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'I invite you to take a sip from the golden fountain and confirm these statements for yourself': preparing undergraduate science students to publicly address pseudoscientific news

Alandeom W. Oliveira [a], Oana Mirel [b] and Adam O. Brown [b]

[a]State University of New York, Educational Theory and Practice Department, Albany, NY, USA; [b]University of Ottawa, Department of Biology, Ottawa, Canada

ABSTRACT

This exploratory study examines an instructional activity in which undergraduate biology students at a Canadian university who, after receiving instruction from an expert science communicator on how to publicly address pseudoscience in online media, were asked to research online a pseudoscientific news of their choice, demonstrate how they would publicly address a pseudoscience-believing audience, and self-assess their communicative performances. An analysis of students' written reflections showed that participation in this activity fostered recognition of the importance of dialogue, with most students adopting an audience-centered (dialogic) stance that took into account the public's interpersonal needs (respect, empathy), communicative needs (comprehensible input) and epistemic needs (scientific knowledge). Yet, inspection of video-recordings of their oral presentations revealed that some students took a combative communicative approach – communicated in ways that suggested a confrontational attitude toward the public that was inconsistent with their dialogic views. Acknowledging interpersonal difficulties associated with the act of implementing their dialogical views, these students stressed the challenging nature of public science communication about fake news. It is argued that, fully developing communicative competence to address fake news requires extended and sustained instruction that allows students to progressively hone their communication skills.

KEYWORDS

Undergraduate science communication education; public science communication about fake news; pseudoscientific news in online media

Undergraduate science educators have grown increasingly cognizant of the critical importance of preparing the next generation of scientists to join a society characterized by a global trend toward disinformation. Nowhere is this trend more evident than in social media outlets, which have in recent years seen a dramatic proliferation of disinformation in the form of fake news, false theories, and pseudoscience (Iyengar & Massey, 2019; Nguyen et al., 2012). With the growing abundance of disinformation in the public sphere, trust in science has consistently eroded, scientific facts have been doubted, and scientists' credibility, competency, and objectivity has increasingly been called into question (Hardy et al., 2019). As the line between myth and reality has become blurred, it has become harder to distinguish between fact and opinion (or fiction). Moreover, the emergence of 'alternative facts' has led to confusion, panic, and propagation of false theories like anti-vaccine sentiments and denial of climate change (Lewandowsky et al., 2017; Krause, 2020), and given rise to

CONTACT Alandeom W. Oliveira aoliveira@albany.edu; jweld@albany.edu State University of New York, Educational Theory and Practice Department, 1400 Washington Ave., Catskill 227, Albany, NY 12222, USA

an online environment that is prone to supporting confirmation bias and science denial (Iyengar & Massey, 2019; Lewandowsky & van der Linden, 2021).

Concern over this rise in disinformation has prompted UNESCO and the World Health Organization to declare the existence of a 'disinfodemic' (UNESCO, 2020; WHO, 2020). Many argue that we are currently living in a 'post-truth' era, that is, a set of '[societal] circumstances in which objective facts are less influential in shaping public opinion than appeals to emotion and personal belief' (McIntyre, 2018, p. 5). In our post-truth era 'facts and objective evidence are trumped by existing beliefs and prejudices' (Lewandowsky et al., 2017, p. 361). This, in combination with the highly polarized political climate at present, has created the perfect environment for anti-science propaganda to spread and for 'truth decay' to occur.

The spread of 'fake science news' within society has made scientists' development of communication ability more important than ever. Within the context of the current disinfodemic, scientists must learn to navigate the daunting challenge of communicating with polarized individuals who may not only be confrontational, but may also feel like they have had enough of experts whose knowledge they view simply as elitist opinion (Lewandowsky et al., 2017). Communicating with these pseudoscience-believing audiences can be difficult given their tendency to be resistant to persuasion (Compton et al., 2021). One difficulty is that these individuals tend to reject factual or evidence-based information at odds with their perceived notions since it conflicts with their values and personal identities (Rekker, 2021). As such, science expert provision of challenging or correcting information becomes less likely to penetrate their cognitive structures (Iyengar & Massey, 2019). To deal with this issue, scientists need access to science communication training that can promote their ability to effectively address 'fake science' in public outlets.

Yet, scientists have been shown to be the least commonly trained group with respect to communication toward the public (Besley & Tanner, 2011). Evidence exists that scientists generally have little formal training in public science communication, even though they are now more active in public engagements than in previous decades (Dudo et al., 2021; Liang et al., 2014; Schiele & Landry, 2012). Brownell et al. (2013) point out that aspiring scientists are not sufficiently taught how to communicate science at an undergraduate level. Similarly, Gray et al. (2005) report that many science students lack the communication skills required for future employment. Experts generally agree that the level of science communication education presently offered to undergraduate science students is far from adequate (Goldstein et al., 2020; Rodrigues, 2021).

To address the above issue and illuminate ways to prepare future scientists to effectively communicate in a societal context fraught with disinformation and polarization, this exploratory study examines an instructional activity in which students in an undergraduate biology class received instruction from an expert science communicator and then set out to publicly address a pseudoscience-believing audience.

Literature review

One critical aspect of becoming an effective communicator is developing more productive and informed *communicative views* (ways of understanding social events). This is because communicative performance (how one communicates) is reflective of underlying communicative views (how one conceives of a communicative event or occasion). Bateson (1972) used the construct *frame* in reference to the frameworks of understanding that enable participants to make sense of social situations and to distinguish among different types of interactional action or activity (e.g. dialogue from debate). This theoretical construct was later expanded by Goffman (1974) who used the term *primary framework* in reference to interpretive schemata that enable individuals to recognize particular types of social events (e.g. friendly talk, combative confrontation). Simply put, a frame or framework refers to a person's sense or perception of the specific nature of what goes on in a given social engagement. For the sake of clarity, in the present paper, we avoid this more specialized linguistic terminology and instead use the term *communicative view*.

Scientists who set out to communicate science to the public have been shown to hold varied views and to take diverse approaches. Traditionally, the scientific community has taken a narrow and deficit-oriented communicative approach based on the commonly held view of public science communication as a linear and unproblematic process whereby a message (factual information) flows from a knowledgeable sender to an uninformed receiver (Leach et al., 2008; Reincke et al., 2020). This view presumes science communication to be a top-down knowledge dissemination process in which a science expert sets out to make scientific information available to an uneducated public (Besley & Tanner, 2011; Cortassa, 2016; Suldovsky, 2016).

In practice, deficit-oriented views tend to bring about science communication approaches aimed at rescuing the public from their ignorance (Gross, 2007). This is problematic as the resulting unidirectional and closed communicative style, also referred to as monologic, has been shown to be ineffective (Kahan et al., 2009), often undermining public trust (Compton et al., 2021). In addition to signaling (explicitly or implicitly) a dismissive attitude toward lay values, knowledge, and ways of knowing (Secko et al., 2013), communicating science in this manner is often perceived by the public as condescending, which can further alienate key audiences (Nisbet & Scheufele, 2009, p. 1768).

Faced with the above complications, many have come to view public science communication more dialogically. Holders of such dialogic views argue that science needs to be communicated in a way that can foster a two-way dialogue with the public (Besley et al., 2016). To be effective, science communicators need to engage the populace in respectful, patient, and empathetic conversations (e.g. MacDonald et al., 2018) wherein lay culture, values, and experiences are not simply dismissed as having less value than scientific knowledge, but rather that they are given serious consideration as an epistemic source. To accomplish this, scientists need to adopt a communicate approach that can 'open up' dialogue and give the public a voice, such as interactive discussions, allowing the audience to interject, express reservation, disagree, etc. It is also critical to communicate in an audience-focused way by selecting appropriate data and constructing targeted messages that reflects the public's core morals and beliefs (Goldstein et al., 2020) and that meets the audience's communicative needs. By considering the perspectives of others, scientists can tailor communicative approaches to specific populations, cultures, and situations, in a process known as *framing* the communicative content (Gamson & Modigliani, 1989). Such targeted and tailored communicative approach has been shown to foster public trust (Besley et al., 2016), and to improve audience retention of information (Hawkins et al., 2008; Goldstein et al., 2020).

Lastly, public science communication has also been viewed as a combative endeavor. With the advent of our highly polarized post-truth society and the spread of disinformation, many have begun viewing public communication of science as a metaphoric 'war'. From this combative viewpoint, addressing the public means 'fighting' an opposing enemy, and communicating science effectively is akin to winning a battle. Holders of this combative view see efforts to address the public as being similar to entering a battlefield where two enemies attack each other, defend their positions, etc. Central to this combative view is the presumption of agonism (Tannen, 2002) – an a priori expectation of an uncooperative audience who will be resistant and defensive, and who can even counterattack. Also assumed by the speaker is the inevitable need for confrontation, who comes ready for a 'fight.'

Holders of this combative view emphasize the need for science educators to be 'armed' with powerful rhetorical weapons such as *refutation strategies* (Songsil et al., 2019; Weeks, 2015), *debunking strategies* (Caulfield et al., 2020; Lewandowsky & van der Linden, 2021; Orosz et al., 2016), and *countering strategies* (Bode & Vraga, 2015; Swire & Ecker, 2018) that can effectively defeat fake science when addressing pseudoscience-believing audiences (i.e. win the battle). However, approaching public science communication in this combative manner can be problematic and ineffective. Recent studies have revealed that the aggressive language often used by scientists during heated debates is ineffective at gaining public trust (Dudo et al., 2021; König & Jucks, 2019). It can also give rise to communicative situations characterized by vitriolic attacks, sarcastic innuendo,

mocking, and even name-calling. The unintended result, particularly in more heated communicative situations, is audience defensiveness (an unwillingness to listen) and unproductive breaks in the channel of communication (disengagement from the communicative event) rather than informed persuasion. Such complications have led to calls for scientists to adopt more respectful, relatable, patient, and kind approaches to public science communication, which have been shown to enhance message credibility and persuasiveness (Saffran et al., 2020). By being less adversarial and more respectful, scientists can create compelling messages that an audience is more likely to empathize and engage with (Dahlstrom, 2014; Schoofs et al., 2019).

In sum, varied views and approaches to public science communication have been documented and advocated in the existing literature, underscoring the need for an improved theory-based understanding of how to prepare novices in the scientific fields to effectively communicate science to the public in a disinfodemic era of post-truth. Toward this end, the present study examines a group of undergraduate science students at a Canadian university learning to communicate with opposing audiences about fake science. After researching a fake science item online, students were asked to respond in writing and then orally demonstrate how they would publicly address it. Our specific research questions are as follows:

(1) How did students view public science communication about fake news?
(2) How did students approach oral performance of public science communication about fake news?
(3) How did students self-assess their performance of public science communication about fake news?

Our dual focus on communicative views and performance is informed by previous scholarship emphasizing the critical importance of *belief* and *action* to professional learning (Richardson, 1996). Not only do beliefs drive actions but reflection on action can also influence beliefs. As such, effective preparation of future professionals requires participation in activities that can help novices developed informed beliefs about science communication that are necessary to enact communicative tasks commonly performed by professional scientists (Yerrick et al., 1997). To this end, we designed a learning experience centered on reflective practice of public science communication about pseudoscientific news in online media (described below).

Methods

This exploratory study adopts a mixed-method research approach (Bogdan & Biklen, 2003; Creswell, 2007), relying on multiple methods of data collection such as student written reflection/self-assessment and video recordings of oral presentations. These were systematically analyzed as part of an exploration of undergraduate students' emergent views and oral performances of public science communication about pseudoscientific news. Such an exploratory research design reflected the largely underdeveloped state of science communication research on the professional preparation of future scientists to publicly address pseudoscience in the media.

The main premise of our mixed-method approach is that expertise development is highly elusive and complex. Our decision to systematically combine quantification and qualification of student communicative belief and action as part of our exploratory work was aimed at providing a richer and more holistic view of this developmental phenomenon than would be possible using either method independently (Greene, 1994). Moreover, using a mixed methodology provided opportunities to triangulate data, reinforce significant ideas (i.e. complementarity), and increase the depth and breadth of emerging themes (i.e. expansion; Greene, 1994). This in turn helped reinforce and validate emergent ideas and provided additional insight that may not have been evident from either analytical method alone.

Participants and setting

Participants in this study included a group of undergraduate science students taking a third-year course called *The Public Communication of Science*. Enrollment consisted of a total of 26 students (see Appendix 1 for a comprehensive list of pseudonyms). The course was taught by the second author (henceforth referred to as Author 2) who held a Ph.D. degree in biology and had approximately 15 years of undergraduate teaching experience and expertise in science communication. Designed to prepare future scientists to communicate science to various non-specialist audiences, the class met twice over the course of two weeks, firstly for a 1.5-hour lecture and then for a 1.5-hour recitation session. The course was structured as a seminar with regular guest speakers – specialists in communicating science to the public from various sectors of society. It covered topics such as public speaking, talking to the media, and government policy reports and briefings. In the fifth and sixth week, the focus was on *addressing pseudoscience and anti-scientific rhetoric online*. Spanning one entire lecture and a recitation session (total of 3 h), the set of classroom activities implemented during these particular weeks (our instructional activity) were subjected to analytical scrutiny in the present study. There were no student absences during this pseudoscience learning module.

The guest speaker for the week was a professional Canadian science communicator who frequently investigates pseudoscientific claims and comments on these issues in the media. The guest speaker received logistical as well as pedagogical support from Author 2 who not only made all logistical arrangements for the sessions (scheduling, room reservations, materials, etc.) but also shared his own insights on science communication about fake news during discussions by elaborating, offering additional examples, etc. Their relationship throughout the instructional activity was one of *complementary expertise* (Jacoby & Gonzales, 1991) – two collaborative experts who complemented each other.

In the first lecture, the guest speaker gave an interactive PowerPoint presentation entitled '*Investigating Pseudoscience and Bad Science*'. Presentation of ideas/topics was followed by discussions with active participation from the course instructor (Author 2) and students (a sample discussion is provided below). Lasting approximately one hour, the presentation comprised several parts, each focused on one of the following framing questions: What is pseudoscience? Why should we care? How to investigate pseudoscience? How does disinformation spread? How do I respond to science denialism? (See Figure 1 for several PowerPoint slides shown by the speaker). Students were provided with definitions, numerous examples, and were introduced to theoretical perspectives such as the science-pseudoscience spectrum as they were encouraged to recognize the nuanced nature of pseudoscience and the demarcation problem of accurately distinguishing between good and bad science. Additionally, students were provided with instruction on how to identify fake science using signs such as poorly conducted surveys, lack of peer-review, lack of or cherry-picked evidence, absence of progress and lack of a plausible mechanism. The guest speaker also shared a *meta-analysis review* – a series of questions to evaluate the quality of science news in the media: Who conducted it? How was it financed? Where was it published? How recent is it? Are there others? Do they agree?

During the presentation, students were also given tips on how to address fake science when communicating with the public. Several communicative strategies were presented, including showing kindness, sharing audience values in message, using storytelling, allowing the audience to come to their own conclusions, providing science-based alternatives and explanations against false beliefs, and avoiding paternalism (Figures 2 and 3). These strategies were reflectively considered and at times demonstrated through provision of illustrative examples.

Throughout the presentation, participants engaged in numerous discussions about effective ways of communicating with pseudoscience believers. For instance, halfway into the presentation, a student identified ageism as possible difficulty commonly faced by younger scientists when trying to address fake science news:

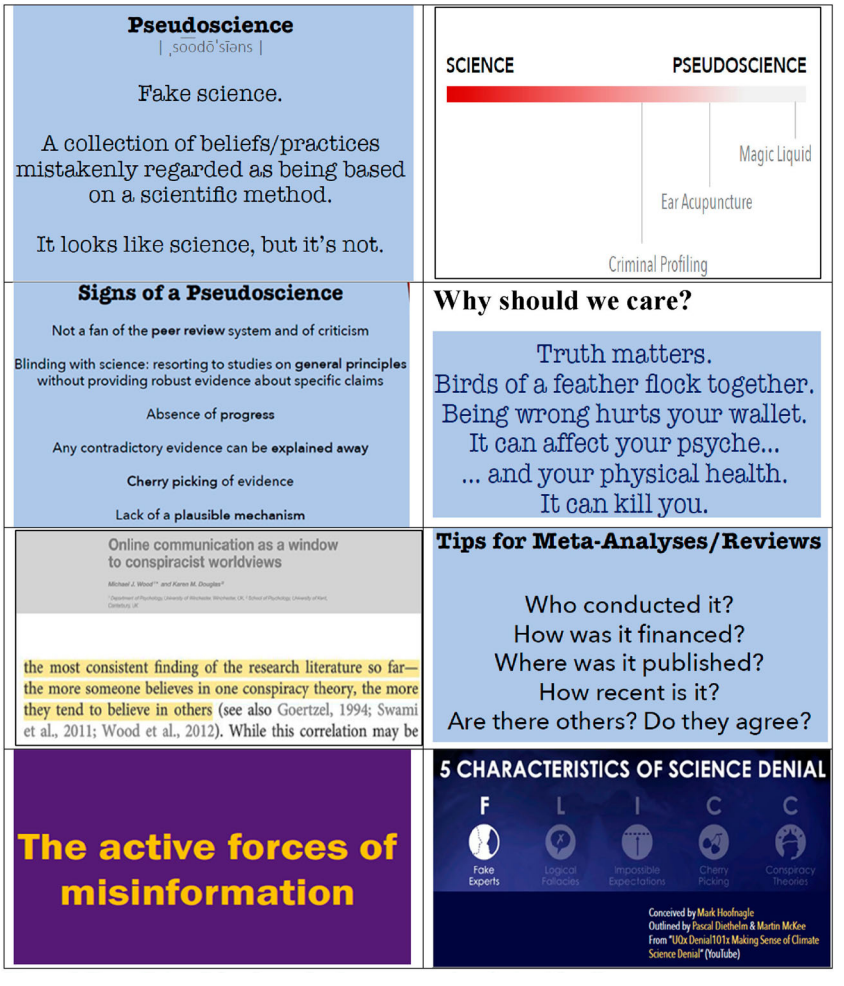


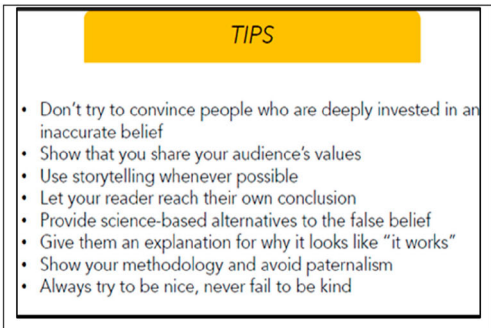
Figure 1. PowerPoint slides shown by the guest speaker during his talk.

Mariah: Usually when I enter in these kinds of debates about pseudoscience, I find that a lot of people, especially when they are older, try to use your age as a reference to the amount of experience that you have, so I was wondering if you have any advice on how to tackle that kind of defense mechanism.

Guest Speaker: I do agree that unfortunately there is this sort of bias where anybody with white hair on the news speaking about an issue will be taken seriously, but you can offer yourself not as the arbiter of truth in a sense, but as a messenger. Like '*Hey, here are the studies I found, do you have better studies? I didn't do these studies, but these studies are out there, these are the conclusions, and they seem to be well done, what do you think?*'

Author 2: It's unfortunate to be treated on the receiving end of any kind of -ism, and this ageism is an uphill battle. I think it is very useful not just to say *Here is the evidence, period*, but to give them an opportunity to explain theirs, then it is not so much '*You seem older and therefore more knowledgeable, and I'm younger therefore not. Let's hear your information*'. Like you are opening up the conversation. It is a rhetorical tool by creating a space that is less confrontational, it seems more like a dialogue, and it also gives them an opportunity to reflect on how valid the information is that they are bringing to the table. It's hard to do, I'll tell you, especially when you are being treated to some -ism of some kind.

Guest Speaker: You may want to look into the Socratic dialogue, which is a way of dealing with this kind of people in a very gentle way … you are kind getting them to the point where they will



Guest Speaker: So, a few tips on how to go about this [addressing fake news]… it can help to show that you share your audience's values. One talk that I saw on GMO's was very inspiring because he [presenter] started by asking all of us in the audience *What do you want in your food supply?* And people are saying *Well, I want it to be safe, I want it to be affordable, I want it to be nutritious, and diversified.* And, he said *Those are all great things, I want the same thing that you want, I also want these things.* So, all of the sudden you realize that the person in front of you who will argue that genetically engineered food is safe to eat, he is on the same side as you, he shares your values on this particular issue, so now is no longer a confrontation, you are trying to look at the evidence together. That can help dampen the polarization. Storytelling is something that we often talk about in science communication, it's not always easy to do, it's not always done, but as much as possible try to tell stories. The human brain loves a good story, that's a good vehicle for scientific information.

Figure 2. Slide and accompanying commentary provided by the speaker while giving tips to students on how to address fake science news.

themselves realize that they are in error. It doesn't always work, and in social media, people can come in and derail the conversation, but this Socratic dialogue is an interesting tool in your tool kit.

Author 2: Absolutely, just to clarify, the Socratic method, also known as the elenctic method, is basically just the process of asking questions, it's kind like '*Now you take turn and explain things, I'm listening, I want to actually understand you, so here you go explain yourself*'. I mean, you don't have to be as challenging as that, just to kind of put it in straightforward terms.

At the end of the presentation, students were provided with a communication task, which was to be completed for the following week's recitation session. Namely to identify a fake science item online (e.g. conspiratorial news, miracle health products, anti-scientific claims etc.), investigate it in depth, and to independently produce a one-page write-up of their investigations by answering four specific questions:

1. Briefly explain the nature of the pseudoscience you are investigating (what is it? What is it claiming to be/do?)
2. How does it get the science wrong and/or what kinds of logical fallacies does it make (signs of pseudoscience, signs of science denial)?
3. What methods would you use to address its claims?
4. How would you communicate a counterargument on the topic to the public?

The above prompts were meant to encourage our students engage in written reflection. As previously demonstrated by Shapiro et al. (2004), reflective writing can serve as a useful tool for

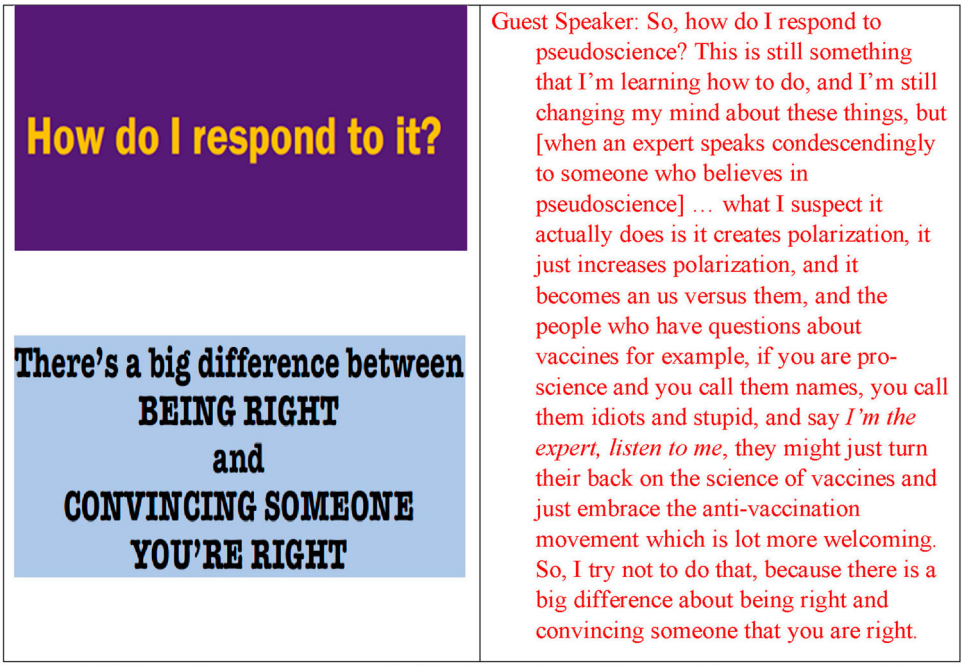


Figure 3. Slides and commentary provided by the speaker while examining a tweet posted by a science expert during an online debate.

encouraging students to engage in perspective-taking and to build empathy. The students' goal was to demonstrate their ability to address fake news. To this end, they were instructed to summarize for the class how they would communicatively engage an imagined audience of pseudoscience believers during their informal oral presentations in the recitation session.

In response, students selected a wide range of pseudoscientific topics to investigate, including various health and wellness products (e.g. diets, beauty products), medical treatments (e.g. vaccines, crystal healing), parapsychology (paranormality) astrology, phrenology, etc. A comprehensive list of pseudoscientific topics and descriptions of online sources selected by each individual student can be found in the Appendix 1. These became the topics of students' oral presentations in the second lecture. Over the course of the recitation session, the pseudoscience findings and responses from the first six students (Bret, John, Laura, Joan, Mariah, and Jack) to volunteer were presented orally, followed by detailed discussions and analysis from the professor, guest speaker, and student peers. These oral presentations became this study's focal point.

The simulated nature of the above communication task must be noted. Although students were called upon to demonstrate how they might address pseudoscience publicly, oral communication with real laypersons did not actually occur as their audience was made up of classmates and instructors who shared the speakers' scientific membership. Instead, students were communicating informally to the members of their peer classroom with an assigned *putative audience* (Martin & White, 2005) – a group of hypothetical addressees who are imagined to hold particular viewpoints and who are anticipated to react in particular ways to the points made by the presenter (e.g. find some ideas problematic). It was this imagined audience of pseudoscience believers that students addressed in their written descriptions (not the instructor or peers).

Despite the absence of a real pseudoscientific audience, this activity was designed to provide science students with an opportunity to safely experience communicative situations involving fake science they might encounter in their future professional lives, to try out new communication strategies that they can possibly use in such challenging situations, and to reflect about their

emergent communicative expertise. As such, it is consistent with recent calls for educators to incorporate role-taking activities that allow students to 'practice imagining/perceiving another's perspective' during classroom instruction (Nonaka & Konno, 1998).

Data collection and analysis

To answer our research questions, data were collected across three main sources, namely students' written assignments, video recordings of oral presentations, and students' video reflections (see Table 1). To determine how biology students viewed public science communication about fake news (Research Question 1), we used student written work (their reflective write-ups). Due to the open-ended nature of the guiding questions on the assignment guidelines, students produced highly individual and personalized responses in a paragraph format, thus allowing for the qualitative capture of diverse viewpoints. For this reason, we adopted an emergent analytical approach that was both interpretive and flexible. Although we did not conduct a full-blown grounded theory analysis (Glaser & Strauss, 1967), our data analysis borrowed several features of this well established qualitative analytical approach. Rather than simply applying a fixed, a priori code scheme to our data, themes were allowed to emerge (to reveal themselves) through an iterative process that was informed by our literature review. More specifically, students' written answers to the questions were individually evaluated and differentiated into analytical categories (themes) through the combined close reading of the data and existing research. Upon completion of this analysis, a qualitative description was produced summarizing and comparing the emergent themes. Data display in this description was enhanced through the inclusion of selected excerpts that served as representative illustrations of prominent patterns in our dataset (Dewalt & Dewalt, 2002).

The above emergent analysis focused specifically on science students' *communicative views* – how they conceived of public science communication about misinformation (e.g. dialogic vs. monologic events, having a combative or collaborative nature), how they construed a pseudoscience-believing audience (e.g. as lacking knowledge, being close-minded, being confrontational, being open to dialogue), and which communicative strategies (e.g. dialogic vs. monologic) they deemed to be most effective when addressing such an audience. Students were considered to hold either dialogic or monologic views depending on the direction of communication as presumed in their written reflections and descriptions. A *monologic view* was recorded if the student positioned his or her audience monologically (as 'silent' receivers of expert knowledge), focused exclusively on ideational aspects of public science communication (aimed at informing the public of the correct ideas and objectively and neutrally presenting the facts). Based on Löfgren et al. (2013), students were considered to hold *dialogic views* when their described approaches contained two-way (open-ended) conversations and identified communicative strategies that indicated consideration of interpersonal aspects of science communication (e.g. storytelling, questions to the audience, display of empathy, emphasis on the need to use accessible terminology, and the need to listen the audience's morals and alternative perspectives, and the need to take the audience's beliefs and needs into account).

Storytelling was included as an indicator of dialogic views since research about the effectiveness of storytelling in science communication suggests that 'dialogues among stakeholders or between

Table 1. Timeline of research activities.

Phase	Research activity
1	Approval of research project by Research Ethics Board (uOttawa).
2	Video-recording of Lecture 1: Guest Speakers' PowerPoint Presentation.
3	Collection of students' write-ups on selected fake news at the end of Recitation Session.
4	Video-recording of Lecture 2: Students' Oral Presentations.
5	Collection of students' video reflections (self-assessment via surveys).
6	Data transcription and analysis.
7	Write-up (results, discussions, conclusions, and implications).

scientists and the public mature through the stories whilst producing personal responses and emotions to science and scientific facts and topics' (Richter et al., 2019, p. 3). Moreover, narratives have been shown to be a helpful tool in accessing 'the types of meaningful engagement and critical reflection amongst participants that science communication activities strive towards' (Constant & Roberts, 2017, p. 1).

The analytical distinction made between monologic and dialogic views in this study is aligned with previous scholarship emphasizing the inherent tension in language-mediated communication between a focus on the exchanges of ideas (information) versus a focus on social relationships (Dabbs, 1985; Davison, 2003; Tracy, 1997; Tracy & Baratz, 1993; Tracy & Carjuzaa, 1993; Waring, 2002). On the one hand, communicators can be primarily concerned with sharing information, exploring and developing ideas about the world, and advancing particular positions on practical and abstract issues. For these communicators, social or relational matters such as saving face, making friends, and developing alliances and networks of social relationships are considered secondary or of minimal importance. Alternatively, discussants can be more focused on social relationships than on the exchanges of ideas and information. These distinct foci tend to give rise to message-focused discourse (e.g. lectures) and involvement-focused discourse (e.g. everyday conversations; Tannen, 1985), respectively. Message-focused discourse is formal, detached, and concerned mainly with the clear statement of content or information. Detachment (social distance) is a result of the emphasis placed by participants on the content being communicated instead of interpersonal involvement with others, who are expected to process discourse analytically and objectively by suppressing their emotional responses. In sharp contrast, involvement-focused discourse is informal, emotional, and has a high degree of interpersonal involvement (i.e. close social relationships).

Lastly, students were considered to hold *combative views* if they anticipated possible hostility, set out to confront the public, or expressed frustration toward their audience. This third analytical category emerged from inspection of the collected data considering current literature on science communication (reviewed above).

The main source of data for answering our second research question (What approaches did biology students take while orally performing public science communication about fake news?) was the video recordings of students' oral presentations. First, video-recordings were transcribed by the researchers. Informed by scholarship on linguistic representation (Bucholtz, 2000), we adopted a *naturalized transcription* style in which the transcriber attempts to preserve original discourse forms (e.g. grammatical and punctuation errors) rather than making them conform to written discourse conventions (*denaturalized transcription*).

Our analytical approach was informed by the theoretical tradition of *linguistic stance-taking* (Martin & White, 2005). We viewed utterances as being stanced in the sense that, when speakers address an audience, they inevitably encode attitudes toward it. For us, speakers inevitably adopt a stance (an evaluative attitude) toward those they address through the adoption of a particular *communicative style* (Tannen, 2005) – a preferred manner of talking. A speaker's communicative style can implicitly signal an attitude of judgement, appreciation, openness, close-mindedness, social distance, closeness, etc., interpersonally positioning the audience in certain ways (as cooperative co-speakers, opponents, dialogic partners, silent hearers, etc.).

Video data were used to assess science students' *communicative styles* while giving their oral presentations. Students' styles were determined based on the presence of stance markers such as word choices, tone, facial expressions (e.g. eye rolling, smiling, etc.), dialogically expansive moves (e.g. asking questions), dialogically contractive moves (e.g. not allowing interjections from the audience). These were taken to be indicative of the speakers' attitudes towards a pseudoscience-believing audiences. A distinction was made among dialogic, monologic, and combative styles.

To determine how students reflectively assess their communicative performances (Question 3), we resorted to video reflections. As revealed by our previous study (Oliveira et al., 2021) video-based self-reflection can serve as an effective pedagogical tool for fostering undergraduate student development of science communication skills. Informed by this work, students who gave an oral

presentation were asked to critically watch their video-recorded performances and assess in writing their own abilities to publicly assess fake science news in the media. Like the students' write-ups, this data were subjected to an interpretative analysis centered on emergent themes. The analytical focus was on how students evaluated their own efforts to translate their communicative views into action. More specifically, we sought to examine the extent to which students were aware of potential discrepancies between how they thought fake science news ought to be addressed in public and how they actually addressed them in practice.

As part of the above analyses, peer debriefing sessions were frequently held to triangulate emerging interpretations of the data. In these sessions, discursive records of students' communicative views, oral performance, and self-assessment were examined collectively, individual analyses shared, and interpretations discussed extensively. The emergent account was gradually adjusted to include any variation that surfaced from this reflective group interpretation of the data (e.g. what constituted markers of dialogism). These debriefing sessions helped guard against individual researcher biases (Robson, 2002) during our interpretative analyses. These were particularly helpful given the researchers' diverse positionalities. Author 1 had a more removed and remote positionality as a scholar who was in a different country and was not directly associated with the research site in any way. In contrast, Author 2 was the course instructor, and Author 3 was a former student who had previously attended the same undergraduate biology program. Such varied positionalities helped ensure a mixture of emic and etic perspectives.

Results

Our findings are presented in this section, focusing first on students' views of public science communication about fake news (Question 1). Attention then shifts to how students approached oral performance of public science communication about fake news (Question 2). Lastly, we report students' self-assessment of their communicative performances (Question 3). Throughout the section, underlining is used to identify key terms and phrases in our participants' quotations that were central to our analysis. Data source is identified in brackets at the end of each quote.

Students' communicative views

Overall, there was variation among students' views of public science communication about fake news. Evidence was found of dialogic, monologic, and combative views, with students adopting varied stances toward their pseudoscience-believing audiences.

Dialogic views

The majority of students (21/26) held dialogic views that were centered on needs (communicative and epistemic) of their audience. Rather than an effort aimed simply at presenting the facts by means of a dry exposition, they viewed science communication was an opportunity to dialogically engage lay audiences. These dialogue-oriented students emphasized the need to cater to the audience's beliefs and to foster open-ended exchanges through use interactive tools and storytelling. Three of these students described their communicative efforts to facilitate respectful and engaging dialogue with a pseudoscience-believing audience as follows:

Natalie: To communicate my counterargument to this public, I have to keep in mind that some people are very deeply invested in this belief and there is no point in trying to convince them. It is also crucial that I let the public know that I am on their side, that I share their belief that self-care is extremely important but provide alternatives to solving issues that are believed to be solvable by chakra unblocking. I would aim to be as respectful as possible and avoid being condescending because that is the last thing that people want [Reflective Write-Up].

Scott: The way I would go about addressing an audience that believes in this technique would be through communication and kindness; I would try to first understand where this belief stems from by

asking them why they think that this works; it would then help me formulate an educated answer that makes sense to them [Reflective Write-Up].

Jeff: To address the idea of Gerson therapy as a treatment for cancer, I would first connect with the audience by sharing my family's battle with cancer. When I was 15, my father passed away from lymphoma after a year-long battle. When it was clear that his treatments were unsuccessful, my family was left hoping for a miracle. This story would show the audience that I can relate to their own cancer journeys [Reflective Write-Up].

Throughout these imagined interactions, students sought to foster a positive relationship with their pseudoscience-believing audience. Rather than taking a strictly informative approach, students sought to communicate their counterarguments using kindness and respect. Recognizing that empathetic and respectful engagement are important aspects of effective science communication, students sought to foster social closeness and build a rapport with their audiences while relaying addressing false or inaccurate information.

Students with these audience-centered views consistently emphasized the need to take a compassionate approach to addressing pseudoscience rather than simply showing the evidence to persuade their audience. As a student wrote:

Tom: Addressing pseudoscience is about more than just having the facts to refute their claims. Instead, I found that it is also important to understand why a person began to believe the pseudoscience in the first place and why they continue to think that it is truthful. Through doing this, I can gain a better understanding of how to communicate with them in a way that promotes learning, rather than simply getting into a yelling match about what facts to believe [Reflective Write-Up].

For the above student, the ability to connect with a target audience and engage in open and learning-focused discussion takes precedence over any other rhetorical technique focused strict on logic and rationality. Like others, this student felt that forming a connection with their audiences was important in effectively communicating science and that doing so would allow them to better help audience members. Indications of students' concern about forging connections with their audience included being considerate of audience morals, values, and non-scientific background, employing latent terminology, and acknowledging the importance of facilitating conversation.

Students who held audience-centered views often found themselves empathizing with their pseudoscience-believing audience. Their comments emphasized how easy it was for laypeople to fall for pseudoscience's false claims. The process of actively researching pseudoscience topics seemed to encourage these students to grasp the complexities surrounding pseudoscience more clearly (e.g. its pervasive and compelling nature) and to better understand why laypeople often fall prey to them:

Joan: I realized that there are a lot (ALOT) of products I use daily that I am attracted to using by their convincing representation, claims and advertising. As such I overlook the actual mechanism or purpose of such products because I am convinced of their effectiveness and to be honest, it is easier to believe something than look further into its truth … . at the end of the day, the people that consume pseudoscience have good in their hearts (ex: believe they are protecting their kids from autism by not letting them get the vaccine, or believing they are alleviating others pain by giving them a magnetic bracelet) [Reflective Write-Up].

Tracy: Pseudoscience and the cherry-picked evidence that supports it can mislead even a person privileged to be educated such as myself to doubt whether that my topic, Chinese Restaurant Syndrome, did exist and was not in fact, racially fuelled and xenophobic studies [Reflective Write-Up].

The above students adopted a more open-minded attitude by holding more accepting images of pseudoscience believers and showing empathy given their inclinations in believing pseudoscience is rooted in good intentions. These students viewed pseudoscience believers as well-intended and gullible consumers. Showing understanding towards their imagined audience's cognitive processes and vulnerable position within society is important in allowing students to engage in relatable, relevant, and thus, productive communication as future scientists.

Students with audience-centered views also tended to value communication that considered their audience's background and diverging perspectives. These students discussed the utility in building a rapport with their imagined audience by using storytelling and other techniques that appealed to audience values:

> Jack: I'd use techniques to appeal to an audience in order to combat pseudoscience. These include storytelling, appealing to common morals, and not focusing on 'expertise' [Reflective Write-Up].
>
> Carla: By understanding how much pseudoscience there is on the internet, and how to address it, I will be better able to communicate science to those who believe in these pseudoscientific claims by knowing what and why they believe, and therefore how to respond to them [Reflective Write-Up].
>
> Brett: I thought that science communication was about making sure that the ideas and concepts that I want relayed is properly understood to my audience in order to effectively communicate science. However, in doing this activity and responding to a seemingly solid claim, I found that I must consider how believers of a pseudoscience must feel when what they believe, which has seemed unshakeable and thought to be true is challenged by someone such as myself. I learned that I need to consider the audience's beliefs … [Reflective Write-Up].

Here, students stress the importance of understanding their audience's beliefs and perspectives as opposed to solely using fact-based evidence to deliver their message effectively. As such, students seem to recognize that fostering context-specific and quality type of communication that takes into account their audience's perspective can be more effective than applying their communicating skills in broad and untargeted ways:

> Laura: Getting frustrated and angry would never give the audience or myself results. However, going about it in a manner where I show the audience that I respect their opinions and provide science-based alternatives allows the audience to stay engaged and become open minded to hearing the other side [Reflective Write-Up].

Monologic views

Two students held views that were strongly monologic and evidence-centered. Concerned mainly with the accuracy of the information being communicated to the public, students who held these views did not comment on the value of establishing a dialogue or consider the public's alternative perspectives when setting out to address fake science news. Instead, their commentary focused exclusively on the content of their message:

> Mariah: By being able to pick out false information as pseudoscience, you are also creating the opportunity to avoid mistakes yourself when communicating to the public. Whether it be using a reliable source, or simply the way in which your [*sic*] voicing your topic, it is important to not only conduct proper research but also look in deeper than what one article may say in order to ensure the most accurate information possible. If you don't believe in something entirely, your readers won't either. It is necessary to perform these tasks when living your daily life or completing a paper [Reflective Write-Up].
>
> Kelly: I think that people being part of the scientific community have a responsibility to communicate the best science available to the public … .I still have a long way until I can be able to talk to the public about pseudoscience, but at this point, I know a few characteristics that pseudoscience usually has like having a lot of testimonials, vague claims, one sentence in a paper that finally reveals that data was [*sic*] inconclusive or that research was made on rats and not humans and other characteristics like that that I can now share with my surroundings to make them better informed about pseudoscience as well [Reflective Write-Up].

In neither of the above responses do students express any concern about creating a two-way dialogue or considering the audience's perspectives or needs. Students only describe how they would construct argumentation to 'inform' their audience about pseudoscience and its falsehoods; no reflection pertaining to the needs of the audience or other stakeholders' perspective is apparent. These students seemed to value the more traditional, monologic model of science communication.

Combative views

The three last students held more confrontational views of science communication about fake science news. Unlike the majority, these students expressed condescending and frustrated attitudes toward pseudoscience believers, making remarks that were rich in sarcasm:

> Antony: I have explained the nature of the misinformation and counter argued the pseudoscience that is urine therapy, however, if you are still not convinced, I invite you to take a sip from the golden fountain and confirm these statements for yourself [Reflective Write-Up].
>
> John: He [pseudoscientist] thought that we should look no further than the bible to understand God's plan for why we see differences (why would anyone need to look any further than God's divine plan?!?!?) [Reflective Write-Up].

The first student's invitation for audience members who did not believe the evidence being presented to take a sip from the golden fountain has a sarcastic tone and suggests contempt toward the imagined audience. Of course, encouraging an audience to verify for themselves and draw their own conclusions is a respectful move. However, the student's wording and tone is hostile toward anyone who may doubt the available scientific evidence, who are positioned as uncritical myth-believing adversaries. Likewise, the second student's rhetorical question expresses a degree of frustration toward the pseudoscientist behind a fake news item, who is positioned as a conniving enemy whose improper use of a sacred text to discourage critical examination is being exposed to the public.

Students' communicative approaches

Analysis of the videos revealed that only three out of the six students (Brett, Laura, and Jack) adopted a communicative oral approach that was respectful and dialogic. These students tended to detach themselves from their personal beliefs and opinions and engage in relatively neutral type of science communication. They also showed empathetic attitudes towards their imagined audience. For example, two students showed concern towards lay people who believed in pseudoscience by pointing out that they were being deceived and potentially exploited by companies that rely on fake scientific information. A second student explicitly acknowledged a general need for scientists to remain compassionate and respectful when educating the public within their presentation.

In contrast, the other three students (John, Joan, and Mariah) displayed a slightly condescending attitude towards pseudoscience claimers and believers while presenting. For example, Mariah repeatedly used the word 'obviously' when identifying falsities regarding her pseudoscientific topic (e.g. '*obviously, I jumped on that*' and '*obviously, the video was full of logical fallacies*'), implying that any elaboration was unnecessary, and that the truth was obvious. Mariah also mentioned that the pseudoscience video she analyzed was 'messy' while laughing which also indicates a level of personal bias regarding pseudoscience. Her combative tone was evident in comments such as:

> Mariah: Supposedly, they were 'healthcare professionals', and they were basically saying that there was metal in the COVID vaccine, alluding to a tracking device, and that somehow it was connected to the 5G grid [laughs] … but the thing that really made me laugh and I shouldn't be laughing, but I did laugh a little bit … This ['nurse'] is so set on her belief that [the COVID vaccine] causes magnetism. She's trying to stick a key to her neck in the video … like why is this sticking to me? [laughs] but it really is not even sticking to her [laughs] … anyways it was it was a messy thing to watch [Oral Presentation].

John started his presentation with the following remark: 'I am one of the unfortunate souls that actually does have an anti-vaxxer for an uncle, so I'm very passionate about vaccines' Through his presentation, John continuously expressed frustration and exhaustion, eventually admitting that this emotional stance was directly linked to his decision to research non-truths tied to COVID-19 vaccination; a current and polarizing topic that was also personal to the student

since he described being unable to convince his antivax family members to stop believing in COVID-19 conspiracies. Therefore, it is likely that the student's own values contributed to a more emotionally charged presentation full of sarcasm and confrontational rebuttals to imagined opponents. His combative tone was evident in comments like:

> John: We all heard about *Vaccines cause autism*. No, they don't … when vaccines were first coming out and the Church was like *No vaccines, that's the devil's work* … One false claim is that vaccines are dangerous because like MSG, antifreeze, phenyl formaldehyde, Aluminum, and lead kind were in the vaccine, and *Oh, big scary words*, or *Oh, some kind of metal, it is dangerous*. Another big conspiracy about this is that Big Pharma is actually just selling vaccines to make money [laughs] off of people, *which is true, but that doesn't mean that they don't work and are harmful to you*. Big Pharma would definitely not be doing a good job of making money if they were curing a disease instead of treating it long term … my big reason why I really wanted to do this topic was because I wanted to talk about how I would like to try to debunk it [Oral Presentation].

Although objective in her statements, Joan scoffed several times during their presentation when discussing false claims made by cosmetic companies:

> Joan: I kind stumbled upon pseudoscience in skincare which, uh, [scoffs] is very prevalent because they are just trying to sell their products … originally, they used to claim that they had technology in this serum that could influence [scoffs] or target your genes that were related to anti-aging proteins, which obviously how we would do gene targeting in a lab, you know that there is no way that can occur in the serum … the only thing they had was like a little side of their clinical trial, which was done on 34 women for like an hour or something, and I was like *That is a sex-based trial* [scoffs], very small sample size considering the fact that they said *It's good for all skin types, it's good for everyone* … and this is a really expensive [scoffs] product, so people would just assume it must be good [Oral Presentation].

The above students seemed to have difficulty orally addressing pseudoscientific claims in a more respectful manner that could open up dialogue with a polarized audience. Although they never explicitly ridiculed pseudoscience believers, some of their remarks and behaviour were at times indicative of underlying judgemental and negative attitudes which they were unable to suppress throughout the presentation.

Student self-assessment

When prompted to assess their communicative performances, students who presented stated that they found it difficult to be dialogic and to foster in open-ended communication when addressing a pseudoscience-believing audience. Students expressed the following sentiments:

> John: I have a tendency to quickly judge and get upset by people who are so invested in their non-scientific beliefs. I think this stems from the increasing prevalence of pseudoscience I've been exposed to in the last couple of years, especially surrounding COVID-19. I was too focused on trying to change people's minds rather than helping them understand. I realize now from this activity that these emotionally driven methods are ineffective in combating pseudoscience, they only strengthen the divide. Responding with kindness, compassion and scientifically approved alternatives is much more effective [Video-Based Self-Assessment].
>
> Mariah: It was hard not to sound like a rigid, know-it-all robot when presenting facts. It would be nice if it was casually intertwined into the conversation without it being too blunt [Video-Based Self-Assessment].
>
> Joan: A potential weakness this highlighted in me may be that fact that I may find it hard to empathize and related to the believers of some of these pseudoscience, I may find it hard to understand there thought process and then try to debunk it [Video-Based Self-Assessment].

Though each student acknowledges their weaknesses they also go on to reflect how they would work to improve upon them in the future. For example, the first student elaborates on their tendency to be judgmental toward others who oppose science while simultaneously evaluating the need for her to integrate kinder and more understanding communication when addressing an audience. The

second student also suggests a desire to adopt a more dialogic approach when publicly addressing pseudoscience. The third student, in a similar way to the first, divulges her difficulty following an out-group's cognitive processes and beliefs, which may suggest that it is not an innate skill and thus, potentially requires self-reflection and training for improvement. Therefore, students' increased degree of self-awareness highlights the importance of reflection and a means to help students identify important science communication skills that may need to be strengthened.

Discussion

Communicative views and audience awareness

Despite some variability, students' views of public science communication about fake science were predominantly dialogic in nature. 21/26 (81%) of students viewed these communicative events dialogically, whereas 2 others held monologic views (7%) and the last 3 expressed combative views (12%). Moreover, students with dialogic views adopted an audience-centered stance that took into account the public's interpersonal needs (e.g. its need for respect, empathy, etc.), communicative needs (i.e. its need for comprehensible input) as well as their epistemic needs (i.e. its need for accurate scientific knowledge). In sharp contrast, students who held monologic views tended to overlook their audiences' interpersonal and communicative needs, instead taking a communicative stance that was strictly evidence-centered and strictly focused on their audience's epistemic need (i.e. their need to be scientifically informed). Lastly, students with combative views favored an antagonistic stance focused on the need to win the battle against fake news.

The predominance of dialogic communicative views among students suggests an emergent ability to see beyond ideas. Like other types of intellectual exchanges, scientific communication is stereotypically viewed as a type of communicative event that is more focused on the exchange of ideas and information than on social relationships (Davison, 2003; Tracy, 1997). According to this monologic view, science communication should also be primarily concerned with a one-way sharing of information, the detached presentation of ideas, and an advancement of intellectual positions on abstract issues. Social or relational matters such as respecting and connecting with the audience, developing alliances and networks of social relationships, etc. are considered secondary or of minimal importance. However, as previously indicated, approaching science communication in this manner has been shown to be ineffective due to interactional difficulties with the audience (Compton et al., 2021; Kahan et al., 2009; Nisbet & Scheufele, 2009; Secko et al., 2013). To effectively address pseudoscientific news, science communicators need to see beyond the ideas being communicated. As emphasized by the guest speaker on the first day of our instructional activity, science communicators cannot lose sight of the fact that there are people behind the ideas they set out to address who could possibly (mis)construe their critical comments as personally offensive or hostile. Science communicators who lack such awareness often run into interpersonal problems that can damage and even completely disrupt the channel of communication with the public, hence preventing them from effectively accomplishing their communicative goals. Put differently, effective public communication of science requires an increased degree of audience awareness. As such our analysis of biology students' communicative views is supported by an extensive body of previous research not only in the field of communication but also in educational psychology, literacy education, etc.

The above findings are also consistent with scholarly arguments that *communicative competence* (the ability to communicate appropriately in an authentic situation or social context) requires a clear awareness of what can be said, how it can be said, and how it can be interpreted by interlocutors (Hymes, 1987; Saville-Troike, 2003). A competent communicator is critically and reflectively aware of the range of alternative ways that a given topic can be approached and strategically avoids potentially problematic approaches (e.g. use of linguistic forms that may be unclear, misconstrued, or offensive to others). As emphasized by language scholars (Hymes, 1987; Saville-Troike, 2003),

competent communication requires knowledgeability not only about the topic under consideration but also about the linguistic codes in use (e.g. appropriate language), and the sociocultural context in which communication takes place (cultural values and ideologies, social norms, etc.). Consistent with this argument, the undergraduate students of science who participated in the present study not only became more knowledgeable about the scientific concepts and principles behind fake science news, but they also gained new insights into effective ways of socially interacting with audiences who strongly believe in these news. Their gained knowledge was clearly evident in their write-ups (for a sample student write-up, see Appendix 2). However, as discussed next, their new knowledge did not always lead to improved communicative performance.

Communicative competence

Another important finding was students' difficulties orally enacting their dialogic views of public science communication. Despite recognizing the need to engage the public in dialogue about fake science news, some students took a combative communicative approach when asked to demonstrate how they would address an audience of pseudoscience believers. Half of students who gave oral presentations (3/6) communicated in ways that suggested a judgemental or condescending attitude toward the public that seemed inconsistent with the audience-centered views they had expressed earlier. Acknowledging some interpersonal difficulties when attempting to dialogically address a pseudoscience-believing audience, these students stressed the challenging nature of public science communication about fake science news.

The above findings offer new insights into science students' development of *communicative competence*. As theorized in our previous work (Cook & Oliveira, 2015), communicative competence entails *conceptual competence* (ability to communicate scientific knowledge) as well as *interpersonal competence* (ability to socially interact in contextually appropriate ways based on sociocultural knowledge). Examined from this perspective, the above findings suggest a limited gain in interpersonal communicative competence among some biology students despite their increased degree of audience awareness and sociocultural knowledge. Contrary to expectations, some biology students continued to have difficulties taking a dialogic approach to public communication about fake news even after coming to view it in a dialogic manner and becoming more aware of their audiences' needs.

Students' translating their dialogic views into action highlights the complex nature of the development of competence in science communication. Understanding the interpersonal features of effective science communication is an important first step in students' developmental process, but it does not guarantee immediate communicative competence. In addition to interpersonal knowledge, communicative competence also requires considerable practice. Fully mastering dialogic skills may require more than an isolated exercise of oral communication. Instead, a more extended and sustained instruction may be needed wherein students have ongoing opportunities to participate in a series of oral and writing exercises that can allow them to progressively hone their communication skills, including possible engagement (oral or written) with a real audience of pseudoscience believers. In this sense, it can be argued that the simulated communication exercise examined in this study served as a safe curricular space for science students to begin practicing communication about divisive topics in controversial contexts, and to hone their communicative skills, but additional follow-up practice is needed before they are ready to address real audiences, a communicative challenge of considerably higher risk.

Conclusion

This study suggests that the implementation of written and oral science communication exercises using imagined audiences may be beneficial in fostering undergraduate science students' audience awareness and promoting competence in audience-centric communication. To this end, it is

essential for communicative practice to be accompanied by self-reflection. The reflective process is crucial in allowing students to synthesize their newly acquired knowledge (conceptual and interpersonal), identify skill gaps that may require additional practice, and to gain additional insights. Through reflection, students can solidify communicative skills and strategies to which they are introduced while also leaving room to report and identify progress. As illustrated by our findings, written reflection can provide students with great opportunities to explore varied perspectives, and hence achieve a greater understanding of complex communicative contexts such as publicly addressing fake science news. Reflective writing provides students a chance to plan in advance how to share their ideas (i.e. carefully consider what they want to say and how). As a result, speakers are less likely to experience the types of problems commonly associated with unplanned oral discourse (Ochs, 1979), such as poor word choices, unclear constructions, errors, and unintended meanings.

Despite its valuable insights, it should be acknowledged that the present study is not without limitations. First, our results are only reflective of the experiences of students within a single classroom, and therefore should not be generalized more broadly. Additionally, our small sample size and limited data, especially our video corpus, underscores the need for analytical restraint. Future studies will also benefit from a pre/post experimental design wherein data on students' communicative views and oral performances are collected before and after instructional activities similar to the ones examined in the present study. Nonetheless, our exploratory study sheds some initial light on instructional practices that can be helpful to instructors of undergraduate science courses that are committed to improving the communication abilities of the next generation of scientists, and hence effectively preparing them for an era of post-truth and disinfodemic-related science communication challenges. This our hope for the present study.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Ethics statement

The authors declare that this project received Research Ethics Board approval at the University of Ottawa.

ORCID

Alandeom W. Oliveira http://orcid.org/0000-0003-2418-0299
Oana Mirel http://orcid.org/0000-0001-6116-3557
Adam O. Brown http://orcid.org/0000-0002-3640-6067

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Appendices

1. Individual students' pseudoscientific topics, online sources selected, communicative views, and communicative approaches when presenting.

Student	Pseudoscience Topic	Students' Sources and Descriptions	Communicative View	Communicative Approach
Natalie	Chakras	Source: Article entitled 'What Are the 7 Chakras and How Can You Unblock Them?' Description: The article defines chakras and describes the seven main ones which are located at different areas of the body. Its main purpose is to explain to its readers the different ways to unlock each chakra and balance them in order to fix the mental or physical issues related to each one.	Dialogic	Did not present
Antony	Urine Therapy	Source: General Internet search Description: Urine therapy is the consumption of urine, either one's own or someone else's, with a goal of achieving medical benefits derived from the vitamins, hormones and proteins contained within it. People believe it can be implemented for treatment of asthma, arthritis, allergies, acne, cancer, and indigestion.	Combative	Did not present
Roy	Nambudripad's Allergy Elimination Techniques (NAET)	Source: Website https://www.wisechiropractor.com Description: The website by chiropractor Devi	Combative	Did not present

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Student	Pseudoscience Topic	Students' Sources and Descriptions	Communicative View	Communicative Approach
		Nambudripad describes NAET as a non-invasive drug free technique for alleviating allergies in a natural way by using elective energy balancing, testing and treatment procedures. According to the website, the technique is based in the acupuncture, allopathy, chiropractic, nutritional, and kinesiological disciplines of medicine.		
Jessica	Metallotherapy	Sources: the brands 'Beads-N-Style' (https://www.beads-n-style.com) and 'Magnetic Jewelry Store' (https://www.magnetjewelrystore.com) Description: Metallotherapy is the concept that metals (metal bead bracelets) can be used for therapeutic purposes through their ability to rebalance individuals' magnetic fields.	Dialogic	Did not present
Tom	Colloidal Silver	Source: https://colloidalsilverspray.naturalnews.com/colloidal-silver-extra-strength-spray?rfsn=5435092.238e15&utm_source=R_Affiliate&utm_campaign=84057&utm_affiliate=5435092 Description: Colloidal Silver Extra Strength Spray is a product advertised as having anti-pathogenic properties. The nano scale silver particles within it are described as having the ability to displace electrons from pathogens and thus, kill them.	Dialogic	Did not present
Carla	Magnetic Therapy	Sources: General Internet search Description: A practice which uses magnets, placed on various parts of the body in order to heal various health related issues. The magnets are used to rebalance the body's natural magnetic and electric fields and thus, promote healing.	Dialogic	Did not present
Peter	Bermuda Triangle/ UFOs/ Atlantis	Sources: General Internet search Description: The belief that the geographical space between Florida, Puerto Rico, and Bermuda, in which various aircraft and shifts have perished, is linked to extraterrestrial activity and is also the location of the underwater city of Atlantis.	Dialogic	Did not present
Joan	Youth Activating Skincare	Source: Website https://www.lancome.ca/en/skincare/by-category/serums/advanced-genifique-youth-activating-serum/26901c-LAC.html Description: Skincare brands claim to use formulas with prebiotic and probiotic extracts to activate the skin's microbiome and target proteins related to anti-aging. The skincare is supposed to help the skin appear younger and can build up the skin's recovery to external sources like stress and pollution.	Dialogic	Combative
Tracy	Monosodium Glutamate (MSG)	Source: Article 'Chinese-restaurant syndrome' by R.N. Kwok (1968) in the New England Journal of Medicine, Volume 278, Issue 14, page 796. Description: The claim that MSG in Asian cuisine is detrimental to one's health and can lead to chest pain, headache, and weakness.	Dialogic	Did not present
Ted	Chelation Therapy	Sources: General Internet search Description: A medical practice that includes	Dialogic	Did not present

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Student	Pseudoscience Topic	Students' Sources and Descriptions	Communicative View	Communicative Approach
		administering chelating chemicals to the body to eliminate heavy metals. Some practitioners use that chelation therapy as alternative medicine and say that it may heal a range of diseases, including heart disease and autism.		
Brett	Blood Type Based Diets	Sources: General Internet search Description: The claim that diets should be tailored to one's blood type because an individual's blood type is related to various food and health sensitivities.	Dialogic	Dialogic
Emma	Blood Type Based Diets	Sources: General Internet search Description: The claim that diets should be tailored to one's blood type because an individual's blood type is related to various food and health sensitivities.	Dialogic	Did not present
Scott	Crystal Healing	Sources: General Internet search Description: An alternative-medicine practice that transfers the energy in crystals and other precious stones to boost low energy, cure diseases, facilitate birth and labor, prevent bad energy, or transform a body's aura.	Dialogic	Did not present
Daniela	Vaccines Cause Autism	Sources: General Internet search Description: The claim that the MMR vaccine is harmful to children because it could cause them to develop autism.	Dialogic	Did not present
Jeff	Gerson Therapy	Sources: Angeles Health International. (n.d.). *Enhanced Gerson Therapy in Tijuana Mexico*. https://www.angeleshealth.com/enhanced-gerson-therapy-mexico/ Description: A therapy developed by Dr. Gerson which employs a rigid plant-based diet, drinking one glass of fresh juice per hour, and using coffee enemas, to detoxify one's body and reactivate natural healing mechanisms to fight disease.	Dialogic	Did not present
Kyle	Criminal Profiling	Sources: *FBI Law Enforcement Bulletin* Volume: 55 Issue: 12 Dated: (December 1986) Pages: 9–13 Description: A technique used in law enforcement to form descriptions of a suspect based on evidence left at a crime scene. Profilers posit that how the crime scene is arranged can be used to create a profile to aid in the search for a suspect.	Dialogic	Did not present
Jack	Aromatherapy	Sources: General Internet search & doTERRA (https://www.doterra.com) Description: The act of using essential oils for therapeutic and health benefits.	Dialogic	Dialogic
Dave	Paranormal Investigation/ Parapsychology	Sources: 'Pseudoscience and the Paranormal' by Terence Hines, the Ted Talk 'A Scientific Approach to the Paranormal' by Carrie Poppy Description: Belief in the supernatural and processes like exorcisms and paranormal activity.	Dialogic	Did not present
Kelly	Phrenology and Craniometry	Sources: General Internet search and the website: (https://www.penn.museum/sites/morton/craniology.php) Description: The claim in which an individual's characters and tendencies are revealed using skull readings where the shape and size of the brain is examined.	Monologic	Did not present

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Student	Pseudoscience Topic	Students' Sources and Descriptions	Communicative View	Communicative Approach
Ann	Phrenology	Sources: General Internet search and the article '*Phrenology*' from the Encyclopedia Brittanica and 'Trepanation: Our Ancestor's Idea of Neurosurgery' (https://www.medicalnewstoday.com/articles/326281) Description: The claim in which an individual's characters and tendencies are revealed using skull readings where the shape and size of the brain is examined.	Dialogic	Did not present
Marcos	Cupping Therapy	Sources: General Internet search Description: An alternative form of medicine using suction from heated cups. Cupping is thought to suck out toxins and stagnant blood to stimulate energy and increase blood flow, activate the immune system and treat various health conditions.	Dialogic	Did not present
Mariah	COVID-19 Vaccine 5G Conspiracy	Sources: YouTube video (https://www.youtube.com/watch?v=qWl0YiSmTKs) Description: The belief that the COVID-19 vaccines contain metallic tracking devices connected to 5G towers.	Monologic	Combative
John	Anti-Vaccination Movement (AVM)	Sources: General Internet Search Description: A movement promoting the belief that vaccines are unsafe/health risks, ineffective, and violate human rights.	Combative	Combative
Beth	Astrology	Sources: General Internet search and the Co-Star application Description: Astrology points that stars and planet positions influence individual personalities, fate, future, and daily life.	Dialogic	Did not present
Jake	Reiki	Sources: 'How Does Reiki Work?' by Pamela Miles (https://www.takingcharge.csh.umn.edu/explore-healing-practices/reiki/how-does-reiki-work) Description: An ancient Japanese spiritual practice which uses energy healing. A Reiki practitioner work to align one's energy field to promote healing.	Dialogic	Did not present
Laura	Ear Candling	Sources: General Internet search Description: The practice of using a lit candle and the warmth it generates to draw out impurities and wax from a person's ear canal.	Dialogic	Dialogic

2. Mariah's write-up on COVID-19 vaccine 5G conspiracy

While scrolling through YouTube, I came across a video of two antivaxxers, one a doctor and the other a nurse, who argued in favour of a common conspiracy theory about the COVID-19 vaccine. They believed that the vaccine contained some sort of tracking device that connected vaccinated people to 5G towers. They also claimed that the vaccine contained a metallic element in it that made a person's body magnetic and would allow them to stick spoons all over themselves. One of them went so far as to give an unsuccessful demonstration of sticking a key to the skin on her neck.

I decided to do some research on the coronavirus vaccine and I found a list of ingredients for the Pfizer vaccine on the CDC's website. There were three main ingredients; the first was mRNA of the spike protein. It is essential because it allows our bodies to produce some of the spike protein and it gives our immune cells a chance to recognize it and prepare for a future immune response should we come in contact with the coronavirus. The second main ingredient are a list of lipids that aid the spike mRNA pass through the phospholipid bilayer of the cell so that it can be transcribed in the nucleus. The final main ingredient were various salts and sugars that act similarly to food preservatives in protecting the integrity of the vaccine while in storage until it is ready to be used. The CDC article specifically makes a point to say that 'No metals like iron, nickel … or any manufactured products like microelectronics,

electrodes, carbon nanotubes or other nanostructures, or nanowire semiconductors,' were used. This debunks the idea of the presence of a microchip or the ability of the vaccine to make a person magnetic.

Some signs of pseudoscience that I saw in this video was the vagueness of statements made when one woman said, 'Yes vaccines do harm people.' While it was a short clip, she makes no attempt to back up this comment with any evidence and then moves on with her theory about the vaccine's ability to make a person magnetic. There has also been quite the lack of progress in this theory since this video was published on June 10th of this year. No one has been able to provide a sufficient explanation to link the coronavirus vaccine and magnetism, further driving home the idea that this is misinformation about the vaccine. The fact that her argument was a conspiracy theory further underlies the attitude of science denial. I also wonder whether either of these women were really medical professionals; neither their names, nor their credentials were displayed across the screen. It seems as though they may be fake experts, another sign of science denial. There were many logical fallacies throughout this clip; having metallic ions present in a solution is not the same as the 'protein having a metal attached to it.' The most obvious logical fallacy was the failure of one woman to actually prove that she was magnetic which really made the rest of what she said seem irrelevant by comparison.

By being able to pick out false information as pseudoscience, you are also creating the opportunity to avoid mistakes yourself when communicating to the public. Whether it be using a reliable source, or simply the way in which your [*sic*] voicing your topic, it is important to not only conduct proper research but also look in deeper than what one article may say in order to ensure the most accurate information possible. If you don't believe in something entirely, your readers won't either. It is necessary to perform these tasks when living your daily life or completing a paper.

If I were to address an audience about why this video contained pseudoscience, I would explain to them how the covid vaccine works and I would spend a lot of time discussing the ingredients. I would be sure to explain any jargon like mRNA, or nucleus, or phospholipid bylayer as well.