requires different skills and pedagogical approaches than many teachers are probably familiar with and requires them to organize classroom work differently, often introducing unfamiliar practices (Bayram Jacobs, 2019). Recent work by Emvalotis et al. (2021) further highlights the role of personal epistemology in biological sciences education, emphasizing that students' and teachers' scientific beliefs and understanding significantly shape their approach to learning and teaching scientific concepts. This is particularly relevant when teaching SSI, as it demands a reflective and inquiry-based approach.

In many school contexts, little emphasis is placed on SSIs. This is partly because many teachers perceive their primary responsibility as teaching scientific principles and concepts, often viewing any meaningful intervention that incorporates the complexity and open-ended nature of SSI, as well as the need to address values and moral considerations, as a burden (Ratcliffe & Grace, 2003). This viewpoint is supported by Lee and Witz (2009), who argue that teachers' focus on traditional scientific content limits their willingness to engage with SSI. Challenges that teachers seem to face according to Chen & Xiao (2021) can be divided into four categories: insufficient teacher knowledge base, lack of skills, feeling insecure when dealing with SSI in classrooms, and lack of personal interests or beliefs. Teachers in a survey by Borgerding & Dagistan (2018) reported that they consider it misleading to teach multiple perspectives or to maintain teachers' neutrality in discussions of SSIs, fearing that this instruction would make students doubt the scientifically accepted view, as well as that they believe that the students did not have the maturity to face this controversy. Teachers' reluctance to include ethical aspects in SSI teaching is likely to discourage them from adopting effective teaching practices even when they are equipped to do so (Leung, 2022). In addition, research by Ekborg et al. (2013) presented teacher concerns around addressing student questions, critically examining arguments, and using media in the process.

Other research focused on teachers' views on SSI teaching shows that despite their generally positive attitude towards the need to include them in teaching, they express multiple concerns that may stand in the way of implementing SSI planning in the classroom, such as: the position of personal values and their impact on students' values about SSI, lack of relevant educational materials, lack of time to plan and prepare materials, uncertainty about how to

conduct discussions on sensitive issues, and difficulties related to the evaluation of student performance in relation to issues with moral dimensions (Borgerding & Dagistan, 2018; Chen & Xiao, 2021; Kara, 2012; Lee et al., 2006; Tidemand & Nielsen, 2016).

Research in Greece considering teaching SSI mostly focuses on secondary education and investigates students rather than teachers (Georgiou, 2024), concerning their engagement, argumentation skills, etc. (Georgiou et al., 2020). Kokolaki and Stavrou (2022) asked pre-service teachers to create teaching materials (PPTs) to teach SSI and analyzed the findings that teachers chose to focus on the scientific content and ethical aspects of their themes, rather than on the social aspects of science.

2.2 Research Questions

Recognizing, therefore, the importance of teaching SSI in the modern school, but also the obstacles highlighted above, in this research, we will attempt to investigate the views of undergraduate students of Pedagogical Departments of Primary Education as well as in-service elementary school teachers on the processing of SSI in the classroom. More specifically, we focus on the following five (5) research questions:

1. Are the pre-service and in-service elementary teachers that take part in this survey informed about the nature of socio-scientific issues (SSI)?
2. Are they willing to integrate SSI into their classroom teaching?
3. What do they consider to be the potential benefits of teaching with SSI?
4. What do they consider to be the potential disadvantages of teaching SSI?
5. What obstacles do they anticipate encountering when integrating SSI into their classroom practices?

3. METHODOLOGY

3.1 Research Strategy

The use of qualitative data collection methods is deemed appropriate to explore the perspectives of teachers and students participating in this study (Cypress, 2015).

3.2 Research Tool

The semi-structured interview process is the research tool for conducting this qualitative, exploratory study as it allows deeper extraction of information while investigating complex social processes and behaviors, motivations, emotions, attitudes, values, and perceptions (Breakwell et al., 2006). The duration of each interview was approximately 30 minutes.

3.2.1 Main Questions Used:

1. Can you describe your understanding of socio-scientific issues (SSI)?
2. How have you encountered SSI in your education or professional practice?
3. Are you willing to integrate SSI into your teaching? Why or why not?

4. What factors influence your decision to use SSI in your classroom?
5. What do you believe are the potential benefits of teaching with SSI?
6. How do you think SSI can impact students' learning and engagement?
7. What do you perceive as the potential disadvantages of teaching with SSI?
8. Have you faced any challenges when trying to teach SSI?
9. What obstacles do you think you might encounter if you want to integrate SSI into your teaching?
10. How do you think these obstacles could be overcome?

3.3 Sample

This study employed convenience sampling (Bryman, 2016). The sample (N=12) consists of 6 pre-service teachers, students of the Department of Pedagogy and Primary Education of the University of Athens (NKUA) and 6 in-service elementary school teachers.

Pre-service teachers sample: The student sample includes 2 males and 4 females. Three students are in their 2nd year, one in the 3rd year, one in the 5th year, and one in the 6th year. Four of the interviewed students are familiar with the natural sciences, while two are not.

In-service teachers sample: The teacher sample includes 1 male and 5 females. Two teachers are between 20-29 years old, three are between 30-39 years old, and one is over 40 years old. Two teachers have less than 2 years of teaching experience, two have 5-6 years of experience, and two have more than 10 years of experience. Three of the interviewed teachers have completed postgraduate studies, one is currently pursuing a postgraduate program, and two have not completed any postgraduate or doctoral studies.

3.4 Data Analysis

Data analysis in qualitative research can be approached using either the deductive method or the inductive method. The inductive method was employed in this study, as it is more commonly utilized than the deductive method in qualitative data analysis (Galanis, 2018; Tsiolis, 2011).

The twelve (12) interviews were transcribed and divided into two (2) groups: "pre-service teachers" and "in-service teachers," with six (6) interviews corresponding to each category. Each group of interviews was then independently processed by two (2) coders (authors of this paper). The four (4) research questions posed in the introduction served as a guide for coding, leading to the establishment of the following emerging categories based on the responses provided by the participants during the semi-structured interviews:

1. Knowledge regarding the nature of SSI
2. Willingness to implement SSI-based teaching in the classroom
3. Factors/Barriers affecting the implementation of SSI-based teaching in the classroom
4. Benefits of implementing SSI-based teaching in the classroom

The coders then started categorizing their data in the above categories. In each group of data (pre-service teachers and in-service teachers) a high degree of agreement was reached between the two coders (>96%). Any differences between coders were mainly focused on the extract of the text that should be included in each code and not on the kind of code itself.

Subsequently, the data categorization from the two researchers for each group of interviews was consolidated into a final text by another author so, finally, data from all interviews corresponding to each of the above sections were compiled into a new file.

4. RESULTS

4.1 Knowledge concerning the Nature of SSI

4.1.1 Pre-service teachers

From the content analysis of the interview data concerning pre-service teachers, it was found that four (4) out of six (6) are not adequately informed about the nature of SSIs, as they express uncertainty regarding its definition (Table 1). Of the participants, only two pre-service teachers attribute their familiarity with the term SSI to brief discussions during their secondary education (in high school) and at university; the remaining four have not encountered SSI within their studies. One pre-service teacher notes that there are related courses in their department, but they have not yet covered these topics. Despite the lack of information, four out of six participants appropriately describe SSI as issues related to society and science (Table 1). When asked for examples of SSI, four (4) students mentioned COVID-19 vaccines as an example, as it is an issue that has intensely concerned society, especially very recently. One out of six (6) students claim they cannot think of any example of SSI, while another one mentions examples that concern society solely and do not connect with science.

4.1.2 In-service teachers

Similar finding came out of the analysis of the data concerning in-service teachers. Three out of six in-service teachers are not sufficiently informed about the nature of SSI, as they express uncertainty regarding the definition. Conversely, three out of six teachers are familiar with the term SSIs. Nevertheless, all six teachers appropriately define SSIs as issues related to both society and science.

Regarding examples of SSIs, four out of six teachers could provide relevant examples, with most citing COVID-19 vaccines. One could not provide an appropriate example, and one mentioned examples that relate solely to societal issues without linking them to science.

4.2 Willingness to address SSI

4.2.1 Pre-service teachers

Focusing on the willingness to address SSI, the data analysis showed a high willingness among students to teach through SSIs, as all interviewees responded that they would choose this method of teaching. However, five (5) of the six (6) students stated that they would choose this approach for upper grades. Moreover, one of them considers that this type of teaching is suitable exclusively for secondary education classes.

Additionally, two (2) of the interviewees mentioned low self-confidence regarding their cognitive competence on SSI as a deterrent to their willingness to address them in class.

However, both stated that they believe they will acquire this knowledge during their studies and will manage to cope with it.

Other factors highlighted as crucial for their decision to teach through SSI included their personal interest and the interest of the students, the timeliness, and the accessibility of each SSI, the attitude of colleagues, and references in textbooks. (Table 1). Finally, it appeared that the majority were not concerned about a topic being controversial, as everyone except one stated that they would be willing to address even controversial issues in class.

Table 1- Indicative answers of the pre-service teachers corresponding to the theme-categories “Knowledge and Willingness” that emerged from the interviews’ analyses

Themes	Examples
Definition	<i>I have heard the term, but as a term, I don't know what exactly it means.</i>
“	<i>An issue, a problem, a condition that concerns society, the sciences, something for which we need to find a solution.</i>
“	<i>I don't know, science in... and well, practically, practically in society, I don't know.</i>
“	<i>Something that concerns what happens in society in combination with the sciences.</i>
“	<i>Issues concerning society and the social whole (?)</i>
Willingness – upper grades	<i>I think it's in the older grades, third, fourth, fifth, sixth, where children start to think, to wonder, to ask why this exists.</i>
“	<i>Okay, maybe not in the first grades for some topics, depending on the topic and again, but certainly from fourth grade onwards for many things. Anyway, children are looking for things themselves and listening to their parents, and of course, things like vaccines, children are aware of and have discussed and have questions about...</i>
Willingness - confidence	<i>At the moment, I don't have the cognitive background. I hope that as time goes by and through the school when I finish and with the master's degree I would like to do. I imagine that the first thing would be what other colleagues would do, whether I saw this within the school or in some group I would be in, in the media. I imagine that would be the first thing, and secondly, any textbook if it allows us to have material to talk about it (...). I would choose teaching through socio-scientific issues if it were something manageable for the children and I found something interesting.”</i>
Willingness – interest	<i>I would choose it if I found an interesting topic, so timely, maybe yes.</i>
Willingness - controversial	<i>Yes, why not? I would be. In elementary school, one reason more, it's a bit easier to bring it into the classroom.</i>
“	<i>Yes, always without offending anyone, without touching on anything, anyone badly.</i>

4.2.2 In-service teachers

Only two of the interviewees have previously addressed SSI in the classroom. Yet, they all expressed willingness to incorporate SSI into their teaching. Two indicated they would choose this method for older students, while three would apply it across all grades. Notably, one teacher considers primary education to be the most suitable stage for addressing SSIs, as it is not characterized by the intensified focus on exams seen in higher grades.

Four out of six teachers cited their confidence in their cognitive competence regarding the subject matter as a decisive factor affecting their willingness to engage with SSIs. “The only factor that discourages me and makes me not do it is my own lack of knowledge about these

issues. (...) But it's not about intelligence or not. I believe that if I sit down to work on an SSI, if someone helps me and explains it, I could definitely do it".

Other factors affecting the teacher's choice to address SSI in the classroom include personal interest from both the teacher and the students, the accessibility and relevance of the topic for the students, the social context, the socio-economic status of the students, the location of the school, and the cultural heritage of the area.

Regarding their willingness to address controversial issues, four teachers responded positively, emphasizing the necessity of discussing such issues in school as students encounter them in their daily lives. One teacher stated that, despite a general willingness to address sensitive issues, they would consider the classroom climate and assess the maturity of the class before addressing such topics. Moreover, one teacher expressed reluctance to address highly controversial issues, believing it is better to avoid disagreements in the classroom because primary school students are not yet ready to handle them. "Children are heavily influenced by their parents, their home environment, and I prefer more neutral responses. I don't want disagreements. Not that it's not normal, but let's start by looking at only the positive side of, for example, nanotechnology, and as they grow older, they'll see other perspectives. They're not ready yet".

As for the incorporation of SSIs into science lessons, one teacher showed more willingness to address social issues through other subjects (such as History) rather than through the sciences. Teachers predominantly refer to the humanities when asked for examples of implementing SSI teaching in the classroom. "While with social issues, we cover them in scientific contexts, we somewhat lose it... for example, we say that this is a way to teach other issues (purely social issues, gender issues, issues related to politics). For these, I follow this pattern: presenting the issue, discussing pros and cons, and analyzing it. It hasn't happened that the issue has been socio-scientific so far".

4.3 Recognized Pedagogical Value of SSI-based teaching

When asked whether teaching through SSI presents pedagogical benefits and whether it helps to promote additional skills compared to traditional teaching, all students and teachers who participated in this research responded positively. The skills mentioned can be divided into seven (7) categories (see Chart 1).

4.3.1 Pre-service teachers

Regarding the pre-service teachers who participated in this research, when asked to mention some of the skills that could potentially be developed through SSI-based teaching, three (3) out of six (6) referred to the importance of exposing students to a variety of perspectives on a topic. Four (4) out of six (6) pre-service teachers emphasize the contribution of SSI processing to developing skills in critical information processing and problem-solving, fostering critical thinking. Furthermore, three (3) pre-service teachers considered engaging children in argumentation processes as a benefit of SSI processing in the classroom, with one (1) of them also mentioned the impact of developing such skills on students' self-confidence. The development of collaboration and teamwork skills also appears to be an additional benefit of SSI processing, according to two (2) participants. However, three (3) students used language that possibly portrays the student as a passive receiver of information rather than an active

participant in dialogical processes. Additionally, four (4) students referred to the broader acquisition of knowledge about the respective issues that can be processed as a benefit of teaching through SSIs. Finally, five (5) out of six (6) students consider the awareness of students and the connection between school and society as a significant benefit of teaching through SSIs, e.g. "it's more important for the child to understand that school is also connected to the outside world, it's not just something like formulas and facts in history and that's it".

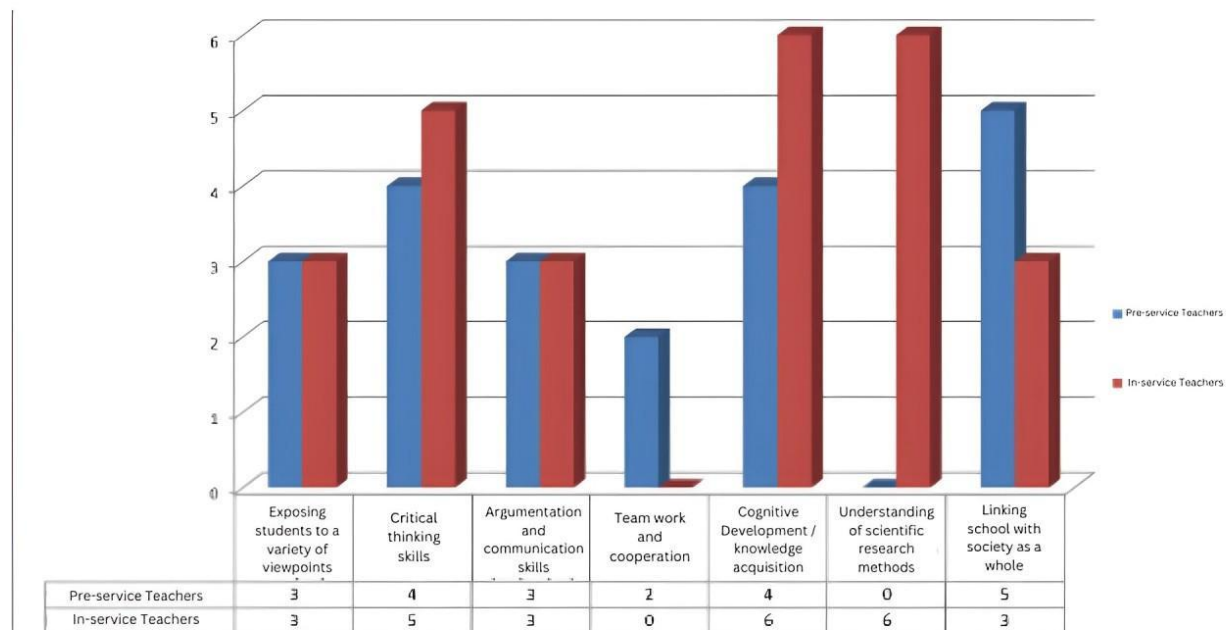


Chart 1 Categories of skills

4.3.2 In-service teachers

Regarding the skills that in-service teachers believe are enhanced through teaching using SSI, almost all participants (five out of six) refer to the development of critical thinking and information processing skills. Three out of six teachers recognize exposing students to various viewpoints on an issue as an important advantage of teaching through SSIs. Three out of six mentioned the connection between school and society as an important advantage of this type of teaching. All teachers who participated in the present study recognize that an important benefit of teaching through SSIs is not only the general acquisition of knowledge on the given topic but also the understanding of the research and methodology that experts in the relevant field follow. Finally, three out of six participants seem to view the student as a passive recipient of information, and did not mention the student as an active participant in dialogue and argumentation processes during the teaching process. Nevertheless, three out of six respondents briefly mentioned the development of communication skills and argumentation skills as a goal that can be pursued through SSI teaching. Of those, two mentioned the development of collaboration skills as a result of SSI teaching.

4.4 Factors Hindering the Choice of Teaching through SSI-based teaching

Despite the benefits recognized by all the participants in teaching through SSIs, several factors were identified as potential barriers to the adoption of this method both by pre- and in-service teachers. Analysis of the data reveals that the cognitive competence of the teacher regarding SSI emerges as the most significant obstacle that all pre-service and most in-service teachers believe they will face when teaching through SSIs (Table 3). Additionally, two (2) of the six (6) pre-service teachers and three of the in-service teachers mentioned that there is no framework for teacher training on these issues, and thus, they rely solely on self-education to increase their knowledge. The majority of participants (four out of six pre- and three out of six in-) consider the characteristics of the students themselves—such as their social context, cognitive level, and interest—as a decisive factor for choosing whether or not to teach through SSIs. Three out of six of the pre- and four out of six of the in- service teachers identify the potential reactions from the educational community (parents, other teachers, principals) or the broader society as a significant obstacle to teaching through SSIs. Two (2) participants of the pre- and three of the in- service teachers expressed concern that due to the controversial nature of these issues, there is a risk of creating tension within the classroom and disrupting the balance. Two (2) of each group expressed concern about the availability of supportive educational materials for SSIs and the need for alignment with the curriculum. Finally, two of the in-service teachers mentioned the lack of teaching time as a barrier to trying to implement this type of teaching.

Table 2- Indicative answers of the pre- and in-service teachers corresponding to the “Barriers affecting the processing of SSI in the classroom” that emerged from the interviews’ analyses

Themes	Frequency among pre-service (N=6)	Frequency among in-service (N=6)	Examples from pre- and in- service teachers
Teachers’ cognitive competence	6	5	-I would hesitate due to knowledge concerns because I don’t want to offer a solution to the children that might not be the appropriate one, given that we’re discussing sensitive topics. (pre) -I think it would be easier if it were closer to my interests so that I would feel more comfortable with the topic. That is, to be able to sit down and study it and believe that I am more competent to analyze it. (in)
No relevant training	2	3	-Because they definitely don’t teach us much at school or at the university later on regarding such issues. So, I think a bit of self-research is needed. (pre) -I don’t feel sufficiently prepared because the knowledge I have comes from individual research and study. (in)
Students’ background	4	3	-... you know how I judge the class, whether they can discuss an issue or not. (pre) - The social environment, the social surroundings, in my opinion... the children’s social starting point, so to speak, plays a huge role in their interests as well as the level of each class. (in)
Community reactions	3	4	- Children have not yet fully formed their character and stable views, and there might be reactions from parents and other teachers, so I think the children are not ready for this (pre)

Themes	Frequency among pre- service (N=6)	Frequency among in- service (N=6)	Examples from pre- and in- service teachers
Disruption of balance	2	3	<i>-For some of these issues specifically, I would find parental opposition. (in) / -... there is no framework for protecting the teacher. (in)</i> <i>-If I know that there are people who will disagree or agree, it will also affect the situation (pre)</i> <i>-To avoid certain disagreements, I would suggest making it more neutral (in)</i>
Supportive material / Curriculum	2	2	<i>-And secondly, whether there is a handbook or material provided for us to discuss these issues (pre)</i> <i>- if it is referenced in some school textbook, so that we can take the cue from there and start analyzing it as part of the lesson (in)</i>
Lack of time	-	2	<i>-Another difficulty I would naturally face is teaching time. Teachers' schedules are very tight, the curriculum is enormous. So, often even though we want to, we cannot find the time ourselves to deal with such issues.</i>

5. DISCUSSION

In this research, most of the pre-service and all the in-service teachers could adequately define SSI, and most could give some examples of SSI. Yet most of them claimed that they feel uncertain about the nature of SSI, and they declare that they have never been officially taught about them. This finding aligns with the research by Tidemand & Nielsen (2016), which concludes that teachers' understanding of SSIs is not ideal, and there are misconceptions about the content knowledge of SSIs (Bing and Enshan, 2021). Interestingly, most participants used COVID-19 as an example of an SSI. The recent context of COVID-19 and its management have highlighted the connections between science and society (Pietrocola et al., 2021).

Given that SSIs are based on controversial topics, teachers need to anticipate potential sources of conflict and address them using suitable pedagogical principles and skills (McCully, Smyth, & O'Doherty, 1999). Educators may strive to present a balanced view of each SSI (Oulton, Dillon, & Grace, 2004), which involves acknowledging multiple perspectives on the issue at hand. However, this stance affects the teacher-student relationship. Alternatively, a teacher might provide students with conflicting views on the specific SSI each time and also share their own opinion, clarifying that it does not mean it is the correct one (Oulton, Dillon, & Grace, 2004). In this study, however, one pre-service teacher, when explaining the definition of SSI, noted the view that these are issues that require a solution, "an answer." Therefore, there is a potential false perception that there is a "correct" answer to these issues.

Focusing on the willingness to address SSI, the data analysis showed a high willingness among pre-service and in-service teachers to teach through SSIs, as all interviewed responded that they would choose this teaching method. Similar results have been shown in previous studies with both pre-service teachers (Alaçam, 2011) and in-service teachers (Sadler, 2006). However, the vast majority of participants stated that they would choose to teach through SSIs for the higher grades of primary education or exclusively in secondary education, as opposed to the lower grades. Their reasoning for this stance is based on the belief that younger students

have not yet developed the capacity to reflect and think about complex issues and their insufficient exposure to such issues in an extracurricular context (e.g., discussions with parents, media exposure, etc.) The dependence of pre-service teachers' willingness to teach SSI on the maturity of students has also been confirmed by the research of Özden (2015). According to the literature in-service teachers as well believe that younger students do not have the maturity to handle discussions about SSIs (Kinskey & Zeidler, 2021; Borgerding & Dagistan, 2018).

Some of the interviewed teachers expressed their concern about whether they are adequate to teach SSI, and they claimed that they should study hard individually to prepare for each issue. Similar concerns about a sense of cognitive inadequacy were noted in the research of Sibic and Topcu (2020). Similar findings regarding the lack of confidence in cognitive competence among teachers concerning SSI teaching are reported by Bryce & Gray (2004). Building this confidence includes specialized training on SSIs, modifications to the curriculum to include more references to SSIs, and continuous self-improvement and openness to students' perspectives.

Many factors affect their choice to address SSI in the classroom, including personal interest, which has also been noted by Michaelidis & Stavrou (2016), the accessibility and relevance of the topic for the students, the social context, the socio-economic status of the students, the location of the school, and the cultural heritage of the area.

There are plenty of pedagogical benefits when SSI are approached. In our research the following emerged, and they are in accordance with the literature: 1. exposing students to a variety of perspectives on a topic (Seow & Ho, 2016; Espeja & Lagarón, 2015), 2. critical thinking competencies and navigating complex ethical terrains (Seow & Ho, 2016; Espeja & Lagarón, 2015; Zeidler & Nichols, 2009; Sadler et al., 2006), 3. argumentation process and debating skills (Kara, 2012), 4. cooperation, 5. acquiring scientific knowledge (Sadler et al., 2007; Bulte et al., 2006), 6. understanding scientific processes and Nature of Science (Ekborg et al., 2013), 7. connecting of the school with the society and applying science understanding in real life situations (Barrue & Able, 2013; Kara, 2012).

However, in agreement with other literature findings of Pitipornatapin, Yutakom & Sadler (2016) and Kilinc et al. (2017) we detect a gap between teachers' beliefs and their expectations. In the literature, teachers seemed to use SSIs mainly in the introductory part of their teaching plans and the role of the student in teaching was limited. Similarly, half of our pre-service and half of our in-service teachers used language that possibly portrays the student as a passive receiver of information rather than an active participant in dialogical processes.

While our findings question the assumption that teachers do not want to adapt their curricula to address more current issues (Leung, 2022), our research also sheds light on the obstacles teachers confront when they wish to teach SSI. First comes their cognitive competence and lack of relevant training. This is expected for university students who are in contact with their professional field for the first time and do not yet feel adequately prepared for it (Sibic & Topcu, 2020). Nevertheless, we acknowledge their confidence that they can handle SSIs after their studies. However, in-service teachers also mentioned the feeling of inadequacy of their knowledge as a deterrent to choosing SSI-based teaching even when they address controversial social issues in their teaching. This may be because a gap has been created between the natural and social sciences, so connecting them requires further

investigation and work by teachers to reveal these connections and create a more dialogic relationship between science, technology, and its development (Pietrocola et al., 2021).

Another factor mentioned as a barrier is concern about the potential reactions of the directly related social group to such teaching, especially when the issues addressed are particularly controversial. Specifically, concerns were raised about parents and other teachers. This is confirmed by the research of Cai & Tang (2021), which shows that the sense of community and collective engagement with new educational methods among teachers motivates each teacher who is part of this to adopt similar teaching methods.

Additionally, there was a fear of creating a tense atmosphere in the classroom during such teaching when students had different views on the issue at hand, which has also been reported by Borgering (2018). In contrast to research that highlights the lack of teaching time as a significant deterrent (Kara, 2012; Lee et al. 2006; Tidemand & Nielsen, 2016), only two respondents, both in-service teachers, mentioned it.

Additional factors are the students' background, lack of supportive material and connection with the curriculum. These barriers highlight teachers' challenges in implementing SSI-based teaching and suggest areas where additional support and resources may be necessary. Teachers can be trained and empowered to manage all the issues mentioned above.

Teachers seem to believe that younger students lack the maturity to engage in discussions about SSIs. This perspective may undervalue the capabilities of younger students and overlook the fact that SSIs are relevant to people's everyday lives, regardless of age. Additionally, responses regarding the approach to SSIs in the classroom suggest an attitude that underestimates the active role of students in the teaching process, primarily relying on a teacher-centered model. Specifically, half of the participants seemed to view SSIs as issues that they would explain to the students, thereby reducing them to passive receivers of information rather than as members of society capable of forming views and discussing them in class.

In conclusion, the findings of this study lead us to agree with the conclusion of Sadler et al. (2006), which emphasizes that promoting the processing of SSIs in the classroom requires resources and training programs specifically aimed at this goal. Specifically, we believe that programs need to be developed, implemented, and evaluated that promote connections between ethics and science, assist current and prospective teachers in addressing the challenges presented above, and provide high-quality resources for the conduct of teaching.

6. CONCLUSION

The findings of this study indicate that many pre-service and in-service teachers possess a basic understanding of SSIs but often lack confidence in their knowledge and training to effectively teach these topics. It is important to acknowledge that the small sample size (N=12) restricts the breadth of the study's conclusions and may limit the diversity of perspectives gathered. While the teachers in this study recognize the significance of using SSIs in their teaching, particularly for older students, there is a concern regarding the maturity of younger learners, which may diminish their engagement with these issues. Additionally, barriers such as feelings of inadequacy and apprehension about community reactions impede the incorporation of SSIs into the classroom. To overcome these challenges, it is vital to implement

comprehensive professional development initiatives that enhance educators' skills and empower them to facilitate dynamic discussions on SSIs, thereby bridging the gap between scientific knowledge and real-world applications in education.

7. IMPLICATIONS

The small sample size (N=12) could impact the generalizability of the findings, emphasizing the necessity for additional research involving larger populations. However, this study highlights the need for targeted professional development programs to support teachers in effectively implementing SSIs in their teaching. It underscores the importance of integrating SSIs into curricula across various educational levels and providing high-quality resources to facilitate this integration. Building supportive teacher networks and addressing student teachers' concerns about their preparedness for SSI-based teaching are also crucial. These measures will help enhance critical thinking and ethical reasoning among students, ultimately improving their engagement with real-world issues.

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