Inviting Controversy into Canadian Classrooms: Socioscientific Issues and Navigating Misinformation

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Author's Note

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This work was supported by a grant from the Social Sciences and Humanities Research Council of Canada (SSHRC) under File #752-2022-0044. I also thank Dr. Kerry Rose, the Centre for Mathematics, Science, and Technology Education (CMASTE), and Glyconet for their support in developing and delivering the teacher workshops described in this paper.

The author declares that there are no competing interests. The author has no financial or proprietary interests in any material discussed in this article.

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Abstract

In an era of widespread misinformation and divisive public discourse, navigating socioscientific issues (SSI) such as climate change and vaccinations has become increasingly complex. This paper explores the crucial role that science education plays in preparing individuals to engage with SSI. It addresses two questions: How might teachers prepare students to analyze SSI and become effective information consumers and decision-makers, and how might teachers be prepared to meet the challenges of implementing controversial SSI? Drawing on the author's experiences teaching and offering professional development to teachers, as well as what was learned from conducting a scoping review on misinformation (Brown, 2026), this reflective commentary argues that science education must expand efforts to invite nuanced and controversial SSI into classrooms to better prepare Canadians to engage with one another and with these key issues. Student preparation could include increased emphasis on SSI, a focus on developing information/digital/media literacy, fostering intellectual virtues, and connecting SSI with the Nature of Science (NoS). Teachers' efforts to integrate SSI could be bolstered through curriculum and assessment modifications, professional development, resource creation and sharing, and enhanced support from administrators. This paper calls on teachers, teacher educators, school administrators, and science education researchers to advance this critical work.

Keywords: socioscientific issues, science education, misinformation, scientific literacy, nature of science

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Inviting Controversy into Canadian Classrooms: Socioscientific Issues and Navigating Misinformation

Canadians can access large volumes of information online and through social media, yet they face a deluge of science and health misinformation (Bilodeau & Khalid, 2024; Statistics Canada, 2023). Socioscientific issues (SSI) such as climate change and vaccinations are increasingly divisive (Azevedo & Jost, 2021; Boulianne & Belland, 2022), and the situation is worsened by political leaders and governments that actively spread false information (disinformation)[1] related to these topics (Hornsey et al., 2020; Strudwicke & Grant, 2020). Misinformation has serious consequences for Canadians' health, well-being, and the environment. For example, misinformation around climate change may lead to public doubt or confusion and impact support for policy or climate action (Cook et al., 2018; Oreskes & Conway, 2010). Similarly, misleading health claims can delay or prevent individuals from seeking medical treatment or preventative care (Canadian Medical Association [CMA] & Abacus Data, 2025; Kemei et al., 2023). Unfortunately, the issue seems to be getting worse. CMA and Abacus Data (2025) warn that many Canadians are susceptible to health misinformation, and that "over the past year, Canadians' encounters with health misinformation has [*sic*] increased significantly" (p. 3).

Science education plays a crucial role in addressing misinformation and in preparing future citizens to navigate complex SSI (Allchin, 2023b; Osborne & Pimentel, 2022). However, in this chaotic and evolving information environment, how might teachers prepare students to analyze SSI and become effective information consumers and decision-makers? Further, how might teachers be prepared to meet the challenges of implementing controversial SSI? This paper offers a reflective commentary on these issues, weaving together what I learned from my experiences teaching high school science, offering professional development (PD) to teachers on a controversial socioscientific issue (i.e., vaccinations during COVID-19), and conducting a scoping review on science education's responses to misinformation (Brown, 2026). I argue that efforts to bring nuanced and controversial SSI into classrooms must be expanded if teachers are to prepare future Canadians to critically engage with the science, health, and environmental issues that impact us all.

Background: Weaving Together Science Literacy, SSI and Responding to Misinformation

Misinformation is a complex problem that requires a multidisciplinary response. Science education is well situated to respond to misinformation by supporting citizens' capacity to evaluate information and make decisions (Allchin, 2023b; Feinstein & Waddington, 2020; Lazer et al., 2018). One lens through which this work is taken up is scientific literacy (Höttecke & Allchin, 2020; Sharon & Baram-Tsabari, 2020). There is no unified definition of scientific literacy, though Feinstein (2011) conceptualizes scientifically literate individuals as *competent outsiders* with respect to science. Competent outsiders recognize the limits of their knowledge and expertise, understand how science relates to their lives, and can engage with scientific information in ways that help them participate in decision-making around SSI (Feinstein, 2011; Feinstein et al., 2013). Thus, this view of scientific literacy acknowledges that individuals are socially and culturally situated, and that decision-making around SSI involves evaluating claims and sources of

[1] While distinctions between *disinformation*, which is spread with intent to deceive, and *misinformation*, which is spread unintentionally, are well documented (Barzilai & Chinn, 2020; Wardle & Derakhshan, 2017), this commentary uses misinformation as an umbrella term unless intent is known. From the perspective of the information consumer, it is not always known whether there was intent to deceive.

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information as well as considering other factors (personal, social, economic, ethical) (Osborne & Pimentel, 2022; Sharon & Baram-Tsabari, 2020).

Claim evaluation and decision-making around SSI have become increasingly complex, given the realities of modern information communication, including biased news media, spin, and reliance on online sources such as social media, which bypass the fact-checking functions of traditional news media (Höttecke & Allchin, 2020; Oreskes & Conway, 2010). In response, educators have incorporated information literacy (Gu & Feng, 2022; Julien & Barker, 2009; Klucevsek, 2017) and digital/media literacy skills (Hodson, 2011; Jarman & McClune, 2007; Reid & Norris, 2016) into science literacy frameworks. Authors (e.g., Höttecke & Allchin, 2020; Klucevsek, 2017) argue that science education must emphasize critical information/digital/media skills for navigating the current information environment, such as source evaluation, understanding the internet and social media, and identifying tactics[2] used to spread disinformation. Thus, how scientific literacy is characterized has evolved: not only do individuals need to understand how science works (the nature of science [NoS]), including how science is communicated and miscommunicated, but they must also be able to identify science-related misinformation, analyze information from multiple (conflicting) sources, and engage in discourse and everyday decision-making around SSI in increasingly polarized environments (Allchin, 2023b; Höttecke & Allchin, 2020; Osborne & Allchin, 2025; Sharon & Baram-Tsabari, 2020).

Questions and Context: Framing This Reflective Commentary

If our aim as science educators and teacher educators is to support the development of scientifically literate citizens who can engage meaningfully in decision-making around complex SSI, then how might we take up this work? Specifically, this paper explores two questions:

1. How might teachers prepare students to analyze SSI and become effective information consumers and decision-makers?
2. What challenges are inherent in the implementation and enactment of SSI in teaching practice, and how might teachers be prepared for these challenges?

In response to these questions, this paper offers a reflective commentary drawn from three key sites of reflection. The first was my experience teaching high-school science in Alberta, and in particular, teaching Science 24 Unit C (Disease Defense & Human Health), which includes discussion around social and economic impacts of pandemic diseases, exploration of immunity, vaccinations, and analysis of the impact of public health initiatives (Alberta Education, 2014). I recalled and journalled my experiences related to teaching this content and engaging students in discussions around SSI. The next site of reflection was my experience creating and facilitating PD sessions with pre-service and in-service teachers within Canada (12 sessions between November 2021 and February 2024).[3] Sessions focused on sharing resources[4] and teaching strategies to help address science and health misinformation and supporting teachers to prepare students to engage

[2] Some examples of such tactics include casting doubt on the scientific consensus, fear mongering, and cherry-picking data (e.g., see Cook et al., 2017; Lewandowsky & van der Linden, 2021; Oreskes & Conway, 2010). These deliberate efforts of deception by politicians, companies, and special-interest groups for economic and/or political gain muddy the waters around SSI, making it more difficult for citizens to locate evidence-based information and engage in decision-making (Gotlib & Groenhout, 2022; Hansson, 2017; Oreskes & Conway, 2010; Scheufele & Krause, 2019).
[3] Data on the number of participants who attended the sessions is not available, nor is the proportion of attendees who were pre-service versus in-service teachers.
[4] These include videos, lesson ideas, and activities developed in partnership with CMASTE and Glyconet. For access to resources, go to: https://sites.google.com/ualberta.ca/cmaste/teacher-resources?authuser=0.

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critically with SSI, with a focus on COVID-19 and vaccines. Sessions were adapted to different delivery formats (online or in-person/hybrid) and varied in length from 75 minutes to three hours. Session titles included: *Vaccines & Hesitancy: Teaching for Critical Thinking* and *Critical Thinking Using Socioscientific Issues (Including COVID).* My reflection on these sessions included reviewing the content, the written notes I kept during development and delivery, the changes made over time, and their implications in relation to the guiding questions of this paper.

Finally, the third site of reflection was my experience conducting a scoping review on science education's responses to misinformation (Brown, 2026). This paper does not present details on the methodology and findings of the scoping review; instead, it draws on my notes and reflections on what I learned while undertaking the review and how it might inform how I approach preparing students or teachers to engage with SSI. Further, in preparing this manuscript, I recognized that literature for the scoping review was limited in several ways: it needed to be updated with more recent literature (as the review included literature up to December 2024), it focused more broadly on science education efforts (though discussion around/exploration of SSI was identified as a promising approach to build resilience to misinformation, see Brown, 2026), and it was not specifically focused on the Canadian context. Consequently, I conducted an additional literature search via Google Scholar, using the terms socio-scientific OR SSI OR socioscientific AND Canada.[5] Thus, this paper draws on science education literature but does not have the methodological rigour of a scoping review. I acknowledge that relevant literature is missing, particularly literature for notable American scholars who focus on SSI, because my focus is on the Canadian context.

This paper offers my perspectives on the questions posed, based on my reflections on a broad but not exhaustive sampling of literature, my experiences as a former high-school science educator, a current pre-service and in-service teacher educator, and an early-career researcher with a deep interest in combating science and health misinformation. It represents my current thinking on this issue and is an attempt to bring together these three areas of my professional learning and growth to generate potential paths forward and points for discussion. It is also an invitation for pre-service and in-service teachers, teacher educators, school administrators, and science education researchers to continue conversations about how we can support students and teachers in engaging with and navigating complex, and often controversial SSI.

Question 1: How Might We Prepare Students to Critically Analyze SSI?

Based on my reflections, four key themes emerged related to preparing students to critically analyze SSI. These were increasing curricular emphasis on SSI, integrating information/digital/media literacy into science education contexts, fostering intellectual virtues such as open-mindedness and skepticism, and explicitly connecting SSI and NoS instruction. Insights from my experiences teaching and offering PD sessions are woven throughout the discussion to provide context and describe how this work might be taken up in classrooms.

Increased Emphasis on SSI

Current science curricula are criticized for underemphasizing SSI (Höttecke & Allchin, 2020; Kienhues et al., 2020). In response, authors (e.g., Duschl, 2020; Hodson, 2020; Lima & Nascimento, 2022; Viehmann et al., 2024) call for greater integration of SSI and the social context of science knowledge development. Viehmann et al. (2024) argue that, even when SSI is part of

[5] Last search using these terms: May 19, 2026.

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the curriculum, it may neglect future scenarios, risk evaluation, and translating knowledge into action, leaving students unprepared to navigate future ethical, social, or environmental challenges. This may apply to the Canadian education context, where a scoping review highlighted that climate change coverage is inconsistent across curricula (Field et al., 2023). This suggests that expansion of SSI in Canadian curriculum documents may be warranted, though additional research is needed to explore the coverage of specific SSI (including controversial SSI such as vaccines) in Canadian curricula.

From my perspective as a former high-school science teacher and current teacher educator/PD facilitator, students need opportunities to discuss and explore increasingly complex SSI as they move through the education system because they are curious about—and impacted by—these topics, even if curriculum documents do not address them. If students are left to navigate complex SSI on their own, they dive into *epistemically unfriendly environments* (i.e., spaces where misinformation is rampant, such as social media) with limited preparation (Chinn et al., 2021; Kalu-Mamji et al., 2024). Instead, teachers can introduce students to controversial SSI in epistemically friendly environments where students feel safe asking questions, changing their minds, and learning to evaluate claims. Science teachers are well situated to help students explore scientific concepts related to SSI, facilitate discussions, scaffold critical thinking, and support the development of skills needed to engage with more controversial topics and move into deeper waters (i.e., epistemically unfriendly environments) over time (Chinn et al., 2021). In my conversations with teachers, I have seen that many already do this work by bringing in current events and topics of interest to students; however, the extent of SSI coverage across classrooms varies. Thus, expanding curricular guidelines around SSI coverage in Canada could support consistent opportunities for students to practice navigating complex issues before they graduate. Teacher education may also support increased inclusion of SSI in classrooms, as discussed in a subsequent section.

Developing Information/Digital/Media Literacy

Another crucial aspect of preparing students to engage with nuanced SSI is cultivating information/digital/media literacy skills. Information literacy refers to the cognitive skills required to find, retrieve, analyze and use information (American Library Association [ALA], 2006; Association of College and Research Libraries [ACRL], 2016). Digital/media literacy refers to an individual's ability to access, critically evaluate, use, and create digital media/content (Allchin, 2023b; Höttecke & Allchin, 2020; Phippen et al., 2021; Wuyckens et al., 2022). Some students and teachers may lack information or digital literacy skills (Belova et al., 2022; Breakstone et al., 2018; Burron & Pegg, 2021). However, evidence shows that educational interventions can support skill development (Scheibenzuber et al., 2021; Tseng et al., 2021). Specific areas of information/digital/media literacy instruction that may support individuals to navigate conflicting science and health information include: knowledge of disinformation tactics (e.g., use of fake experts, manufacturing uncertainty; see Table 1) and features of the internet/social media (e.g., algorithms pushing content) (Allchin, 2023b; Lewandowsky et al., 2017; Estigarribia et al., 2022); evaluating source credibility (Brante & Strømsø, 2018; Estigarribia et al., 2022; Osborne & Pimentel, 2023); and employing strategies of expert fact checkers (Breakstone et al., 2018; Scheibenzuber et al., 2021).

From a practitioner standpoint, if citizens require information/digital/media literacy skills to effectively navigate SSI in their everyday lives (Allchin, 2023b; Osborne & Pimentel, 2023), then SSI are the logical context for developing these skills. Specifically, in the PD sessions I have

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offered to teachers, I have argued that social media and online sources of information should be leveraged, wherever possible, to bring emerging SSI into science classrooms. Young people already use online sources to acquire science and health information (Belova et al., 2022; Morote & Hernández, 2022), and these sources provide more authentic environments to engage with SSI than textbooks (Belova et al., 2022). For example, educators can utilize web searches, social media platforms, YouTube, and podcasts to introduce different arguments and perspectives on SSI while scaffolding students to develop their information/digital/media literacy skills. This could include evaluating sources of information by considering credentials, education, experience, track-record/reputation among peers, and conflicts of interest (Allchin, 2023a; Brante & Strømsø, 2018; Herrick et al., 2023; Osborne & Pimentel, 2023). Teachers could also model skills like *click-restraint* (skimming search results and evaluating different sources before clicking on one) and *lateral reading* (consulting other sources/websites/books for information about an author's credibility or about a particular claim) (Barzilai et al., 2023; Breakstone et al., 2018; Scheibenzuber et al., 2021). Anecdotally, teachers I have worked with were encouraged by how easily they could integrate and model these skills as a part of activities they were already doing in their classrooms. However, time constraints may limit teachers' ability to give students opportunities to practice and refine these skills (see Question 2).

Fostering Intellectual Virtues

Based primarily on my reflections on conducting the scoping review (see Brown, 2026), intellectual virtues such as open-mindedness, skepticism, and intellectual humility play an important role in effectively navigating contentious, politically charged SSI (Lapsley & Chaloner, 2020; Lombard et al., 2020; Sharon & Baram-Tsabari, 2020). Skepticism and open-mindedness involve suspending judgement until a claim can be investigated and being willing to follow the evidence and change one's perspective (if warranted) (Lapsley & Chaloner, 2020; Sharon & Baram-Tsabari, 2020). Intellectual humility can be described as a "willingness to own up to one's intellectual limitations, to embrace fallibility and be ready to yield convincing evidence or stronger argument" (Lapsley & Chaloner, 2020, p. 133). Authors (e.g., Lombard et al., 2020; Sharon & Baram-Tsabari, 2020) argue that science education should focus on scaffolding the development of these virtues as a response to misinformation. Some promising pedagogical approaches to support the development of these virtues include facilitating discussion around SSI, exploring alternative explanations, reflecting on bias, and perspective-taking (Lombard et al., 2020; Viehmann et al., 2024).

Related to the virtues of open-mindedness, skepticism, and intellectual humility, authors (e.g., Barzilai et al., 2023; Beauvais, 2022; Estigarribia et al., 2022; Herrick et al., 2023; Lombardi et al., 2016; Scheibenzuber et al., 2021; Tabak, 2020; Tseng, 2018) also described the importance of teaching students about their thinking. There is evidence that helping students to reflect on and slow down their thinking (e.g., through prompts or targeted questions) can support them to more effectively evaluate conflicting information and engage in decision making around SSI (e.g. Barzilai & Chinn, 2020; Chinn et al., 2020; Estigarribia et al., 2022; Flener-Lovitt, 2014; Lapsley & Chaloner, 2020; Lombardi et al., 2016; Sinatra & Lombardi, 2020; Tseng, 2018). Further, supporting students to reflect on and recognize the limits of their own knowledge and when to defer to experts (i.e., practice intellectual humility/epistemic dependence) may also help them navigate complex SSI (Allchin, 2023b; Barzilai & Chinn, 2020; Bromme & Goldman, 2014; Chinn et al., 2021; Höttecke & Allchin, 2020; Kienhues et al., 2020; Osborne & Pimentel, 2022).

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For educators, supporting the development of intellectual virtues in classroom contexts relates to how we cultivate the environment and the modelling we do for our students over the term. Teachers can encourage curiosity and ask questions in their classroom, provide space to respectfully discuss multiple perspectives, and provide examples (personal or historical) to demonstrate why it is a good thing (and, in fact, core to the practice of science) to change your mind on a science/health issue when new evidence emerges. Chinn et al. (2021) suggest: "as a start, teachers can bring in data that are messy and information that is questionable. Or teachers might hold explicit discussions about core intellectual virtues… that are relevant to their planned class activities" (p. 51). When thoughtfully planned, these virtues can be incorporated into activities, discussions, and assignments throughout the term, while meeting knowledge and skill outcomes in curricula.

Connecting SSI and the Nature of Science (NoS)

Another theme that emerged from my reflections, largely based on the literature I reviewed (see Brown, 2026), was the intertwining of SSI and NoS. SSI can be leveraged to develop NoS understanding (Maia et al., 2021) and, conversely, a nuanced NoS understanding may support citizens navigating complex SSI (Höttecke & Allchin, 2020). Further, NoS instruction may help to combat misinformation, as harbouring misconceptions about science is associated with denialist rhetoric and rejection of scientific expertise (Feinstein & Waddington, 2020; Kienhues et al., 2020). Discussion continues about what NoS instruction should entail (Allchin, 2011; Lederman & Lederman, 2014; Stroupe et al., 2024); however, some NoS ideas may help students navigate SSI and spot misinformation. These include:

- Scientific knowledge is tentative and evolving as new evidence emerges. Science cannot provide 100% certainty or absolute proof (Allchin, 2023b; Bellocchi et al., 2022; Benjamin & McLean, 2022; Duschl, 2020; Feinstein & Waddington, 2020; Lombard et al., 2020; Maia et al., 2021).
- Scientific knowledge is trustworthy because experts develop it through consensus-building. Consensus does not mean that all experts agree. Experts are people who have specialized knowledge gained through education (graduate degrees), training, and experience working and/or conducting research in the field (Allchin & Zemplén, 2020; Benjamin & McLean, 2022; Cook et al., 2017; Kienhues et al., 2020; Osborne & Pimentel, 2023; Valladares, 2022).
- Consensus in the scientific community differs from public consensus. Public debate/controversy about science or health topics does not necessarily reflect the perspectives of the scientific community (Höttecke & Allchin, 2020; Lewandowsky et al., 2017; Scheufele & Krause, 2019; Sharon & Baram-Tsabari, 2020).
- The nuance, context and complexity of scientific research/topics are often lost in translation to lay audiences. Scientists/researchers communicate and debate ideas through peer-reviewed literature and presentations at academic conferences (Allchin, 2023b; Benjamin & McLean, 2022; Höttecke & Allchin, 2020; Osborne & Pimentel, 2023).

SSI provide rich opportunities for teachers to address multiple NoS learning outcomes in curricula (in addition to knowledge and skill/attitude outcomes) and address potential misinformation students may encounter, as explored in Table 1. Ideas for classroom implementation are also described in Table 1.

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Table 1

Exploring Core NoS Ideas Through SSI as a Response to Some Common Mis/Disinformation Tactics

Mis/Disinformation Tactic	Related NoS Idea	Ideas for Classroom Implementation
Unrealistic expectations/ burden of proof. e.g., *"I won't get vaccinated unless there is a guarantee of no side effects."*	Scientific knowledge is tentative and evolving, but trustworthy. Science cannot provide 100% certainty or absolute proof.	Discuss how knowledge is developed in science (show the struggle, see Duschl, 2020). Explore the limits of science (science can provide pretty good knowledge, but not absolute proof). Use local/current SSI to practice weighing evidence *(e.g. should drinking water be fluoridated?).*
Use of fake experts or unqualified individuals weighing in on science and health topics. e.g., *Someone claiming to be a chiropractor on YouTube tells you that home-made sunscreen is safer than commercially available sunscreen.*	Scientific knowledge is trustworthy because it is developed through consensus building among experts. Experts have specialized knowledge gained through education, training, and experience working in the field.	Use historical examples that describe the gradual development of scientific knowledge. Teach students about what expertise means and how to evaluate expertise in science/health. Have students make evaluations of experts/non-experts on SSI/topics related to curricula. Use *lateral reading* to gather information on sources (Scheibenzuber et al., 2021).
Fear mongering/manufacturing uncertainty. e.g., *Cigarette companies continued to cast doubt on the scientific consensus that cigarettes were harmful to health (see Oreskes & Conway, 2010).*	There is a difference between consensus in the scientific community and consensus in the public. Public debate/controversy about science topics does not mean it is controversial in the scientific community.	Differentiate between scholarly and non-scholarly sources of information. Teach students about false-balance media coverage (Cook et al., 2017; Höttecke & Allchin 2020; Koehler, 2016). Use examples of SSI where the body of scientific evidence was/is not well reflected in public discourse: climate change, GMO's, cigarettes, sunscreen, raw milk.
Appealing to emotion, hyping and sensationalizing content to encourage clicks/likes/shares. e.g., *Synthetic chemical in consumer products linked to early death, study finds (LaMotte, 2021).*[6]	The nuance, context and complexity of scientific research is often lost in translation to lay audiences.[a]	Have students compare and discuss popular articles and the scientific (scholarly) articles they are based on (see Lombard et al., 2020). Prompt students to pause and consider the trustworthiness of information sources and the reason information is being shared (Herrick et al., 2023; Osborne & Pimentel, 2022; Vamanu & Zak, 2022).

Note. Mis/disinformation tactics identified in this table were derived from a variety of sources, including Cook et al. (2017), Lewandowsky and van der Linden (2021), and Oreskes and Conway

[6] For more information on why this headline is misleading, see American Chemistry Council (2021).

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(2010). Table 1 did not differentiate between misinformation and disinformation, as some tactics/ways of thinking (e.g., unrealistic expectations) could apply in both contexts.

[a] Journalists and others who translate scholarly research to lay audiences may unintentionally misrepresent science (misinformation). In contrast, others deliberately use tactics like appealing to emotion, hyping, or sensationalizing content to spread false information (disinformation).

Question 2: How Might Teachers Be Prepared for the Challenges Inherent in Implementing SSI?

Based on my reflections, challenges faced by teachers related to the implementation of SSI may include lack of confidence related to teaching controversial SSI, concern over caregiver/community backlash, gaps in knowledge related to SSI, inadequate resources for introducing emerging SSI,[7] lack of time to implement SSI or feeling constrained by curricula, and/or lack of support from administrators.

Lack of Confidence, Fear of Backlash, and Gaps in Knowledge

Lack of confidence and concerns about backlash related to teaching controversial SSI were two key themes in reflections on my experience teaching and offering PD to teachers. In my reflections on the PD sessions I delivered, I recalled that teachers were concerned about navigating challenging conversations or circumstances in their classrooms and feared caregiver backlash for introducing controversial topics (specifically, vaccines or masking mandates during COVID-19). That is, teachers expressed concern about implementing controversial SSI and their preparedness to respond to unexpected circumstances, which I also experienced as a classroom teacher.[8] Similarly, Hall and Woika (2018) identified that American teachers may fear teaching evolution due to concerns of inciting conflict. In the Canadian context, Asghar et al. (2007) explored pre-service teachers' perspectives on teaching evolution; they reported concerns related to their understanding of evolutionary science, pedagogical knowledge, and the religious beliefs of students and parents.

Concerns about subject-area/content knowledge may also affect teachers' implementation of SSI. I recall feeling nervous about introducing immunity and vaccines in my first year teaching Science 24 because I had limited background in this area, which constrained the types of activities I felt comfortable implementing in my classroom. Similarly, Bird et al. (2022) described how post-secondary biology educators in New Zealand felt they "lacked the expertise to discuss these topics [gender and sexuality] in depth and access useful resources that could be provided to students" (p. 233). McNeal et al. (2014) focused on American teachers' subject-area knowledge of climate change and found that, despite educators being generally knowledgeable, misunderstandings persisted. Further, teachers' knowledge and perceptions of climate change differed by political orientation (McNeal et al., 2014). In my reflections on the PD workshops I offered, participants did not describe concerns about subject area knowledge as a factor that influenced their participation; however, it is plausible that teachers who attended the sessions were interested in expanding their knowledge of vaccines or COVID-19. Furthermore, some discussion about the political climate in teachers' communities arose during the PD sessions. Similarly, in a survey exploring the experiences of Canadian and American social-studies and science teachers,

[7] Such as COVID-19 vaccines in 2021, when I first developed the PD sessions.

[8] I recall, in particular, an instance where I was unsure how to respond to a student who told me they were not vaccinated because their parents did not believe in vaccination. I was concerned about offending the student and their parents.

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Waddington et al. (2024) reported that teachers' approaches to teaching controversial issues were impacted by the political climate in which they worked. Future exploration of how teachers' political orientation and the political orientation of the broader school/community impact SSI implementation in Canadian classrooms could provide greater insight into the complex realities teachers face.

Not Enough Resources, Not Enough Time

Lack of resources and time to implement SSI was another theme in my reflections, particularly from the PD sessions I delivered, where teachers expressed difficulty finding quality resources on COVID-19 and COVID-19 vaccinations. This may have been because information was rapidly evolving during that period of *science-in-the-making* (Herman et al., 2022). Further, discussions with teachers highlighted that providing opportunities to explore nuanced SSI can be difficult in content-heavy courses, where they felt constrained by the knowledge outcomes they needed to cover. Similarly, the literature I reviewed critiqued current curriculum documents for underemphasizing SSI (Beatty et al., 2021; Field et al., 2023; Höttecke & Allchin, 2020; Kienhues et al., 2020; Zhao, 2019),[9] as was mentioned under Question 1. For example, Beatty et al. (2021) argue that current science education is "divorced from social issues" (p. 1) and too focused on scientific knowledge and methods. Similarly, Zhao (2019) suggests that:

> We may have placed too much emphasis on the instrumental purposes of STEM [Science, Technology, Engineering and Math] education, on its uses and functions for global competition, job security, and monetary gain, and not enough on learning the art of thinking and transferring such learning to students' social and personal lives. (p. 394)

When curricula continue to prioritize preparing future scientists and acquiring knowledge for the sake of innovation and economic competition over socio-environmental well-being, teachers may be limited in their ability to integrate SSI.

Will My Administration Back Me Up?

The last theme from my reflections was that some teachers may lack support from upper administration related to teaching controversial SSI. Teachers highlighted the importance of a supportive administrative team in their decision-making around whether or how they might include topics like COVID-19 vaccinations in their classrooms, particularly if they were concerned about caregiver or community backlash. Anecdotally, teachers may feel more confident in integrating these topics if they expect administrators to support them if a caregiver or community member questions what is happening in their classroom. Conversely, one participant described an instance where a superintendent explicitly instructed teachers not to discuss COVID-19 vaccines/mask mandates. Others have identified a lack of administrative support (e.g., Chen & Xiao, 2021) as a factor related to teachers' implementation of SSI.

Recommendations and Possible Solutions

Based on the reviewed literature, my reflections on teaching, and conversations with science educators, I propose four recommendations to address the challenges teachers face in

[9] The majority of these papers were written outside the Canadian context. Specifically, Beatty et al. (2021) and Zhao (2019) were writing from an American perspective. Höttecke & Allchin (2020) and Kienhues et al. (2020) were writing broadly but are situated at German and American institutions.

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implementing SSI. These include curriculum and assessment modifications, professional development, resource development/curation, and support from school administrators.

Modifications to Curriculum and Assessment

As described in previous sections, scholars have called for increased emphasis on SSI across science curricula (Duschl, 2020; Hodson, 2020; Lima & Nascimento, 2022; Viehmann et al., 2024). Shifting the focus of curricula would signal to teachers, students, and the public that understanding the social dimensions of science and engaging with SSI are core priorities of science education and could better realize the goal of preparing future citizens as competent outsiders with respect to science (Erduran, 2023; Feinstein & Waddington, 2020; Lima & Nascimento, 2022). This work needs to be done thoughtfully—not by adding more to curricula, but rather by deepening engagement with issues and allowing time for exploration and conversation. For example, Viehmann et al. (2024) argue that curricula should explicitly integrate risk evaluation and the translation of knowledge into action, so that students are better prepared to navigate decision-making related to future social and environmental challenges. In addition, opportunities to further integrate digital/media/information literacy in science curricula could be explored (Höttecke & Allchin, 2020). In the Canadian context, this could be taken up through the lens of science, technology and society (STS) and science, technology, society and environment (STSE), building on the work of Aikenhead (2006), Pedretti (2005), and Pedretti and Nazir (2011).[10] Other curricula could also be modified to emphasize the interdisciplinarity of SSI; for example, Viehmann et al. (2024) advocate for greater emphasis on SSI in social studies curricula. Interestingly, a recent analysis of how climate change was incorporated into Canadian curricula by Field et al. (2023) reported that in some provinces (e.g., Manitoba and Ontario), social studies curricula included more climate change expectations than science curricula. Future research in the Canadian context could explore how social studies, science, and other curriculum documents engage with other SSI, and where opportunities for cross-curricular exploration of SSI might exist.

Another consideration is whether science curricula should identify specific SSI, or whether teachers should have choice in the topics addressed. Lima and Nascimento (2022) recommend that the "decision on which socioscientific issues should be addressed … is collectively constructed by the teacher and the school community, based on concrete problems and concerns of the community" (p. 1377). However, leaving decisions of which SSI to address up to local groups could be logistically difficult for schools and teachers. From my perspective, teachers and students should have opportunities to select SSI relevant to their local context and interests, but some SSI should be required in science curricula. Specifically, globally spanning issues, particularly those where citizens are likely to encounter misinformation such as climate change and vaccinations, should be included as an invitation for students to begin to familiarize themselves with the scientific evidence related to these topics, practice digital and information literacy skills, and learn to engage respectfully with one another. Including such topics in curricula could help students become better informed and engaged future citizens (Morote & Hernández, 2022).

In advocating for curricular change, I also acknowledge that implementing new curricula is slow and cannot easily adapt to the realities of an ever-evolving information environment and yet-unforeseen SSI. Modifying assessment may be a more effective starting point for driving change. To Osborne and Pimentel (2022), assessment is "the most powerful and immediate lever"

[10] For more on the relationships between STSE, SSI, and "science-in-context" (Bencze et al., 2020, p. 825) approaches, see Bencze et al. (2020).

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(p. 5) in addressing scientific misinformation and better preparing students to evaluate SSI. Because assessments are high stakes, they serve as an important signal to both teachers and students (Osborne & Pimentel, 2022). A notable example of this shift is the *Programme for International Student Assessment* (PISA), which, for 2025, added a new competency which evaluates students' ability to "research and evaluate scientific information, claims and arguments in a variety of representations and contexts, and draw appropriate conclusions" (OECD, 2023, p. 23). Specifically, 15-year-olds who take this exam are now assessed on their ability to:

- Search, evaluate and communicate the relative merits of different sources of information (scientific, social, economic, and ethical) that may have significance or merit in arriving at decisions on science-related issues, and whether they support an argument or a solution;
- Distinguish among claims based on strong scientific evidence, expert vs. nonexpert, and opinion, and provide reasons for the distinction; and
- Critique standard flaws in science-related arguments using epistemic and procedural knowledge, e.g., poor assumptions, cause vs. correlation, faulty explanations, generalizations from limited data. (OECD, 2023, p. 23)

The inclusion of these competencies in PISA 2025 highlights the OECD's (2023) increased emphasis on evaluating skills necessary for navigating SSI and misinformation. Once data on the quality of such assessments is available, standardized assessments within Canada (i.e., provincial tests, where applicable[11]) could follow suit and adopt similar competencies.

Professional Development

Another recommendation emerging from my reflections is the need to train pre- and in-service science teachers. Areas of focus for PD programs may include deepening knowledge of key SSI (Morote & Hernández, 2022; Sullivan et al., 2014), developing teachers' epistemic cognition (Bellocchi et al., 2022) and understanding of the NoS (Farmer, 2020a, 2020b; Watson & Ragoub, 2025), developing information/digital literacy skills (Breakstone et al., 2018; Burron & Pegg, 2021; Ginosaur & Tal, 2018), and debunking skills (Schubatzky & Haagen-Schützenhöfer, 2022).

Deepening Teachers' Knowledge of Key SSI

As described previously in this paper, teachers' self-perceptions of confidence and expertise may impact their implementation of SSI (Bird et al., 2022; McNeal et al., 2014). Further, depending on their educational background and teaching experience, teachers may have limited background knowledge of specific SSI (Bird et al., 2022; McNeal et al., 2014), or the field may have advanced since they last formally studied it. Consequently, professional development should deepen teachers' subject area knowledge of specific SSI, especially in instances where prolific research is taking place (e.g., Artificial Intelligence [AI]) or where misinformation is common (e.g., vaccinations). Furthermore, PD topics should be driven by the teachers' needs and interests and aim to bolster teachers' confidence.[12] Thus, research in the Canadian context that explores teachers' perceptions of their own PD needs around SSI should drive the delivery of future opportunities.

[11] Not all provinces and territories within Canada have provincial assessments, and there is variability between provinces in testing systems (Cowley & MacPherson, 2022).

[12] An example of a future topic of interest could be generative AI, which PD programs could explore as an SSI while concurrently supporting teachers to build AI literacy (Estaiteyeh & Mindzak, 2025).

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Developing Teachers' Epistemic Cognition and Understanding of NoS

Epistemic cognition, while variously characterized, relates to an individual's ideas about knowledge and knowing (Bellocchi et al., 2022; Hofer, 2016). Greene et al. (2016) define epistemic cognition as "how people acquire, understand, justify, change, and use knowledge" (p. 1). In science education contexts, epistemic cognition has been linked to NoS, which describes the epistemological underpinnings of science (i.e. what science is and how knowledge is generated in science) (Greene et al., 2016; Höttecke & Allchin, 2020; Sinatra et al., 2014). Developing students' epistemic thinking and understanding of knowledge development in science was a primary focus of the literature I consulted during the scoping review (e.g., Barzilai & Chinn, 2020; Lombardi et al., 2016; Tseng, 2018), but teachers' epistemic cognition and understanding of NoS is also worthy of attention. Specifically, Bellocchi et al. (2022) highlight the importance of developing the epistemic cognition of science teachers, which is "a necessary step before pedagogies like those we have discussed [which aim to enhance students' epistemic cognition—including science inquiry, NoS, refutational texts, and developing communities of knowledge] can be widely embraced and understood" (p. 48). Similarly, Chinn et al. (2020) acknowledge that implementing discussions and activities in classrooms that prompt students' epistemic cognition may be challenging for teachers and recommend that teachers take opportunities to "slowly expand their repertoire" (p. 177) of approaches that support students to develop apt epistemic aims, criteria, and processes.

PD programs around NoS may be one way to enter these conversations and develop teachers' epistemic cognition. Indeed, direct and explicit instruction in NoS may be necessary to shape how teachers perceive science and teach the epistemic aspects of science (Farmer, 2020b; Watson & Ragoub, 2025). In the Canadian context, Watson and Ragoub (2025) highlight that secondary science teacher education programs may have limited inclusion of the nature, history, and philosophy of science. Thus, future PD programs in Canada could address these gaps. Drawing connections between SSI, such as COVID-19 and NoS, was not a key focus of the PD sessions I delivered between 2021 and 2024; however, moving forward, I would more explicitly focus on NoS and encourage teachers to do so in their classrooms as well.

Supporting Teachers' Information/Digital/ Media Literacy and Debunking Skills

Based on the literature and my reflections, PD on information/digital/media literacy could support science teachers in navigating SSI and responding to misinformation (Breakstone et al., 2018; Burron & Pegg, 2021; Schubatzky & Haagen-Schützenhöfer, 2022). For example, Burron and Pegg (2021) highlight that pre-service science teachers may be overconfident in their search behaviours and suggest that pre-service teacher instruction should include demonstrations of search string construction, using databases and search engines, and using curriculum documents in generating relevant search terms. Effective searching skills could help science teachers locate resources related to their teaching (Burron & Pegg, 2021) and could better prepare them to model these skills for their students.

In addition to support with information searching, teachers should also be able to access PD opportunities on how to evaluate online information and sources (Breakstone et al., 2018; Sinatra & Lombardi, 2020) and that explores how digital media impacts the communication (and miscommunication) of science (Allchin, 2023b; Schubatzky & Haagen-Schützenhöfer, 2022). For example, Schubatzky and Haagen-Schützenhöfer (2022) argue that teacher education should:

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> Not only address digital media or the digital landscape from an effectiveness point of view (e.g., how can we use digital media to enhance learning processes), but also thematize how digital media and growing digitality shape how we as consumers interact with science. (p. 16)

Teachers also need time to discuss how to respond to misinformation, for example, how they might prepare in advance to address common false claims (prebunking/inoculation)[13] or what they might do if misinformation arises unexpectedly (debunking) (Schubatzky & Haagen-Schützenhöfer, 2022).

Schubatzky and Haagen-Schützenhöfer (2022) provide an example of how PD programs on SSI can incorporate information/digital literacy skills and explicit instruction on pre- and debunking. In their exploratory case study, they developed an intervention for pre-service physics teachers that included both inoculation/prebunking and debunking around climate change misinformation. Their intervention improved the teachers' debunking skills and perceived knowledge about climate change. Further, these authors found that pre-service teachers "greatly overestimated their actual debunking skills before the intervention. However, through the intervention, the participants not only regained their initial level of self-efficacy, but they were also able to better self-evaluate their actual debunking skills" (p. 15). This case study, while preliminary, is significant because it highlights that teachers may overestimate their debunking skills, and that interventions for teachers that focus on pre/debunking in the context of SSI may positively impact teachers' knowledge about the SSI addressed (climate change, in this example) and ability to pre/debunk misinformation. Taken together, these studies suggest that future research is needed to explore how similar interventions impact teachers' classroom practice, and that investing in PD for science educators is warranted to better prepare teachers to evaluate information, identify misinformation, and model these skills for students (Breakstone et al., 2018; Burron & Pegg, 2021; Hodson, 2020; Schubatzky & Haagen-Schützenhöfer, 2022; Sinatra & Lombardi, 2020).

In reflecting on the PD sessions I offered, teachers responded well to integrating digital literacy skills into discussions and activities around SSI. As part of the sessions, I provided a list of common questions and misinformation around COVID-19 and COVID-19 vaccinations, encouraging teachers to look up information online to address one of these questions (or another of their choice) with a partner. Next, we discussed the strategies we used to locate and evaluate information and how we might respond to particular questions/claims in a classroom context. Anecdotally, this component of the PD session prompted rich and engaged discussion, sharing of teachers' personal experiences, and opportunities to compare and contrast different approaches to information searching and evaluation that could be modelled for students.

Bringing It All Together

Based on my reflections, future PD could support teachers to name, use, and model strategies to evaluate information (e.g., click restraint, lateral reading) and respond to misinformation (e.g., inoculation and debunking). Further, future PD could incorporate opportunities to connect information/digital/media instruction to SSI and deeper conversations around NoS (Breakstone et al., 2018; Schubatzky & Haagen-Schützenhöfer, 2022). Teachers could also be supported through

[13] Pre-bunking involves warning and preparing individuals for misinformation they are likely to encounter. Debunking involves refuting false information after it has been encountered (Cook et al., 2017).

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instruction on how to integrate their learning in the classroom context and by providing time to plan with colleagues to ensure coverage across grades and subjects (Breakstone et al., 2018).

Resource Development

Informed primarily by my reflections as a science educator and teacher educator, resource development and curation of pre-existing resources is another area where teachers could be better supported in engaging with SSI. Specifically, there should be funding and time to create and compile resources around emerging SSI. Investments from school districts, governments, or post-secondary institutions could support initiatives where teachers can collaborate and/or consult subject matter experts[14] to develop resources that could be shared widely. Furthermore, resources that are easily modifiable and applicable across a broad range of topics and grades (e.g., discussion frameworks, digital literacy tools) would be highly valuable for teachers (Burron & Pegg, 2021). Finally, sharing of resources, whether newly developed or collections of resources that have been curated and vetted by experienced educators, will be most powerful if accompanied by PD that explores how teachers could employ them in practice (Chinn et al., 2021).

Support from Administrators

The need for support from administrators emerged from my reflections on the PD sessions I offered, as well as my own classroom teaching experiences. Anecdotally, teachers may feel more confident teaching SSI when they can approach administrators with concerns or questions, engage in open dialogue, and know administrators will support them when caregiver or community concerns arise. Based on these reflections, the following recommendations are offered to administrators:

- consider and identify which SSI may be controversial or divisive in your community;
- be proactive in connecting with science teachers and department heads/subject area leads regarding how they approach these topics, and how these topics relate to science curricula (i.e., identify specific connections to grades, courses, units) and broader frameworks (e.g., STSE, Indigenous Ways of Knowing);
- draft potential scenarios in collaboration with teachers (e.g., caregiver concern over teaching content, student disagreement in class) and identify appropriate responses for teachers and administrators;
- collaborate to co-create clear and consistent expectations for students, caregivers, and community members with respect to bringing concerns forward; and
- prioritize opportunities for science teachers to attend PD programs that could support them to navigate these topics/issues.

Administrators, like teachers, cannot predict all circumstances they might encounter when integrating complex SSI in schools; however, some advance consideration and preparation may make navigating difficult situations easier.

[14] For example, the resources and PD sessions I offered were supported by the Centre for Mathematics, Science and Technology Education at the University of Alberta, with funding from Glyconet. Through this partnership, I was able to meet with experts including Dr. Dawn Bowdish (Immunologist and Canada Research Chair, Department of Pathology and Molecular Medicine, McMaster University) to support the development of resources for teachers around COVID-19 and vaccine hesitancy.

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Limitations

Themes reported in this article should be taken in the context of the following limitations. First, this work is a reflective commentary, and though it is informed by my experience conducting a scoping review, it does not have the methodological rigour of a scoping review. Further, the themes presented here were impacted (and limited) by the search terms used to locate papers. Thus, if alternate terms had been used (for example, to focus on barriers to SSI implementation or teachers' experiences), additional literature may have been located that contradicts or supports the themes identified herein. Finally, my reflections on the PD sessions and my teaching were based on anecdotes and personal experiences and do not represent the experiences of teachers across Canada. Future review studies that explore teachers' experiences related to the integration of SSI, like the work of Chen and Xiao (2021), and additional research on teachers' implementation of specific SSI (e.g., COVID-19, vaccines) within Canada could address some of these limitations.

Final Thoughts

Science education plays a crucial role in equipping students to navigate complex and polarizing SSI. However, it requires teachers to invite in the topics, conversations, and technologies that are sometimes eschewed from classrooms. To better prepare students to analyze SSI and identify science and health misinformation critically, I argued for increased curricular emphasis on SSI and an enhanced focus on information/digital/media literacy, intellectual virtues, and NoS ideas. Teachers face challenges integrating SSI in their classrooms. However, curriculum and assessment modifications, expanded PD programs, generation and sharing of resources, and expanded support from administrators could bolster teachers' efforts. This work is challenging but necessary to prepare future Canadians to engage with one another and with issues that impact us all.

Generative AI Disclosure Statement

During the preparation of this work, the author used Gemini (2.5 Flash) to decrease the word count of the paper. This involved pasting the drafted manuscript into Gemini and asking for sections that could be condensed to be indicated in bold. The AI output was then used to guide revision; text was not copied directly from Gemini. The author reviewed and edited all content in this document and takes full responsibility for the accuracy, originality, and integrity of the final manuscript. The manuscript reflects the author's own intellectual work.

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