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Identifying Pre- and In-service Teachers' Stances on Teaching Socioscientific Issues: A Systematic Review of Empirical Studies

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Abstract There is a prevalent consensus among science education scholars that teaching socioscientific issues (SSI) has notable importance for promoting functional scientific literacy and raising responsible citizens. However, teachers encounter numerous problems when teaching SSI, so they may not prefer to teach them. Today, we still do not know many specific particulars about how teachers' own opinions, beliefs, or experiences influence the way in which they present controversies and which teacher's role is best suited for teaching SSI. This paper aims to review the empirical studies that include teachers' stances during teaching SSI and, if stated, their rationales about preferred stances. We employed the Web of Science and Education Resources Information Center (ERIC) databases and Google Scholar to find the relevant literature. Then, we independently screened the titles, abstracts, and full texts of the selected studies for eligibility. Based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement checklist, eighteen empirical studies were included in this review. Three main profiles of teachers' positions while addressing SSI were identified: excluders, neutrals, and disclosers. Two subprofiles were identified for both neutrals and disclosers. Neutral teaching was found to be the most adopted and preferred teacher position for introducing SSI. It was followed by the avoidance of SSI teaching because the teachers viewed value-free education as important. Teachers' own opinions, beliefs, epistemological orientations, concerns of indoctrination, and external factors were reported as the main underlying reasons for their preferred positions. Obviously, the studies conducted with in-service teachers yielded different reasoning patterns for their neutrality. We concluded that, given the pedagogical and epistemological challenges of teaching SSI, more research on teachers' positions in addressing SSI in science classrooms is needed.

Résumé Les universitaires du domaine de l'enseignement des sciences s'accordent de plus en plus à dire que l'enseignement des enjeux socioscientifiques (ESS) revêt une importance considérable pour la

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promotion d'une littératie scientifique fonctionnelle et la formation de citoyens responsables. Toutefois, les enseignants se heurtent à de nombreux problèmes lorsqu'ils enseignent les ESS, ce qui fait qu'ils peuvent préférer s'abstenir de les enseigner. Nous n'en savons toujours pas beaucoup encore aujourd'hui en ce qui concerne l'influence qu'exercent les opinions, les croyances ou les expériences des enseignants sur la manière dont ceux-ci présentent les controverses et au sujet du rôle le mieux adapté à l'enseignement des ESS. Dans cet article, notre objectif est de passer en revue les études empiriques qui traitent des attitudes des enseignants lorsqu'ils abordent les ESS en classe et, lorsque cela est énoncé, de découvrir les raisons pour lesquelles ils adoptent ces attitudes. Nous avons utilisé les bases de données de « Web of Science» et du fichier du Centre d'information de ressources pédagogiques (ERIC) ainsi que « Google Scholar» pour trouver la documentation pertinente. Nous avons ensuite vérifié de manière indépendante l'admissibilité des titres, des résumés et des textes complets des études choisies. Sur la base de la liste de contrôle de la déclaration PRISMA (« Preferred Reporting Items for Systematic Reviews and Meta-Analyses»), on a sélectionné dix-huit études empiriques pour cette analyse. On a identifié trois profils principaux d'attitudes enseignantes en ce qui a trait aux ESS: les excluants, les neutres et les divulgateurs. En ce qui concerne les deux derniers profils, on a distingué deux sous-profils. L'enseignement neutre s'est avéré être l'attitude la plus adoptée et celle privilégiée par les enseignants pour initier les élèves aux ESS. Suit ensuite l'évitement de l'enseignement des ESS, car les enseignants considèrent qu'il est important d'offrir une éducation qui est dénuée de valeurs. Les opinions, les croyances, les orientations épistémologiques, les préoccupations en matière d'endoctrinement et les facteurs externes ont été signalés par les enseignants comme étant les principales raisons sous-jacentes de leurs attitudes favorites. De toute évidence, les études menées auprès d'enseignants en exercice ont donné lieu à des modèles de raisonnement différents pour expliquer leur neutralité. Nous avons conclu qu'en raison des défis pédagogiques et épistémologiques associés à l'enseignement des ESS, il est nécessaire de mener davantage de recherches sur les attitudes des enseignants à l'égard des ESS dans les classes de sciences.

Keywords Socioscientific issues · Systematic review · Teachers' stances · Neutrality

Introduction

Socioscientific issues (SSI) are "complex and contentious societal issues with substantive connections to science ideas and principles" (Sadler et al., 2017, p. 75). Such issues represent a challenge for society; they provoke debate and even conflict and are often the subject of media coverage. Although all SSI involve scientific elements, each issue is singular and depends on the social and cultural context (Zeidler et al., 2019), as the social actors involved, the knowledge or values at stake, the degree of uncertainty, and the mediatization are all different. Some issues can be controversial in both scientific communities and social groups; these include controversies surrounding technological development (Genetically Modified Foods, 5G, etc.) or land-use planning (e.g., local solutions for adapting to climate change). Other issues are especially controversial in society and involves question about the boundaries between scientific knowledge and beliefs; examples include some social and political debates associated with vaccination against COVID-19 or the theory of evolution.

Given the increasing number of SSI, developing a scientific, humanist, and political culture is considered an important challenge for the development of modern societies (Bencze et al., 2020; Zeidler & Sadler, 2023). Reasoned decision-making, argumentation, evaluation of information, socioscientific reasoning, moral reasoning, and complex and critical thinking are just some of the objectives targeted by SSI education (Bencze et al., 2020; Zeidler et al., 2019).

However, few teachers teach SSI (Ekborg et al., 2013; Sadler et al., 2006; Sund, 2016), as they face a variety of problems while adopting SSI in their classrooms. These challenges were reported in the Chen and Xiao's (2021) review at five levels: teacher, student, school, community, and policy. The most significant obstacles are found at the teacher level and include insufficient content knowledge, deficiency in instructional capabilities, feelings of insecurity, and a lack of personal motivation to introduce SSI. Indeed, uncertainty, the interdisciplinary nature of knowledge (at the intersection of science, social science, and the humanities) and the inherent values of SSI distract teachers from their areas of expertise, which derive from their mastery of disciplinary knowledge (Pedretti et al., 2008). In addition, SSI teaching promotes pedagogies such as discussion, debate, controversy mapping, or empirical inquiry with stakeholders impacted by SSI, which are student-centered pedagogies that teachers rarely practice (Bossér et al., 2015; Pedretti et al., 2008; Saunders & Rennie, 2013). Enabling students to express an opinion or an emotion and helping them formulate moral reasoning is achieved within a pedagogical framework designed for this purpose, which moves away from the traditional format of transmitting scientific knowledge. Addressing issues that often have a political dimension in the classroom can also require teachers to commit to go beyond the simple transmission of knowledge and explicitly promote values of social transformation and the emancipation of students (Bencze et al., 2020). Teachers may then be in a state of tension, not knowing which position to adopt, whether in expressing their own opinion (the 'disclosure dilemma' according to Journell, 2011) or in deciding which part to include in their commitment between remaining neutral and impartial and advocating a particular point of view.

No best practice for teachers' positions concerning teaching controversies has been acknowledged, and teachers do not take any positions in a systematic and planned way; however, broadly speaking, neutrality is evaluated as the most morally appropriate teacher behavior (Journell, 2013; Oulton et al., 2004). Some scholars advocate teacher neutrality (e.g., Stenhouse, 1983) on the grounds that the nonappearance of objectivity resembles endeavours of indoctrination (Journell, 2016). In the context of teaching controversial issues (CI), research mentions different roles apart from neutrality that teachers assume, and different terminologies with similar meanings are used to describe teachers' positions (Table 1).

Stradling (1984) asserted that there could be restrictions in teaching CI that arise from a teacher's own perceptions or personality, the school structure and organization, students' expectations or beliefs, external pressures (such as school senior management, family, or local structures), and the issue itself. Depending on these factors, teachers can adopt a role such as objectivity by *sticking to the facts*, *balanced teaching*, *devil's advocate*, *neutrality*, and *committed approach*. Similarly, Kelly (1986) proposed four theoretical categories of teachers' roles during the discussion of controversial issues: *exclusive neutrality*, *exclusive partiality*, *neutral impartiality*, and *committed impartiality*. He used the term neutral impartiality, in which teachers provide a 'fair hearing' while withholding their own beliefs and ideas. This can be achieved by using the strategy of devil's advocate to ensure that all ideas are presented equally. According to Kelly, teachers may adopt this stance for several reasons: (1) teachers are engaged in public service and have the merits of "being industrious, obedient, disinterested, unambitious and

Table 1 Teachers' roles in the literature

Authors	Teachers' roles
Stradling (1984)	Stick to the facts, neutral chairperson, balanced, devil's advocate, commitment approach
Kelly (1986)	Exclusive neutrality, exclusive partiality, neutral impartiality, committed impartiality

intelligently loyal" (p. 122); (2) a school, in the pluralistic view, is an essential platform for the presentation of miscellaneous values, and teachers must adopt the role of impartial arbiters to promote fair competition among the ideas that come up in the classroom; (3) remaining silent protects from accusations and conflicts that threaten job security; (4) teachers may internalize 'ethical relativist' perceptions that no one value is superior; (5) teachers may have ambivalent views about the issue itself; (6) teachers may limit sharing their personal ideas to create an equitable and stable classroom; and (7) teachers may have 'rationalist perspectives' with the goal of allowing students to resolve possible value assertions for building up their own positions by avoiding a moral absolutist position. Although teachers have justified their reasons for thinking in these ways, Kelly privileged the 'committed impartiality', in which teachers can disclose their own opinions without trying to persuade their students but encourage them to discuss competing viewpoints to discover their own opinions, as the most tenable teacher role to adopt. While these two categorizations are still vital because they provide the basis for some studies about teachers' positions, there are questions as to whether they are sufficient to explain teachers' positions in practice. In this paper, we attempted to provide an overview of various preferences and interpretations of teachers' stances on addressing SSI and the underlying reasons for these stances. We started this study with the question "What are the main approaches, debates, and concerns with respect to science teachers' stances on teaching SSI?", and we developed four research questions to better understand the researchers' approaches and teachers' stances:

(a) What are the main objectives, the sample of interests, and research methods of the studies presenting teachers' stances on teaching SSI?
(b) On what grounds did the studies approach the issues related to teachers' stances?
(c) How did the pre- and in-service teachers' stances vary in the context of addressing SSI?
(d) What are the main factors that affect teachers' stances?

Method

In this review, we followed the PRISMA guidelines (Page et al., 2021) when compiling studies to ensure unbiased data collection and interpretation (Fig. 1). This section describes our method in detail.

Search Strategy and Selection of Studies

We conducted a series of searches, like a pilot search, to decide the best way of selecting key search terms. When we ran very specified terms such as 'teacher position' OR 'teacher role' 'disclos*' OR 'neutral*' OR 'impartial*' AND 'teacher', we could find fewer than five articles. We therefore decided to use broader search terms so that we did not miss any study providing evidence for our review. We searched by the key search terms 'teacher' AND 'socio-scientific issue' OR 'socioscientific issue' in the field of abstract and title. We performed the final database search on the twentieth of October 2021 by using the Education Resources Information Center (ERIC) and Web of Science (WoS) journal databases to determine relevant papers. We did not set any appraisal criteria but only included studies published in peer-reviewed journals. We used Google Scholar during the whole process for backward searching and gray literature. We performed two different searches for the WoS and ERIC databases and then eliminated duplicate articles. Then, we screened titles and abstracts by hand and selected the related articles. We searched the *gray* literature deeply, checked the reference lists of relevant articles, and then searched in the articles by using the CTRL + F function with the keywords of 'neutral', 'impartial', 'disclosure', 'teacher's position' (or role), and 'objectivity' to avoid any data loss. Any date restriction was defined to examine as many studies as possible and to observe the alteration over time. In short, we

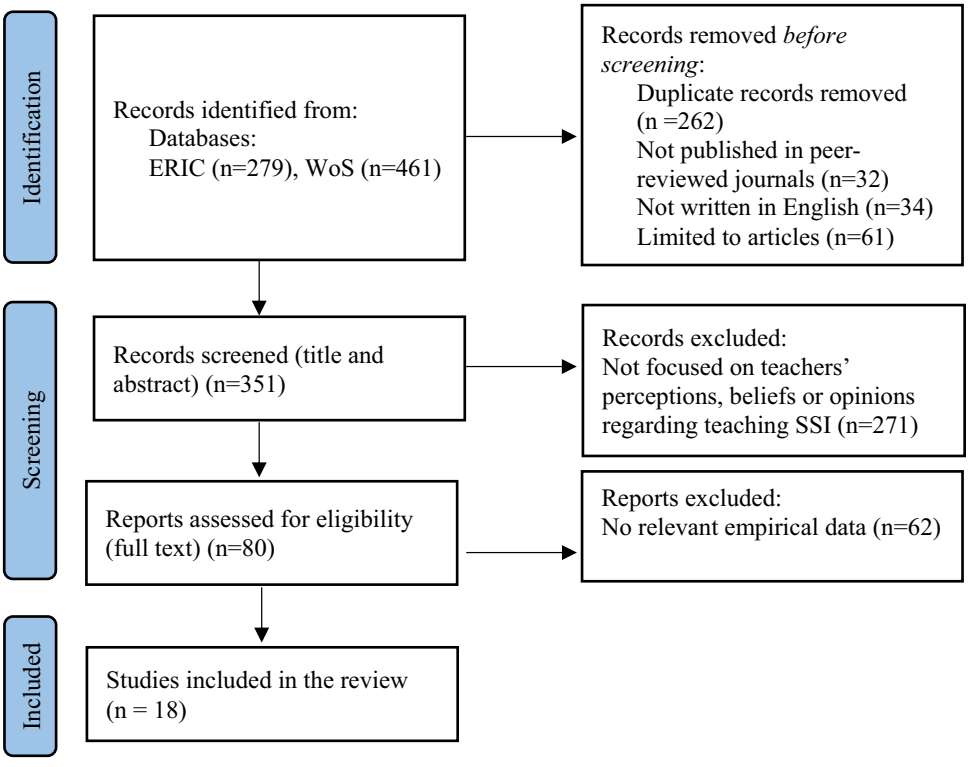

Fig. 1 PRISMA review process

applied three criteria as follows: (1) be published in peer-reviewed journals, (2) be written in English, and (3) involve teachers' stances on a detailed or superficial way in the results or discussion section.

We found 279 records from ERIC and 461 records from WoS. Studies were eliminated if they were not published in peer-reviewed journals ($n = 32$), not written in English ($n = 34$), not in the article category ($n = 61$), or duplicates ($n = 262$). We screened records from the abstract and title and removed studies that were not focused on teachers' perceptions, beliefs, or opinions regarding teaching SSI and conducted with the students ($n = 198$). The full texts of the remaining 80 articles were read by the two authors independently to assess their eligibility, and eighteen articles were ultimately included.

Analysis Framework

We extracted two types of data from primary research reports: characteristics of the studies and findings regarding teachers' positions. First, the first author extracted the following essential information from each article: detailed information about participants, objectives of the study, research method, and country of the study, as listed in Table 2. Then, two authors separately read all the articles, highlighted the evidence regarding teachers' stances, and revealed preexisting themes made by the authors, if any. For example, in the study of Lee et al. (2006), "… these teachers avoided SSI because they wanted to remain 'neutral' on these issues" or "… interview questions indicated that many teachers perceived scientific knowledge 'proper' to be value-free and more or less clear-cut" (p. 110). Alternatively, "Alice approaches evolution from an advocacy standpoint and does not permit students to discuss the extent to which their religious beliefs may impact their understanding of evolution" (Hermann, 2013, p. 609). After highlighting such quotes in the articles, we performed a detailed analysis and revealed emerging

Table 2 Summary of study characteristics

Reference of the study	Number of participants by level of education					Research method of the study	Country of the study	Subject of the study
	Preservice elementary teachers	Preservice secondary teachers	Primary teachers	Elementary teachers	Secondary teachers			
Cross & Price, 1996					$n=12$	Qualitative	Scotland and USA	Teachers' perceptions and personal value positions with regard to teaching CI
Bryce & Gray, 2004					$n=41$, $n=10$[a]	Mixed	Scotland	Teachers' handling of CI discussions and their rationalization about changing the pedagogy of science
Griffith & Brem, 2004					$n=15$	Qualitative	USA	Biology teachers' cognitive and affective reactions to teaching evolution
Oulton et al., 2004			$n=15$		$n=11$	Mixed	England	Teachers' readiness to use CI in the classroom, their practices, and opinions with respect to controversy in the classroom
Lee et al., 2006					$n=86$, $n=12$[a]	Mixed	Korea	Teachers' perceptions of SSI and situational factors that might influence their instructional practices related to these issues
Sadler et al., 2006				$n=8$	$n=14$	Qualitative	USA	Teachers' perceptions on the position and significance of ethics in SSI curricula

Table 2 (continued)

Reference of the study	Number of participants by level of education					Research method of the study	Country of the study	Subject of the study
	Preservice elementary teachers	Preservice secondary teachers	Primary teachers	Elementary teachers	Secondary teachers			
Forbes & Davis, 2008	$n=4$					Qualitative	USA	How PSTs critique and adapt materials dealing with SSI and the factors that mediate this process
Oliveira et al., 2011					$n=1$	Qualitative	USA	The strategies that the teacher implement to frame evolution discussion intellectually
Hermann, 2013					$n=6$	Qualitative	USA	Teachers' concerns and opinions regarding teaching evolution
Weinberger & Dreyfus, 2013		$n=23$			$n=74$	Quantitative	Israel	Teachers' ambivalence concerning environmental issues and their readiness to adopt a stance
Sullivan et al., 2014				$n=877$		Quantitative	USA	Teachers' perceptions of climate change, instructional patterns, top concerns, and strategies used to address controversy
Ozden, 2015	$n=114$, $n=8$[b]					Mixed	Turkey	The perceptions of preservice teachers (PSTs) on SSI
Kilinc, Demiral et al., 2017	$n=1$					Qualitative	Turkey	The nature of resistance against dialogic discourse in SSI t eaching by investigating a PST case

Table 2 (continued)

Reference of the study	Number of participants by level of education					Research method of the study	Country of the study	Subject of the study
	Preservice elementary teachers	Preservice secondary teachers	Primary teachers	Elementary teachers	Secondary teachers			
Kilinc, Kelly et al., 2017	$n=323$					Qualitative	Turkey	The beliefs underlying PSTs' role preferences during SSI teaching
Borgerding & Dagistan, 2018		$n=12$			$n=1$	Qualitative	USA	PSTs' ideas, concerns, and approaches for teaching SSI and societally denied science
Sibic & Topcu, 2020	$n=30$					Qualitative	Turkey	The views of PSTs toward SSI, SSI-based instruction, and their self-efficacy beliefs for integrating SSI
Eryasar & Kilinc, 2021				$n=3$		Qualitative	Turkey	The nature of coherence between science teachers' epistemologies and their SSI teaching discourses
Nation & Feldman, 2021					$n=26$, $n=4$[a]	Mixed	USA	Teachers' instructional practices and beliefs about mitigation strategies and understandings of climate change

[a]These participants were chosen from among those who participated in the quantitative part

[b]These participants were not the same as those who participated in the quantitative part

codes separately. Initially, we decided to use Kelly's preexisting four themes for teachers' positions as a general guideline. As we deeply read the articles, we noticed that teachers' positions were not directly addressed by some articles, but they generally appeared with their underlying reasons, as seen in the examples above. We have therefore continued our analysis inductively by keeping the authors' descriptions of the teachers' stances and by noting the underlying rationales of their preferred stances, if these are presented (Table 4). Two authors are doctors in science education, and the second author is a specialist in the didactics of socially acute questions, so we examined and discussed all of the codes together to enhance reliability. Finally, we reached a consensus on the codes that emerged, and we organized them thematically according to three main teachers' stances (excluders, neutrals, and disclosers) and their justifications (concern of indoctrination, teachers' own opinions and beliefs, teachers' epistemological orientations, and external factors), as shown in Table 3. For example, avoiding, ignoring, and refraining from SSI were the emerged codes of the *excluders* category, while presenting, expressing, or sharing their own values were the codes of the *disclosers* category. By reanalyzing the entire corpus with the stabilized codes, we were able to distinguish subcategories for the teachers' stance (for example, there are two ways of being 'disclosers': 'presenting values' or 'imposition'). We were also able to specify the justifications given for each stance, and we present this consolidated analysis in the next section.

Results

RQ 1: What Are the Main Objectives, the Sample of Interests, and Research Methods of the Studies Presenting Teachers' Stances on Teaching SSI?

Seven research studies were conducted with PSTs, and 11 studies were carried out with in-service teachers, including primary teachers ($n=15$), elementary teachers ($n=888$), and secondary teachers ($n=298$). Three studies (Oulton et al., 2004; Sadler et al., 2006; Sullivan et al., 2014) included samples of teachers from different teaching levels. In addition, Oulton et al. (2004) involved teacher participants from different subject areas (primary teachers, secondary science teachers, and secondary geography teachers). The studies of Weinberger and Dreyfus (2013) and Borgerding and Dagistan (2018) focused on both pre- and in-service teachers. Regarding countries, there were two studies from Scotland, nine studies from the USA, five studies from Turkey, and one study each from Korea, Israel, and England. We found that more than half of the studies used a qualitative approach ($n=11$), some applied a mixed approach ($n=5$), and only two studies utilized a quantitative approach.

Nine of the research studies that we included in our review attempted to investigate participants' perceptions, beliefs, or opinions regarding teaching SSI (Borgerding & Dagistan, 2018; Cross & Price, 1996; Ozden, 2020; Eryasar & Kilinc, 2021; Kilinc, Kelly et al., 2017; Lee et al., 2006; Nation & Feldman, 2021; Oulton et al., 2004; Sibic & Topcu, 2020). In addition, seven studies focused on teachers' concerns, their use of strategies to introduce SSI, and the factors that influence their teaching of controversies (Bryce & Gray, 2004; Forbes & Davis, 2008; Griffith & Brem, 2004; Hermann, 2013; Lee et al., 2006; Nation & Feldman, 2021; Sullivan et al., 2014). A few of them evidently concentrated on teachers' stances during SSI discussion (Cross & Price, 1996; Kilinc, Kelly et al. 2017; Sadler et al., 2006; Weinberger & Dreyfus, 2013).

RQ 2. On What Grounds Did the Studies Approach the Issues Related to Teachers' Stances?

The selected articles in this review included, in detail or superficially, at least one of the teachers' stances on teaching SSI within the scope of the studies. Sometimes, although the treatment of teachers' positions was appropriate for the purpose of the study, they had not been examined in depth; instead, only

Table 3 Themes, categories and codes built by the analysis

Theme	Categories and subcategories	Codes
Teachers' stances	Excluders	Avoiding, ignoring, hiding, refraining from CI or SSI Science is value-free and composed of facts
	Neutrals	
	Neutrality	Safeguarding neutrality, procedural neutrality, excluding personal values and opinions
	Balanced teaching	Presenting both or all sides, impartiality, balanced approach, democracy advocators
	Disclosers	
	Presenting values	Presenting, expressing, sharing own values and ideas, values necessarily emerged, committed impartialists
	Imposition	Revealing truths, imposers, leaning toward one side, teaching as facts
Justifications of teachers' stances	Concern of indoctrination	Not impose their own views; to make students their own decision
	Teachers' own opinions and beliefs	Genetically modified foods (GMF) are dangerous, climate change is wrong/right, teachers should be neutral, expressing values has a democratic value, teachers are responsible for teaching truths, teachers are models for responsible behaviors
	Teachers' epistemological orientations	Science is value-free, science should be separate from other contexts, teachers as a knowledge source
	External factors	Repercussions from children, parents, or colleagues, concerning about legal ramifications

Table 4 Teachers' stances and their rationales with the number/percentage of participants

Articles	Included teachers' stances	Number or percentage of participants	Underlying reasons if mentioned
Cross & Price, 1996	Presenting 'both sides'	One example teacher was explicitly given. Additionally, researchers referred to '*many teachers*'	Concern of indoctrination Science is value-free or objective To make students decide by their own interpretations
	Expressing own values	One example teacher was given	Values are parts of teaching Exclusion of teachers' own values is impossible and artificial Expressing values has a democratic value
Bryce & Gray, 2004	Safeguarding neutrality (Devil's advocate strategy)	The teachers involved in the study	Perception of that neutrality is the most proper stance for teachers Feeling of pressure from various parties To ensure that discussion was even-handed
Griffith & Brem, 2004	Restriction of sensitive topics, thoughts and feelings (Selective teachers)	Seven teachers (of 15 teachers)	To create harmony and a comfortable environment
	No place for CI (Scientist teachers)	Five teachers (of 15 teachers)	Science should be separate from other contexts, particularly religion Learning about evolution as important and valuable
Oulton et al., 2004	Withdrawing their opinions completely	For racism 29% For factory farming 33%	Fear of disapproval Repercussions from pupils, parents or colleagues Feeling of an obligation to prepare pupils to be able to live within the law of their country
	Balanced	For racism 62% For factory farming 83%	To allow students to make up their own mind about the topic
	Adopting particular attitude	For racism 34% For factory farming 7%	Influence of external factors from the wider community
	Presenting biased view	For racism 21% For factory farming 12%	Not mentioned
Lee et al., 2006	Avoid addressing controversial science-related issues	Six participants (50%)	Being not clear about their own values and positions regarding SSI Not imposing their own values on students To remain neutral on SSI Perception of that science is value-free

Table 4 (continued)

Articles	Included teachers' stances	Number or percentage of participants	Underlying reasons if mentioned
Sadler et al., 2006	Exclude values	Two example teachers were given (Additionally, researchers referred to "*a large number of participants*")	Not imposing their own values on students To promote critical thinking and student exploration of their own values Feeling that it is inappropriate to share personal opinions Concerning about the legal ramifications of a teacher sharing ideas
	Express values when asked	Two example teachers were given	To justify their positions in response to criticism
	Values necessarily emerge	Only one teacher	Teaching includes implicit values
	Present values	Two example teachers were given	Teachers share their personal beliefs as to be models for responsible behavior and decision-making
Forbes & Davis, 2008	Value-neutral approach	One participant (of four teachers)	To promote scientific standards, and minimize the effects of their ideas
	Presenting multiple perspectives	Three participant (of four teachers)	Giving importance to individual sense-making and 'many-sidedness' of SSI
Oliveira et al., 2011	Nonauthoritative, neutral and nonimposing science expert	Single-participant study	To promote understanding rather that acceptance To remain neutral To teach human macro evolution
	More authoritative science expert		To teach bacterial micro- and macro evolution (noncontroversial part of topic)
Hermann, 2013	Advocacy standpoint	One example teacher was given (but we do not know the exact number out of six)	Religious beliefs are barriers to learning evolution Religious beliefs may impact their understanding of evolution Evolution is one way of knowing about the world
	Procedural neutrality standpoint	One example teacher was given (but we do not know the exact number out of six)	To help students understand the boundaries and limitations of religious beliefs
Weinberger & Dreyfus, 2013	Impartiality	Not stated	Feeling of ambivalence about the issue

Table 4 (continued)

Articles	Included teachers' stances	Number or percentage of participants	Underlying reasons if mentioned
Sullivan et al., 2014[a]	Teaching only one side	Mostly/only science aspects: 40% of Survey 3 respondents Mostly/only societal dimensions: 10% of Survey 3 respondents	"The existence or human-attribution of recent climate change to be false" "Climate is changing due primarily to human activities"
	Desire to teach both sides	50% of Survey 3 respondents	Participants did not share their motivation to teach both sides
Ozden, 2015	Being impartial	One example teacher was given	Not to impose their own views
Kilinc, Demiral et al., 2017	Balanced perspective	Single-participant study	To make students find their own ideas
	Revealing truths		"To inform students about the GMF", "to make students conscious consumers", "belief of that teacher as a knowledge source"
Kilinc, Kelly et al., 2017	Stickers to Facts	Twenty-seven (8.4%) participants	"Seeing legitimate science as value-free", "showing proper cultural sensitivity", "maintaining focus on science not values", "minimizing the undue influence of teachers' values on students"
	Democracy Advocators	One hundred eighty-eight (58.2%) participants	"Achieving a better learning environment", "promoting broad skill development", "embracing a *guide* role in discussing SSI", "minimizing the distracting effect of teacher self-disclosure", "enhancing more autonomous student decision-making", "understanding what students think and know"
	Imposers	Twenty-four participants (7.4%)	"Protecting children from harmful foods", "reaching absolute truths", "embodying the proper authoritative role of teachers"
	Committed Impartialists	Eighty-four participants (26%)	"Reaching important truths through a fair-minded, objective process", "raising awareness about GMF", "encouraging students' expressiveness", "creating a democratic environment", "cultivating character development", "modeling thinking skills", "protecting children from harmful foods"

Table 4 (continued)

Articles	Included teachers' stances	Number or percentage of participants	Underlying reasons if mentioned
Borgerding & Dagistan, 2018	Present multiple points of view	Five teachers were given as examples (not exact numbers)	To allow students make their own decisions or choices
	Teacher neutrality	Three teachers were given as examples	Not to reflect their own prejudices on the students To avoid politization to portray science instruction as value-free
	Teaching as fact	Only two PSTs (exact number)	No need for neutrality for some issues Scientific community did not doubt the validity of some issues
Sibic & Topcu, 2020	Being impartial	Four of 30 PSTs	No further explanation is provided
Eryasar & Kilinc, 2021	Expressing opinion as factual (Imposing, indoctrination)	Two teachers (of three teachers)	Being absolutist and static position about scientific knowledge
	Presenting alternative scenarios	One teacher (of three teachers)	Scientific knowledge is relative and dynamic
Nation & Feldman, 2021	Remaining neutral or nonbiased	17 occurrences in the code book (across the four cases)	To avoid politization To avoid from external pressures

[a]In this study, data were collected by four different surveys between 2009 and 2011. The number of participants in each survey differed. The values given in Table 4 were obtained from Survey 3 ($n=119$)

the findings were reported. This was the case, for example, with the studies by Ozden (2015) and Sibic and Topcu (2020), who aimed to investigate preservice teachers' perceptions about SSI and its instruction in the Turkish context. Although the teacher participants in these studies noted their impartiality as an important dimension of teaching SSI, the authors made no statements on this subject. In contrast, Kilinc, Kelly et al. (2017) examined Turkish PSTs' preferred role during teaching SSI and their beliefs that impact the choice of that role. The authors created four teachers' profiles classified into two major categories (i.e., monologic and dialogic teaching roles) that emerged from previous research. They provided a rich description of these roles during classroom discourse, particularly for addressing SSI. These profiles were referred to as *stickers to facts*, *imposers*, *democracy advocators*, and *committed impartialists*. Kilinc, Kelly et al. (2017) concluded that teachers' roles are the sum of their beliefs, teaching goals, and epistemologies. Similarly, the studies of Kilinc, Demiral et al. (2017) and Eryasar and Kilinc (2021) grounded teachers' roles in their pedagogical core beliefs, above all their epistemological beliefs, and examined PSTs' monological and dialogical discourse choices. In another study with PSTs in the USA, Forbes and Davis (2008) emphasized the importance of teachers' role in SSI-based instruction, particularly as it contributes to students' learning by fostering their informal reasoning about SSI. In this study, while the participants showed slightly emotive and intuitive reasoning patterns, they largely adopted rationalistic reasoning patterns based on the idea that their responsibility was to teach content as a value-neutral agent. Similarly, Borgerding and Dagistan (2018) conducted a study with PSTs as a part of a semester-long science method class in the USA to understand their beliefs about controversial issues and their teaching approaches to different SSI. The authors reported that PSTs had different stances on the various issues and that their choice of teaching approaches depended on the kind of science controversies, such as socially denied science or SSI, along with their awareness about the characteristics of these issues. Weinberger and Dreyfus (2013) conducted an intriguing study in Israel in which they stressed the differences among 'ambivalence', 'neutrality', and 'impartiality'. The researchers examined the pre- and in-service teachers' ambivalence regarding environmental issues and their leaning toward embracing a stance. They concluded that it is significant to be tolerant of teachers' ambivalence about an issue, because it does not prevent teachers from adopting a pro-environmental stance.

In the same regard, studies conducted with teachers mostly presented ample discussion on teachers' stances, including teacher neutrality, avoidance of controversy, concerns of indoctrination, value-free science teaching, teaching both sides or alternative views, and teacher epistemologies. Regarding teaching of evolution, while two of the three studies (Oliveira et al., 2011; Hermann, 2013) directly included teachers' neutrality, Griffith and Brem (2004) did not openly address teachers' positions; instead, they focused on the controversial nature of evolution theory and teachers' approaches to teaching it. In particular, researchers attempted to reveal the conflicts that teachers encounter during teaching evolution and their strategies for coping with these conflicts. This was revealed in the results of issue-specific teachers' roles.

RQ 3. How Did the Pre- and In-service Teachers' Stances Vary in the Context of Addressing SSI?

Table 4 shows how the teachers' stances are formulated in each article selected, as well as their reasons for preferring these positions. In this part, we were only able to report the number of teachers or the percentage of teachers as indicated in the studies. This number is highly variable from one study to another, as some studies are qualitative (e.g., case studies with a very limited number of teachers), while others are quantitative. This review has led us to identify three main profiles concerning teachers' positions when addressing SSI: excluders, neutrals, and disclosers. Once the characteristics of each profile had stabilized, we created subprofiles, as teachers can adopt a position depending on various factors. Table 5 shows the number of articles providing evidence of these profiles. For example, six of the 18 articles present or discuss cases in which teachers do not want to teach SSI (excluders). Similarly, only

Table 5 Number of articles including teachers' stance by three main profiles

Profiles	Number of articles	Articles
Excluders	6	Griffith & Brem, 2004; Lee et al., 2006; Forbes & Davis, 2008; Kilinc, Kelly et al., 2017; Hermann, 2013; Sadler et al., 2006
Neutrals		
Teachers who hide own opinions	8	Oliveira et al., 2011; Hermann, 2013; Nation & Feldman, 2021; Bryce & Gray, 2004; Oulton et al., 2004; Sadler et al., 2006; Griffith & Brem, 2004; Borgerding & Dagistan, 2018
Teachers who advocate balanced teaching	10	Cross & Price, 1996; Sullivan et al., 2014; Eryasar & Kilinc, 2021; Borgerding & Dagistan, 2018; Weinberger & Dreyfus, 2013; Sibic & Topcu, 2020; Kilinc, Demiral et al., 2017; Ozden, 2015; Kilinc, Kelly et al., 2017; Forbes & Davis, 2008
Disclosers		
Teachers disclose their own views without attempting to convert students	3	Kilinc, Kelly et al., 2017; Cross & Price, 1996; Sadler et al., 2006
Teachers disclose their own views by attempting to convince students	4	Kilinc, Kelly et al., 2017; Eryasar & Kilinc, 2021; Borgerding & Dagistan, 2018; Sullivan et al., 2014

four articles include situations in which teachers reveal their own opinions while trying to convince students (imposers). In the following sections, we explain the characteristics of each profile and the reasons behind them.

Profile 1. Excluders

Teachers with this profile do not want to bring SSI into the classroom. They may be strongly attached to scientific knowledge and not think that science includes social aspects. Excluder teachers prefer a value-free teaching approach. Teachers' naïve epistemological beliefs toward scientific knowledge and their rationalistic informal reasoning patterns, such as that *science is value-free and composed of 'facts' and teachers should be impartial*, may result in a preference for monologic orientations or ignorance of SSI (Sadler et al., 2006; Sullivan et al., 2014; Cross & Price, 1996; Lee et al., 2006; Oulton et al. 2004; Forbes & Davis, 2008; Kilinc, Kelly et al., 2017). Forbes and Davis (2008) demonstrated that PSTs considered themselves value-free agents while addressing pesticide usage and exhibited rationalistic reasoning in which they relied on logic and reason. In another study with PSTs, Kilinc, Kelly et al. (2017) revealed that of the participants, 51.8% were in the category of *stickers to fact*, and they embraced absolutist epistemology by holding the ideas that science and its teaching do not comprise values. Regarding the teaching of evolution, Griffith and Brem (2004) classified some teachers as 'scientists', those who thought that science, its process and evolutionary theory were separated from social and religious issues. These teachers embraced teaching evolution with great commitment and confidence. In a similar vein, Hermann (2013) found that teachers may eschew arguments related to religious beliefs and demonstrate an *advocacy standpoint* toward teaching evolution. The teacher who was in this position did not allow her students to exchange their views on their religious beliefs, which might influence their comprehension of the theory of evolution. These studies show that both pre- and in-service teachers who have naïve epistemologies mostly adopt value-neutral teaching approaches. In addition, these teachers refrain from addressing SSI in their classrooms due to their lack of skills or feelings of ill-preparedness to lead SSI discussions and their ambivalent values about the issues (Lee et al., 2006; Oulton et al., 2004; Bryce & Gray, 2004).

Profile 2. Neutrals

Many studies use the terms 'neutrality', 'impartiality', or 'balanced teaching' interchangeably, despite the slight nuances in their meanings. We separate neutrality and impartiality using De-Shalit's (2005) definitions. Impartiality implies not choosing topics and teaching materials according to his or her own beliefs but due to their coherence and appropriateness. Furthermore, impartiality includes the denotation of equality by alluding to both sides. In contrast, neutrality refers to a teacher's motivation not to exert influence on their students' ideas. Balanced teaching can therefore be seen as a method of maintaining impartiality that teachers use when presenting issues. If there is more than one party in an issue, balanced teaching gives equal consideration to all parties. In the studies that we examined, this was mostly expressed in the form of *teaching both sides* or *presenting multiple views*. According to Stradling (1984), balanced vision not only gives equal place to all opinions but also represents a safe environment. Balanced teaching thus refers to a teacher's position when he or she emphasizes his or her willingness to present different points of view on an issue in an unbiased way. In contrast, neutral teaching occurs when a teacher justifies his or her position by highlighting his or her willingness not to show his or her opinions during teaching. Therefore, we deemed it suitable to create two subprofiles for neutrals: teachers who hide their own opinions and those who advocate balanced teaching.

Profile 2A. Teachers Who Hide Their Own Opinions One of the teacher positions mostly stated in the reviewed studies is that teachers should remain silent about their views when discussing SSI ($n=8$). We could indisputably determine this position under various descriptions, such as neutrality or procedural neutrality (Oliveira et al., 2011; Hermann, 2013; Nation & Feldman, 2021), safeguarding neutrality (Bryce & Gray, 2004), or the exclusion of values and opinions (Oulton et al., 2004; Sadler et al., 2006). Teachers with this profile attach great importance to keeping their views confidential by several rationales. As an illustration, Nation and Feldman (2021) indicated that climate change was seen as contestable and political by some teachers. These teachers eliminated their own ideas related to the issue to protect themselves from external pressures such as parents, school administrations, or stakeholders. Similarly, Bryce and Gray (2004) reported that participating biology teachers advocated that neutrality was an indispensable requirement during teaching controversial biotechnology progress due to their feelings of pressure arising from social reactions or school examinations.

Regarding teaching evolution, researchers have defined teachers' endeavours in various ways. In the study of Hermann (2013), a participant teacher preferred to be neutral and promote religious discussions in the classroom to show the epistemological differences between religious beliefs and scientific knowledge. Hermann named this stance *procedural neutrality*. Similarly, Griffith and Brem (2004) explored biology teachers' stresses and overcoming strategies to teaching evolution. Teachers were divided into three categories in this study, namely, *selective*, *scientists*, and *conflicted.* Among them, selective teachers not only delimited their feelings and opinions to draw safe boundaries for themselves but also chose some specific topics to teach evolutionary theory. Another strategy used by teachers during teaching evolution was indicated by the study of Oliveira et al. (2011). A first-year secondary biology teacher reserved his stance on evolution, embraced the role of facilitator, and created a courteous and respectful environment by withholding his own views about the issue and emphasizing social and moral principles such as mutual respect and understanding, tolerance, or nondiscrimination.

Profile 2B. Teachers Who Advocate Balanced Teaching Ten studies have examined teachers who advocated the necessity of a balanced approach during teaching SSI. Presenting 'both sides' (Cross & Price, 1996; Sullivan et al., 2014), sharing 'alternative scenarios' (Eryasar & Kilinc, 2021), introducing 'multiple points of view' (Borgerding & Dagistan, 2018), showing 'impartiality' (Weinberger & Dreyfus, 2013), 'being impartial' (Sibic & Topcu, 2020), and employing 'balanced teaching' (Kilinc, Demiral et al., 2017) were mentioned in the reviewed articles as approaches to balanced teaching. Kilinc, Kelly et al. (2017) named PSTs in this category as *democracy advocators*, and more than half of the participants (58.2%) opted out of this stance for several reasons, such as creating more effective learning conditions, supporting students' skills development related to critical thinking, communicating, presenting empathy, or making students reveal their ideas confidently. Weinberger and Dreyfus (2013) asserted that ambivalence is not always the most common attitude toward environmental issues and that a great number of nonambivalent participants could perceive environmental issues as genuinely contentious. It was advocated that impartiality can be achieved by providing diverse arguments about the issue, particularly through offering pro- and nonenvironmental assertions. They also claimed that fostering ambivalence can encourage teachers to be impartial even though it depends on the nature of the environmental issue.

Profile 3. Disclosers

Teachers with this profile share their own opinions and values in the classroom during teaching SSI. While some teachers just tell students what they think, others try to convince them about their own perspectives; hence, there are two subprofiles in this category.

Profile 3A. Teachers Disclose Their Own Views Without Attempting to Convert Students Only three studies reported teachers making disclosures without attempting to convert students. We identified this position in these studies by the statements of expressing or presenting teachers' own values and Kelly's (1986) term of *committed impartiality*. Kilinc, Kelly et al. (2017) revealed that PSTs advocated presenting their own ideas to encourage students to disclose their own and help them improve their thinking skills in a democratic classroom atmosphere. The aim of these PSTs was to draw students' attention to the GMF, protect them from unhealthy nutrients, and help them form reasoned opinions. In Cross and Price (1996) and Sadler et al. (2006), some teachers adhered to presenting their own opinions about the issue to be a model for students and to create a democratic environment. These teachers thought that the exclusion of their own values was not easy to achieve and did not comply with the responsible teacher and citizen. In addition, Sadler et al. (2006) revealed that three groups of teachers expressed their viewpoints. The first group thought that they would disclose their own ideas if they felt pressure from their students on a particular issue. The second group (one teacher) claimed that teachers' values always become apparent in the classroom by implicit transfer during teaching, and the last group of teachers thought that disclosing opinions was one of the teacher duties to be a model for civic behaviors.

Profile 3B. Teachers Who Disclose Their Own Views by Attempting to Convince Students Four articles reported that participating teachers reflect their own ideas and create a partial classroom climate. Teachers who advocate one side as factual knowledge might adopt this position with the intention of being responsible teachers who reveal the truths (e.g., about the effects of harmful foods in Kilinc, Kelly et al., 2017), creating environmental awareness (Eryasar & Kilinc, 2021), or preventing the teaching of multiple perspectives from being misleading to students (Borgerding & Dagistan, 2018). More specifically, personal values and opinions emerging from the issue itself influence teachers' approach to teaching SSI (Eryasar & Kilinc, 2021). For example, climate change (Borgerding & Dagistan, 2018; Sullivan et al., 2014) and GMF (Kilinc, Kelly et al., 2017) were the SSI where some participants do not feel any obligation to be neutral and want to teach these issues as factual. Paradoxically, in Eryasar and Kilinc's (2021) study, a nonconstructivist teacher disclosed her views on technology and radiation as if they were facts when evidence was missing. This teacher was described as *mostly absolutist* regarding knowledge-based epistemology and had *static* epistemologies in terms of science-based epistemologies.

RQ 4. What Are the Main Factors Affecting Teachers' Stances?

Stradling (1984) identified four types of restrictions on the teaching of controversial topics: teacher constraints, school constraints, external constraints, and issue-specific constraints. Our review demonstrates that these restrictions still have a great influence on teaching SSI. However, the underlying causes of teacher stances were not the main objective or outcome of most of the studies. While some studies straightforwardly sought to investigate the underlying reasons for teachers' preferred positions (e.g., Kilinc, Kelly et al., 2017), some studies only reported the position chosen by the participants. As an example, Sibic and Topcu (2020) mentioned the participants' desire to remain impartial but did not discuss the underlying reasons for that approach.

There is a great body of research showing that teachers' beliefs are intricate and depend on many different factors and that these beliefs determine their teaching styles (e.g., Anderson, 2015; Mansour, 2013). Teachers' epistemological orientations are considered one of the factors controlling teachers' behavior in the classroom (e.g., Hofer & Pintrich, 2004). The misperception that "science is value-free" was expressed by the participants of a number of studies to justify their positions while teaching socioscientific issues. In general, participants with this belief avoid teaching SSI or teach only science content knowledge without touching the social context of the issue. Additionally, they may think that it is not their responsibility to step outside the scientific knowledge. Moreover, two studies conducted

with preservice science teachers in Turkey discussed that PSTs' positivist and absolutist science-based epistemologies resulted in more monologic classroom discourse in a more authoritative manner (Kilinc, Demiral et al., 2017; Kilinc, Kelly et al., 2017). Some conflicting results were presented by Kilinc, Kelly et al. (2017). While most participant PSTs embraced dialogical roles such as democracy advocators and were committed impartialists, some of them exhibited absolutist epistemologies of scientific knowledge and beliefs that were not suitable for their preferred teaching role. In addition, Cross and Price (1996) discussed almost twenty-five years ago that indoctrination was seen as a prominent concern of teachers while teaching controversial issues. To not indoctrinate students, both pre- and in-service teachers exhibited distinct stances, namely, avoiding the issue altogether (Lee et al., 2006), presenting both sides (Cross & Price, 1996) and excluding values (Borgerding & Dagistan, 2018; Kilinc, Kelly et al., 2017; Sadler et al., 2006; Cross & Price, 1996; Griffith & Brem, 2004; Lee et al., 2006), or using strategies such as the devil's advocate (Oulton et al., 2004) or Socratic position (Eryasar & Kilinc, 2021).

Additionally, external constraints such as fear of disapproval and feel of pressure were reported in only three articles as a reason to be neutral (Bryce & Gray, 2004; Nation & Feldman, 2021; Oulton et al., 2004). In these studies, teachers expressed their fear of backlash from students, parents, or colleagues about the issues of biotechnological processes (Bryce & Gray, 2004), climate change (Nation & Feldman, 2021), and acute debates in society (Oulton et al., 2004). In summary, in addition to external pressures, teachers' beliefs and values are seen as the main reasons for teachers' preferred positions when teaching SSI.

Conclusions and Implications

This review included research studies conducted in different geographical distributions (i.e., the USA, England, Turkey, Canada, Korea, Israel) and thus enables us to expose teachers' positions in various samples and create teachers' profiles. In previous research, teachers emphasized that teaching SSI was difficult and time-consuming to address in science classrooms or even irrelevant to scientific knowledge by having social values (e.g., Chen & Xiao, 2021; Borgerding & Dagistan, 2018). Scholars hitherto seek to understand how teachers' perceptions of these issues have an impact on their treatment of issues or the way of presenting to the students. We sought to understand different profiles of science teachers when teaching SSI in terms of how they display their stances. In the many studies that we examined, teacher position was not the main concern of the authors, but they had findings regarding it. It is significant to note that neutrals (Profile 2) were the most adopted and preferred teacher profile in the reviewed articles. According to Oulton et al. (2004), it is unfeasible to accomplish balanced teaching in the reality of the classroom, so students should be informed about the existence of prejudices, and they should be provided opportunities to gain the necessary skills to recognize and evaluate them.

This paper implicates five major points in terms of results. First, the four-teacher approach that Kelly (1986) proposed theoretically does not adequately explain teachers' stances on SSI instruction. We suggest that teacher stances are multifaceted and that even inconsistencies may appear in stances. Different teacher profiles may emerge depending on the issue itself with changes in opinions, beliefs and attitudes, or content information. Therefore, teachers can demonstrate inconstant positions when addressing controversies. Two studies with a single case supported this result by providing different motives. Kilinc, Demiral et al. (2017) showed that despite a professional development program, a science teacher at the beginning of her teaching career executed variant stances when teaching SSI due to her naïve epistemologies, classroom conditions, and her personality. Oliveira et al. (2011), similarly, focused on one case and revealed that the teacher changed his stance from micro to macro evolution, as he did not want to disturb a warm and respectful classroom environment with the sensitivity of the topic. Changing the positions of teachers according to the sensitivity or importance of the topic has not been found only

in science education research. Similar results were reported in social science education. For example, Kello (2016) indicated that various pedagogical positions were embraced by teachers depending on the sensitivity of controversial historical issues. Second, teachers may have the same constraints, but they can differ in their stances while teaching controversial issues. For example, to create a democratic classroom environment, while some participants preferred to remain neutral, some wanted to share their opinion as responsible citizens. Or, because of the fear of indoctrination, some participants opted for a neutral stance, while some of them avoided the issue altogether. Therefore, we proposed that in addition to its controversial features, the profile adopted by teachers is very complicated to understand. Third, in-service teachers exhibited diverse reasoned stances compared to PSTs. None of the studies implemented with PSTs mentioned the fear of disapproval or feeling pressure from parents, stakeholders, administrations, or students, unlike the studies conducted with in-service teachers. Moreover, the teacher participants emphasized the creation of a positive, reasonable, and democratic classroom environment. That is, the in-service teachers were more aware of considerations other than student learning when teaching SSI. Fourth, different teacher stances have emerged according to the SSI used in the studies. Although for environmental and biotechnological issues teachers showed several positions by citing diverse reasoning, they opted out of limited stances regarding the issues of climate change and evolution (i.e.; neutrality and scientific advocacy) because they wanted to stick to scientific knowledge as much as feasible. According to some teachers, teaching both sides would not be appropriate for all issues. Borgerding and Dagistan (2018) reported that although PSTs committed to a neutral stance for teaching fracking and cloning, some of them were confused about teaching multiple sides of climate change and evolution. In addition, teachers exhibited conflicting or mixed positions about these issues, which could be explained by their lack of content knowledge (e.g., Sullivan et al., 2014). On the other hand, teachers adopted a more protective attitude about health issues, such as GMF or radiation, and attempted to persuade their students of their own thoughts. Last, it should not be overlooked that there might be differences between the stances of the teachers in the real classroom environment and their responses to questionnaires or interviews. Oulton et al. (2004) asserted that although experienced teachers as assume that they are neutral, they can be biased by their choice of classroom activities. Teachers sometimes can make holes in their neutrality by commenting ironically, using meta-discourses, or choosing one-sided materials, although they aim to frame the lessons in a neutral manner (e.g., Oliveira et al., 2011). Hodson (2020) emphasized that many teachers perceive avoiding contentious matters, particularly those with substantial political implications, as a way of taking a neutral stance. However, the proliferation of political issues involving science and technology and the need to strengthen democracies require a stronger coupling of science education and political education (Bencze et al., 2020; Sjöström et al., 2017). This is why we believe it is necessary to draw attention to the diversity of teachers' stances when teaching SSI, to enable them to complexify their point of view on this teaching and to be able to adapt their stance to their context of practice, their pedagogical objectives and the issue at hand.

We have noticed that when teachers stress their concerns or justifications about their own stances, they can sometimes be handled superficially by the researchers. The reviewed studies did not explicitly describe "what are the expected teachers' stances where the study was conducted in?" or "how should be the stance of teacher while addressing SSI?". In addition, creating teacher profiles was quite thorny, depending on the underlying causes, or because what they thought was different from what they adopted in the classroom. As mentioned in the "Results" section, a teacher can switch between profiles depending on the nature of the subject (e.g., macro and micro evolution) or the teacher's sensitivities about the issue (e.g., eating healthy food, environmental awareness, feeling responsibility). We suggest that teachers' stances are not limited to the profiles in our study, but they provide a good basis for further exploration. Contrary to their social studies counterparts (e.g., Cotton, 2006; Kello, 2016; Pace, 2019), teachers' stances have given less empirical attention thus far in science education research, and it has been accepted that teachers should be neutral. However,

if the needed stance is to tend toward neutrality, how they could ensure this and how they could control their own feelings and beliefs during teaching SSI have been disregarded. It is clearly seen that pre- and in-service teachers need pedagogical support to introduce SSI effectively, especially on issues that have received strong reactions from society.

On the other hand, one of the limitations of this study is that it examines a limited number of peer-reviewed and empirical studies written only in English and conducted with science teachers. There is a need for more studies covering different languages and a more comprehensive literature, such as dissertations, theoretical, or conference papers. Another limitation of our study is the difficulty in making interpretations from original data. When drawing data from the original articles, we adhered to the data provided by the authors. However, if there was a finding about our point of interest (teachers' stances) in the article and it was not mentioned as a major finding or there was not a detailed explanation, we emphasized this situation and included these articles in our review. We can say that there is not enough data to make a meta-analysis or a meta-synthesis on this issue. However, this systematic review can help to reveal the current situation and guide future studies. Nevertheless, there are many studies in the field of social sciences that examine teachers' stances during the presentation of CI. Journell (2013) emphasizes that science and humanities teachers struggle with similar pedagogical problems while teaching controversial issues, so teachers working in these two domains should benefit from each other's experiences. Accordingly, future studies could examine teachers' stances on sensitive and controversial issues using a comparative and interdisciplinary approach. Apparently, teachers need to be empowered with specific skills and methods to address SSI. Thus, more work is needed in a real classroom environment to understand teachers' approaches to different SSI. To this extent, how teachers' pedagogical content knowledge, personal beliefs, understanding of the nature of science, and experiences influence their classroom stances should be investigated in the context of varied SSI. Relatedly, further research should include how the sociocultural and political context of school districts influences teachers' stances in the classroom. Rather than seeing the role of the teacher as that of an objective narrator who only guides the discussion to run smoothly and helps the development of students' skills such as informal reasoning or critical thinking, it is necessary to consider them as a part of society with their own values, thoughts, and beliefs. Thus, teacher preferences should be addressed by multiple lenses for promotion SSI-based instruction, and as Bryce and Gray (2004) stated, teachers' confidence should be supported by means of a well-developed pedagogy.

Teachers' beliefs are factors that cannot be ignored in their responses to curriculum innovations (Cotton, 2006). To help teachers adopt reform changes that are considered significant, their reactions to these reforms and the reasons behind these reactions should be investigated in detail (Ryder, 2015). Teachers' perceptions of teaching SSI have been examined in many studies. However, the issue of teachers' stances is rarely interrogated by researchers. The necessity and applicability of teacher neutrality should also be clearly put forth. Neutrality may not be a principled position but a process that can arguably be achieved in a variety of ways in the classroom, depending on the teacher, the issue, and the school environment, which may warrant teachers presenting their own ideas and viewpoints at times. It is therefore important to understand the conditions and dynamics of this process.

To conclude, teachers need to be equipped so that they are comfortable teaching issues that have political dimensions (Nation & Feldman, 2021). Otherwise, they can be expected to teach only the scientific part of the issue, leaving out anything that touches on social, religious, and personal values. For this reason, specific work on teachers' stances should be reinforced when introducing SSI into pre- and in-service teacher training programs.

Declarations

Conflict of Interest The authors declare no competing interests.

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Note: Studies analyzed in the review are indicated with an asterisk.

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