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Feeling the heat: undergraduate science students' emotional management during classroom debates

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ABSTRACT

Addressing a need to prepare the next generation of scientists to effectively engage in adversarial science communication, the present study examines a group of undergraduate science students from a Canadian university who, after receiving expert instruction, participated in classroom debates about science controversies recently politicized in the Canadian social media (e.g. the flat Earth, genetically-modified foods, and human overpopulation). Our research questions were: (1) What emotions were experienced and how were these managed by students while participating in classroom debates? (2) How did students' emotional management influence their debate performance? A video-based micro-ethnography revealed that more than half of the students (16/28) experienced feelings of stress and nervousness when engaging debaters with opposing/disagreeing views. Although some were able to manage these emotions, others were unable to feel relaxed, which negatively influenced their debate performance. These latter students' initial confidence and preparation were undermined by their felt anxiety, leading to rhetorically weak and error-filled performances that went against their expectations. Highlighting the complexity of pedagogically promoting student development of communicative competence in adversarial social contexts, our findings reveal a need for science communication instructors to find ways to effectively prepare science students to manage their own emotions.

KEYWORDS

Undergraduate science; adversarial science communication; classroom debate; student emotional management; politicized science controversy

Introduction

There currently exists a pressing need to prepare future scientists to effectively communicate in societal contexts fraught with controversy and polarization (Rekker, 2021). In today's polarized societies, scientists must learn to face the challenge of communicating highly politized science topics (Nisbet & Fahy, 2015; Scheufele, 2014) to individuals who are fed up with experts whose knowledge they view simply as elitist opinion (Lewandowsky et al., 2017). Communicating with these individuals can be difficult given their tendency to confrontationally resist persuasion (Compton et al., 2021) and willingness to resort to underhanded tactics such as characterizing those who disagree with them as misguided zealots, seeking out 'gotcha' moments, and even misrepresenting themselves (e.g. lying about their status as local concerned citizens) (Brossard, 2009; O'Grady, 2022). The result is an environment of increased likelihood of public engagement turning into heated (i.e. emotional, angry) disputes, wherein disagreeing interlocutors fight to push their viewpoints over others. Public engagement has become increasingly combative as many societies around

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the world grow more polarized (e.g. Hundleby, 2013; Kidd, 2020; Rooney, 2012) and the line between science and political communication is blurred (Nisbet & Fahy, 2015).

Far from being unique to North America, this trend has been documented in other parts of the world like in Brazil, a developing country where political radicalism (via the Trump-inspired Bolsonarist government) recently gave rise to extreme scientific denialism and dismissive public attitudes towards science (Silva, 2021a). As Silva (2021b) adds, the advent of the COVID pandemic in Brazil exacerbated this situation, leading to an anti-scientific movement characterized by the spread conspiracy theories on social media, misrepresentation of scientific research, and highly publicized clashes with the scientific community (e.g. cuts in funding for research universities).

In addition to contributing to larger problems such as proliferation of disinformation (Iyengar & Massey, 2019; Nguyen et al., 2012), erosion of trust in science (Hardy et al., 2019), and increased science denialism (Lewandowsky & van der Linden, 2021), participation in combative engagements can have adverse negative effects on participants. The stress associated with being subjected to verbal aggression (e.g. personal insults, attacks on capabilities, allegations of dishonesty/corruption, threats of physical and/or sexual violence, and harassment) can result in negative mental and physiological health outcomes (Aloia, 2020). As reported by scientists who faced hostility for their role in communicating information about COVID-19, this can lead to emotional and psychological distress, anxiety, depression, and even suicide (Nogrady, 2021; O'Grady, 2022; Sridhar, 2022). Also triggered are emotions like anxiety and stress, which can negatively impact participants' social performance (Oliveira et al., 2021).

The possibility of there being such emotional toll underscores the critical need for future scientists to develop *emotional management* (Jasso, 1993; Turner & Stets, 2005) as part of their professional preparation. To effectively participate in controversial debates and to engage with adversarial audiences, scientists need to become skilful in managing their own emotions (David & Baram-Tsabari, 2021; Kuchel, 2019; Yuan et al., 2017). Coping with the distress associated with adversarial situations requires science professionals to develop *emotional self-regulation* – that is, an ability to regulate one's own feelings and emotions.

However, underlying much of the science communication learning opportunities available to undergraduate students is an unfounded expectation that they will always be facing audiences who are friendly or passive enough to accept their communicative efforts without any contention. Considering this lack of attention to adversarial public science communication, the present study examined undergraduate science students from a Canadian university who, after receiving expert instruction, participated in *classroom debates*. With an eye towards better understanding student development of emotional management ability in the context of adversarial science communication, our research questions are:

> Q1: What emotions were experienced and how were these managed by students while participating in classroom debates?
>
> Q2: How did students' emotional management influence their debate performance?

In this paper, the term 'debate' is used in reference to a type of classroom activity pedagogically designed to mimic public debates – communicative events in the public sphere that are characterized by combativeness and opposition such as presidential debates. As Walton (1992a; 1992b) notes, debates are rule-based (e.g. follow a sequence of turns with specific lengths), can involve aggressive adversarial clashes (e.g. personal attacks, accusation of bias, and general accusations/insinuations that the other side cannot be trusted to have an actual opinion), and often involve partisan and emotional argumentation (a degree of heated and passionate rhetoric).

Unlike K-12 argumentation activities (e.g. Felton et al., 2009; Garcia-Mila et al., 2013; Polo et al., 2017) wherein emphasis is placed on formally and dialogically arguing from evidence as students seek to develop an improved understanding of a topic, the classroom debates examined in this study were primarily an exercise of emotional management in the face of adversariality (e.g.

managing body stress responses). Although terms like 'argument' and 'rebuttal' are used at times in our analysis, these should not be taken as a conflation of debate and argumentation (two distinct notions), or as a focus on the soundness and logical coherence of students' arguments in a Toulminian sense (beyond this study's scope). Like Herman and Serafis (2019), our focus is on *argumentativity* (emotional stance-taking) rather than argumentation.

Literature review

Debate is only one of several ways of approaching argumentation in classroom settings. Kroll (2005) describe four different approaches: (1) an *adversarial approach* (an arguer advances and supports a position while disputing the claims of those who hold contrary views); (2) a *conciliatory approach* whose goal is to get people who disagree to listen rather than respond defensively; (3) an *integrative approach* wherein arguers work towards agreement based on common interests and shared goals; and, (4) a *deliberative approach* aimed at building consensus. Our focus on debates is consistent with the first approach. Although less confrontational/adversarial approaches to argumentation are possible (and even desirable if the goal is to increase students' content knowledge), at the undergraduate level it is also essential to promote science student development of emotional self-regulation. As elaborated below, developing such an ability can help future scientists become prepared to cope with the emotional demands of increasingly common adversarial communication.

Adversarial communication

Adversarial science communication is a type of oral discourse characterized by an oppositional framing (Goffman, 1981). A defining feature of this type of exchange is the presence of contrary voices or opponents – interlocutors who actively counter and resist being convinced by an arguer. Participants adopt an adversarial footing (interactionally align themselves in relation to one another as adversaries) as lines are drawn, sides are taken, and attempts are made to persuade others that one is correct. Within this framing, addressing an interlocutor means 'fighting' an opposing enemy, and communicating science is akin to winning a battle. Underlying such efforts is a presumption of agonism (Tannen, 2002) – an a priori expectation of an uncooperative interlocutor or audience who will be resistant and defensive, and who can even counterattack. Confrontation in the form of a heated exchange of words is assumed to be inevitable as participants come ready for a 'fight.'

Two common features of adversarial communicative events are argumentativeness and verbal aggression. Infante and Rancer (1982) conceptualize argumentativeness as one's predisposition to engage others over controversial issues in an adversarial manner. For example, an argumentative individual is someone who may find exciting to challenge others' and defend their own stance. Those who are high in argumentativeness may not necessarily be high in verbal aggressiveness – a predisposition to derogate and establish superiority over others. While argumentative discussants seek only to debase and deflate opponents, verbally aggressive debaters enjoy the thrill of attacking conflicting views and of refuting others – such as those who regularly participate in inter-student debate teams, clubs, and competitions.

Adversarial science communication runs contrary to collaborative epistemic exchanges during which parties work together to critique each other constructively, are open to conceding aspects of their views, and ultimately come to an enhanced understanding of a topic. Unlike cooperative or dialogic forms of argumentation (Asterhan, 2013; Baker et al., 2013; Isohätälä et al., 2018; Nussbaum, 2008) wherein participants learn from each other (i.e. improve their epistemic position), adversarial science communication is more focused on winning the approval of an attending audience, being epitomized by the popular TV debates. One example is the recent debate between Bill Nye 'The Science Guy' of TV renown and Ken Ham, founder of the Creation Museum in the USA. Dubbed 'Scopes 2,' this debate was widely publicized and watched, similar to a highly anticipated

boxing match (Answers in Genesis, 2023). Accordingly, we conceive of undergraduate science students' oral debating of politicized science controversies as exercises in pedagogically designed engagement in adversarial science communication.

Training on adversarial science communication

The need for training that can help scientists develop communicative skills is underscored in the existing literature (e.g. Baram-Tsabari & Lewenstein, 2017; Ceccarelli, 2011; Kuchel, 2019; Mercer-Mapstone & Kuchel, 2015; Yuan et al., 2017). Despite such general recognition, little attention has been given specifically to the need for improving scientists' emotional competency, and training in adversarial communication is rare (Rancer & Avtgis, 2006). For instance, public debates are noticeably absent from Lewenstein and Baram-Tsabari's (2022) list of science communication activities/environments for which training should be offered. Although the authors acknowledge that science communication learning involves affective aspects, their focus is limited to general motivations and attitudes (e.g. science professionals should learn to 'feel comfortable interacting with the media,' 'develop sensitivity towards audience views and concerns' and 'approach communication with openness, honesty, and responsibility'). The implication is that future scientists may be left unprepared to face situations involving combativeness and confrontation (Brownell et al., 2013; Ceccarelli, 2011).

The problematic nature of this situation is discussed by Infante (1995), who emphasizes that, to be able to effectively engage the public, communicators need to become aware of and be able to handle verbal aggression. To accomplish this, a curriculum needs to be created that can help undergraduate science students build skills in de-escalating verbal aggression rather than responding in kind, which may exacerbate hostility and preclude any constructive outcomes.

Underlying this lack of training opportunities is scientists' commonly held assumption of audience passivity. Gross (1994) posits that the assumption of passivity is based on expectations that audiences will always trust communicators and always defer to and be persuaded by the science being presented. However, research shows that, in the context of public scientific discourse, audiences holding different stances will not always be willing to passively sit and listen, choosing instead to actively antagonise science communicators and, in extreme situations even resort to insults, mockery, hate speech, and death threats/calls for violence (Anderson & Huntington, 2017; Uldam & Askanius, 2013). Faced with such hostility, many scientists adopt a dismissive attitude, thereby shutting down deniers of evolution, and anthropogenic climate change without successfully persuading them (Ceccarelli, 2011). However, dismissive modes of communication have been shown to not contribute positively to persuasion, instead alienating public audiences and fuelling anti-scientific attitudes (Gross, 1994; Wynne, 1989).

To deal with this issue, scientists need access to training that can help develop their ability to effectively communicate science in adversarial social contexts. Novice scientists who set out to communicate with the public need to become aware of the possibility of their communicative efforts being met with resistance and opposition. They must also be prepared to cope with the emotional demands of adversarial situations characterized by verbal aggression in the form of vitriolic attacks, sarcastic innuendo, and name-calling. To this end, this study investigates a new undergraduate course designed to prepare students at a Canadian university to engage with adversarial public science communication through classroom debate practice.

Theoretical framework

We adopt a socio-psychological stance on emotional management. From this theoretical perspective, socialization into productive ways of feeling during public debates constitutes an important, yet often overlooked part, of the professional preparation of future scientists. We believe that effective communicative performance in the public sphere requires expert-guided socialization into

productive ways of managing felt emotions during combative social engagements. To succeed in their communicative efforts concerning politicized science controversies, science professionals need to be able to recognize, understand, label, express, transform, manipulate, and regulate one's own emotions as well as those of others.

Several strategies for managing one's emotions during public speaking can be found in the literature. For instance, one can imagine being in a 'happy place' to reduce stress-related thoughts like anger or imagine one's audience naked to overcome nervousness by making the audience seem less threatening (Wang & Yin, 2023). However, some critics argue that the latter technique violates an essential requirement for being an effective speaker, namely to respect one's audience (rather than mentally mock them). An alternative way to calm one's nerves down is to use *cognitive reappraisal* (Gross, 2014), an emotion regulation technique wherein speakers calm down by re-framing their nervousness as excitement rather than anxiety (such as by saying 'I am excited' out loud).

Such emotional regulation skills are a critical part of one's emotional literacy (Brackett & Kremenitzer, 2011) and can be developed through various means, including *cognitive reflexivity* (Rosenberg, 1990; 1991), a process of self-analysis whereby emotions are managed through careful identification, display, and bodily awareness; *emotion work* (Hochschild, 1983), such as invoking positive thoughts and pleasant ideas; and *cognitive manipulation* (Thoits, 1991), the capacity to mentally reinterpret the meaning of a situation (e.g. adopting a more positive standpoint). In practice, this self-analysis can be accomplished through classroom activities that allow people to evaluate their emotional experiences differently and even alter feelings towards more positive emotional outcomes. It is precisely this supportive type of emotional learning that we set out to offer our undergraduate science students.

While the oral side of communication is likely the most discernible during communication events (e.g. Is one's voice soft, monotonous, and/or fast? Do people stammer, pause frequently, and/or are unable to think of what words they want to say?), our investigation also steeps itself in literature that has spotlighted the role of non-verbal behaviours in signalling the underlying emotions. Thompson (2002) and Seiler et al. (2020) identify non-verbal behaviours that can signal anxiety: (1) facial expressions (Do they [presenters] make eye contact with their audience? Are they grimacing?); (2) posture (Are they holding their body in a tense manner?); (3) orientation (Are they facing their audience?); (4) overall body movements that go beyond finer-scale gestures (Are they fidgeting, swaying, or shuffling their feet?); and (5) breathing (Are they breathing heavily? Are they clearing their throat often?). Such behaviours have been well established as signs of anxiety that can arise while engaging in public speaking activities (Collins, 2004; Seiler et al., 2020).

Additionally, Lee and Kleinsmith (2019) suggest that non-verbal behaviours can represent not only one's anxiety while public speaking but also one's coping strategies that they use to alleviate/mitigate the discomfort they experience. This was evident in the results of Aripin et al. (2020), Kondo and Ying-Ling (2004) and Netta et al. (2020), who studied the strategies used by students to manage their anxiety while delivering a speech such as avoiding eye contact and engaging in distracting physical actions (e.g. walking around, fidgeting, playing with one's own hair). Yet, these anxiety-relieving behaviours may not necessarily be appropriate for science communicators and may serve to work against those who perform them. For example, while limiting one's own eye contact with the audience may mitigate a speaker's anxiety, it may also inadvertently cause one to be negatively perceived by the audience as an untrustworthy, dispassionate, bored, or lacking confidence. Likewise, performing small movements like fidgeting may distract and even irritate audiences. Communicators need to be aware of the messages that their body language can send to their audience.

Methods

This study adopts a mixed-method research approach (Bogdan & Biklen, 2003; Creswell, 2012) and has an ethnographic design (Robson, 2002). As part of this study, descriptive data were collected

through open-ended research methods such as video-recorded classroom observations and student surveys and then analyzed inductively to build a naturalistic account (Lincoln & Guba, 1985) of students' emotional management in the context of debates. This methodological approach is aligned with interactionist research traditions in the field of sociology of emotions (Turner & Stets, 2005).

Our research design is reflective of the fact that human emotionality is not directly observable due to its elusive nature. As such, there inherently exists a degree of subjectivity in any analytical effort aimed at uncovering the emotions and attitudes that underlie human behaviours (Thompson, 2002). Our use of open-ended survey questions in which students were asked to disclose how they felt while undertaking the debate activity was meant to address this issue. Rather than second-guessing their feelings, participants were asked to identify their emotions themselves. Their answers were then triangulated with video-based observations informed by empirical research, thus enhancing the validity and trustworthiness of our study.

Setting and participants

This study investigates a third-year science communication course titled 'The Public Communication of Science.' The course was designed to prepare science students for future situations involving communication of scientific information to non-specialist audiences (i.e. the public). Students attended lectures facilitated by the co-author (who had a PhD in biology and 18 years of teaching experience) and an assortment of guest speakers – science communicators with various types of expertise, including science journalism, science business, pseudoscience, etc. Additionally, having grown up in a family of performing artists and performed since he was a child, the instructor considered theatricality to be a valuable aspect of science communication.

During the lectures, students were provided with expert guidance on topics on how to talk to the media (i.e. dealing with antagonism, keeping messages simple, being able to improvise responses while still staying on-message, managing body stress responses, figuring out a delivery style, having accessible language, and being relatable) and participated in a variety of interactive in-class activities – a mock media interview, a science podcast, and a mock debate (Table 1).

With the overarching goal of developing public communication ability, the above activities were designed to prepare students to (1) communicate in a concise yet clear manner; (2) write communication pieces with attention-grabbing introductions, memorable metaphors, and strong conclusions that could leave strong impressions; (3) design creative and engaging presentations; (4) present oneself in an engaging yet authentic manner; (5) manage stress and anxiety experienced during public speaking; (6) improvise what one wishes to communicate; (7) interact with aggressive audiences; and (8) convincingly reply those who support pseudoscience.

The course culminated with an activity involving in-class practice in adversarial science communication (for the guidelines handed to students, see Appendix). Central to this activity was

Table 1. Interactive class activities on public science communication.

Activity	Description
Mock Media Interview	Roleplaying as research scientists, students were questioned and sometimes grilled by a guest journalist who sought to catch them off-guard and pretended to antagonise them.
Pseudoscience Assignment	Students learned to identify and respond to pseudo-scientific news online and practiced non-disputative/non-adversarial strategies such as being understanding and empathetic and demonstrating shared values.
Accessible Science Presentation	Students were challenged to give an oral science presentation in an accessible manner and practiced adapting the language of their scientific explanations to their specific audience type.
Accessible Science Centre Exhibit	Students designed a science centre exhibit that broke down scientific concepts to museum visitors and visually communicated in an accessible manner.
Bias Assignment	Students were asked to identify and analyze the biases behind their own ideas/mindsets.
Body of Evidence	Students learned to recognize their body language and practiced adapting their energy level to match that of their audience.
Mock debates	Student teams sought to antagonise and catch the other side off-guard to win over the audience.

student participation in informal reasoning (Kuhn, 1991), wherein competing positions on a science-related issue are presented and justified as part of a classroom activity framed as a 'debate.' Similar to debaters in Kuhn et al. (1997), students were explicitly instructed to be as deliberative as possible. For this debate activity, a total of 29 students (18 females and 11 males) were divided into 13 teams of two and one team of three. Each of the seven pairs of teams were allowed to choose a particular science topic they wished to argue about, with their final selections being whether or not: (1) the Earth is flat; (2) the human population should be limited in growth; (3) drugs should be legalized in Canada; (4) applied science is more important than basic science; (5) veganism is healthier than omnivory; (6) genetically-modified food is toxic to human health; and (7) social media is a cause of mental illness in youth.

Students were informed beforehand that teams would not know in advance from which position they would be arguing. Instead, a coin toss before each pair's debate would decide which team would argue for or against the proposed notion. This was a strategy designed to encourage students to investigate the selected scientific issue more broadly rather than limiting their learning to a single perspective.

Seven student debates were held in total. Each debate consisted of three phases: (1) five-minute presentation of opening arguments, (2) five minutes for rebuttals from the opposing team, and (3) two minutes of closing remarks. Additional time was allowed for deliberation among the debaters, audience voting for the most persuasive side of each debate and spontaneous discussion and analysis of the debates afterwards. Each debate lasted about 30 min (2×12-minute per group = 24 min plus time for getting audience feedback). This short debate time was due to the limited instructional time available (four 80-minute lectures). Together, the debates lasted 210 min ($7 \times 30 = 210$) out of 320 min ($4 \times 80 = 320$) that could be devoted to this activity.

Throughout the three debate phases, students were expected to call upon the rhetorical techniques and communication competencies they had priorly learned and to demonstrate an effective debate performance. Effectiveness, in this context, referred to their *rhetorical competence* and it was measured by their ability to persuade the third-party audience of classmates. More specifically, after the third phase, students who were not debating voted on which side had 'won' the debate, in a persuasive sense. Additionally, the audience was allowed to offer criticisms and feedback (e.g. identifying debaters' argumentative strengths and weaknesses).

Our intervention did not include training specifically on formal argumentation. Students were not presented with formal and precise definitions for specific argument components by which they should abide nor were they encouraged to make more nuanced distinctions such as counter-alternatives vs. counter-critiques (Goldstein et al., 2009), simple vs. integrative rebuttals (Kuhn, 1993), and different types of counter-claims (Kuhn, 2010; Kuhn & Udell, 2007). Instead, the only distinction they were encouraged to make was between an argument (an assigned stance on a scientific issue) and a rebuttal (an opposed stance that ran against the one taken by the first arguer; see handout on Appendix).

Data collection

The two main data sources for this study were an open-ended student survey and video-recordings of student debates. To examine students' felt emotionality and emotional management (Research Question 1), students were asked to fill out an open-ended survey that included the following prompts: (1) What did I learn most from doing this activity? (2) How will this communication skill help me progress towards my goal of communicating science more effectively? (3) What was something that surprised me about the research that went into this assignment? (4) What was something that surprised me about the work I put into this assignment? (5) What do you think were the strong aspects of your communication (could be content-related or style-related or both)? And, (6) What do you think were the weak aspects of your communication (could be content-related or style-related or both)?

These survey prompts were designed to foster post-activity reflection. It was expected that students would recount any negative emotions they had felt during the debate activity. Additionally, students were asked to watch a videorecording of their debate performance and then respond to the prompt: 'Name something that surprised you about watching the video of your communication.' Due to time constraints, participant viewing of video-recordings and filling in of surveys were both completed after class. Collection of such video-based student reflections was informed by our previous work (Oliveira et al., 2021).

To investigate how students' oral performance was impacted by students' emotional management (Question 2), oral debates were video-recorded. These videos served as an ethnographic record of students' interactive work as they sought to cope with the emotional demands of an adversarial exchange and attempted to manage their feelings in rhetorically effective ways. Focused specifically on the physical manifestation of discourse under stress, this video data illuminated what Gee (2015) termed 'Big D' discourse, that is, the specific ways that students acted out an adversarial social identity (a debater) and performed the social activity of debating. Rather than being narrowly focused on 'little d' discourse (documenting classroom debates as simply a socially recognizable way of talking), we sought to collect data that also captured the social language of classroom debates, documenting it in a more expansive manner as a way of doing and being in the social world that can be improved or honed through training. In this sense, it can be said that participants were recorded while 'Discoursing' science debates.

Data analysis

Once anonymized, the surveys underwent a grounded theory analysis (Glaser & Strauss, 1967). This approach calls for the iterative and combined use of interpretative and flexible methods of analysis such as close reading, inductive or open coding, and creating memos (Bernard, 2002; Emerson et al., 1995). Instead of a priori hypotheses or codes, analytical categories emerge and are gradually refined based on close examination of meanings and patterns in the collected data. Its specific focus was on how students described their emotional experiences during the debates (feelings such as *nervous*, *surprised*, *fun*, *stressful*). Attention was given to students' emotional management (accounts of how they sought to manage their feelings) and self-evaluations (perceptions of their own debate performances as well as their peers').

Transcribed video-recordings underwent a micro-ethnographic analysis (Erickson, 1996) – the study of video-recorded social interaction in minute detail through an up-close and exhaustive examination of how people use language to communicate. This analysis combined systematic examination of transcribed recordings with detailed sequential analysis and playback of video-recorded interaction. Discursive records of classroom interactions were carefully examined to identify behavioural signs of anxiety as revealed by the existing literature on public speaking activities (Collins, 2004; Seiler et al., 2020; Seiler et al., 2020; Thompson, 2002). Multi-focal, this examination centred specifically on students' (1) orientation (e.g. body facing the audience, eye contact); (2) facial expressions (e.g. grimacing); (3) posture (e.g. tense body); (4) body movements (e.g. fidgeting, swaying, shuffling feet); (5) breathing (e.g. breathing heavily); (6) voice (e.g. soft, monotonous, fast); and (7) fluency (e.g. stammering, pausing).

Initial inspection of the videos revealed three students in particular whose oral performances and reflective accounts stood out in terms of their felt emotionality and emotional management during the debates. Referred to under the pseudonyms of Frank (who argued in support of Flat Earth Theory), Gary (who argued in support of genetically-modified organisms [GMOs] meant for consumption), and Larry (who argued in support of limiting human population), these students became the foci of a second analytical phase wherein key scenes of naturally occurring communicative interactions during the debates were further scrutinized and systematically triangulated with survey data (i.e. quotations from student self-reflections and peer feedback). These excerpts served as

illustrations of the themes that emerged from coding the texts, thus enhancing the validity of our emergent interpretations (Robson, 2002).

Results

Student's felt emotionality and emotional management

Sixteen students indicated that the debates caused them to feel stressed or nervous:

> Student 15: Being able to articulate myself in an engaging way under pressure while people are watching you was a nerve-racking [*sic*] thing for me.
>
> Student 21: I looked very calm and in control [in the video recording of my performance] but inside I was dying.
>
> Student 23: I was surprised to see that even though I was very nervous before the debate I did not sound too nervous and spoke confidently.
>
> Student 24: Something that surprised me when watching the video was how calm both my partner and I appeared when we both felt so nervous.
>
> Frank: I think what surprised me was that I really did look like I was having fun [in the video recording]. Debates are stressful.

Particularly noticeable in the above quotations is a distinction made by students between their projected feelings (the emotional state in which they wished to be seen) and their actual feelings (true emotional state). These comments suggest student development of image management ability through cognitive reflexivity. In other words, through careful identification, display, and bodily work, these students were able to hide emotions such as nervousness and to project an image of 'calm and control' consistent with the objective demeanour expected of science experts.

Four of the sixteen described how such nervousness/stress resulted in their committing errors, with each respectively lamenting:

> Student 5: [Referring to when her partner cut her off from presenting her opening arguments] This rattled me a little bit and shook my confidence during the rebuttal, in which I missed some important points that I had planned on addressing.
>
> Student 24: I think the weak aspect of our communication was the difference in our [speaking] tones. While it was probably a large part nerves – having a better flow between the two of us in tone would have made the debate easier to follow along with.
>
> Gary: Although I had prepared for lots of arguments for the debate, the moment when I spoke to the audience, my mind just went blank, I was too nervous to recall some information that I prepared before the debate.
>
> Larry: Despite being very expressive in the tone of my voice, I was looking down at my sheet and had my body folded tight in a ball with my legs up. This probably represented a lack of adequate preparation and memorization.

Some of the 16 stressed/nervous students expanded on their reflections by naming the sources of their negative emotions. As Student 5 mentioned, one such example was the mistakes/errors that she made, which ended up flustering her. Meanwhile, other students alluded to their general lack of experience with debating as well as their lack of familiarity with spontaneously reacting and responding to the messages and arguments of their opponents:

> Student 15: For myself, I've never done a debate before, and I was surprised at how you couldn't really tell on the video that I was nervous when, in reality, I was extremely nervous on the spot.

Nevertheless, twelve of the stressed/nervous students revealed that they were able to manage the stressful nature of the debate. These students credited their emotional management ability to their profuse preparation for debate. Extensive study of the chosen scientific topic and practice

presenting arguments allowed them to comfortably anticipate opponents' messages and to avoid being caught off-guard by any unexpected arguments/rebuttals:

> Student 15: Practicing our introduction with my partner was key, and it made us feel more prepared going into the actual debate. I was surprised how much practice it took between the two of us to really nail our points and make sure there were no redundancies in our arguments.

> Student 24: I think learning how to be prepared was the critical communication skill learned in this project. When you aren't is when nerves start to show. Really researching all avenues and practising orally are applicable skills to apply to any communication problem and crucial to doing well.

These students also attributed their emotional management ability to what they had learned from the course's lectures, activities, and assignments, which included strategies to deal with the stress of debating:

> Student 5: I also found myself feeling a lot less nervous for this presentation than I have in the past. This may have been because I was prepared and excited to share my arguments with the class, but I also think this is due to the fact that I have now had a lot more experience speaking in front of a group, and it has gradually become a lot easier to do.

In sum, participation in adversarial debating exchanges about controversial science issues caused most students to experience stress and nervousness. Yet, many of these students were able to manage this emotional state by hiding how they truly felt, and instead projecting the appearance of calmness and control that was more consistent with the cultural expectation of objectivity (i.e. with the cultural norms of science communication). This emotional management ability was contingent upon preparation (scientific knowledge and familiarity with communicative strategies) as well as practice, which enabled students to anticipate and effectively respond to opponents' arguments/rebuttals.

Student performances

Overall

Our review of the video footage showed that 19 of the 29 students demonstrated behaviours indicative of nervousness/stress while debating, including avoiding eye contact with their opponents and audience; having a gaze that was mostly downward; speaking at a heightened pace; speaking monotonously; stumbling through what they are saying (e.g. mispronouncing words, holding awkward pauses, and using filler words such as 'um' or 'uh'); or, partaking in distracting body language (fidgeting, shuffling their feet, swivelling chairs, etc.).

These signs of nervousness were particularly prominent among students who, in the moments leading to the debate, were assigned to defend an 'anti-scientific' viewpoint (e.g. the Earth is flat). These were described by the students as being a challenging task:

> Student 1: I was surprised about how difficult it would be to switch gears when preparing for both sides of the argument. I really had to convince myself of the sides while preparing myself for them, which was mildly confusing.

> Student 17: It was difficult to push aside personal bias towards a certain side of a topic especially when reading research articles to effectively prepare for both sides.

Frank's performance

The first student spotlighted by this study is Frank. He and his partner had learned minutes before their debate that they would be arguing in favour of the statement of 'the Earth is flat.' Given other students' experiences with anti-scientific stances, one might expect that Frank would find himself overcome with stress from the abject difficulties of his position. Yet, this was not the case. As he relayed:

> Frank: I think what surprised me [when watching the video] was that I really did look like I was having fun. Debates are stressful. I got into more once we started going, but I am glad I looked at ease. Even in the heat of the debate I was having a ton of fun.

Despite the difficulty of his task, Frank's post-activity responses indicated a level of flexibility, specifically in the form of a willingness to adopt alternative strategies steeped in style, charisma, and stage presence:

> Frank: The side we chose immediately put us in a hole. However, it was our job to come back from that … what I learned most from this is that communication is not always about being right. We had to argue the non-scientific side and it was difficult. We had to bend the truth to come across to our audience. You need to play to your strengths and know to whom you are speaking … a strong aspect of my communication was my physicality. Paired with what I was saying, I felt like, to have a shot at winning, I needed to make a connection with the audience. That meant turning to look at them, speaking with my hands, and using physical examples [to demonstrate my arguments]. In terms of style, again, we had the non-scientific side, and so we had to play up the sentimental angle. I thought we did a very good job.

The blatantly incorrect nature of Frank's stance on the debate topic provoked a realization that he needed to detach somewhat from the arguments he was putting forward lest he fail to win over the audience. As he later added, such detachment came about in the form of adopting a persona:

> Frank: This was a very cool experience, and I am somewhat glad to see that I was showing my enjoyment. Hopefully not too much, because it was also neat to see how into my persona I was. When debating a side that has less merit, I knew I would have to act a little and get into character. I think that I was surprised with how into I was – although I really liked it!

Yet, while Frank's persona was adept at being engaging and presenting ostensibly legitimate rebuttals to those against Flat Earth Theory, he appeared to still acknowledge and lean into the comical nature of his stance. In other words, his lines of argument were able to bring the proverbial heat while simultaneously keeping a tongue-in-cheek nature. This was evident when Frank launched through his opening set of arguments with a well-acted serious manner and tone that did not betray how silly/fun he had found his words to be:

> Frank: Our model is a disk [his hands gesticulate in the shape of a circle] on which we are on the center … and, around us, what you think is the South Pole is actually an ice wall that surrounds our disc as we barrel through space in our solar system … So, if I were to stand up to you today, you would see a 6'3' man. I, based on the curvature of the Earth, should see no more than five kilometres. However, if I'm looking over flat water [he turns towards the audience and gives a slight pause] FLAT water, might I add [the audience laughs] I can see far, FAR further than I am supposed to … The globe itself [takes another dramatic pause] globers would say, is not really a perfect sphere, right? That's what you've [his opponents] told us. It's an obloid; it has mountains and stuff, so it's not a perfect sphere … well our disc is not a perfectly flat disc [snarky tone and incredulousness] … that would be crazy!

As underlined above, Frank resorts to name-calling (the nickname 'globers') as part of a *reductio ad ridiculum* strategy, eliciting laughter from the audience while mocks his opponent's position. This strategy leads to the emergence of a collective emotional climate (Bellocchi et al., 2014) characterized by sarcastic attacks, aggressive humour, and amusement, like that of a comedy roast. Also known as onomatophilia (the embrace of name-calling to trigger shame and blame), this manner of debating is common in political debates with the recent rise of a roast culture and shame-based politics (Blumberg, 2017). Similar to a presidential candidate, Frank resorts to name-calling as he seeks to shame his opponents.

Despite the absurdity of Frank's arguments, he forwarded several heated barbs to his opponents and other scientific establishments, having attempted to evoke a sense of distrust amongst his audience:

> Frank: [In photographs of Earth taken from space] We observe for ourselves not the true Earth; we observe pictures. How can we trust pictures, everyone [gently slaps his thigh, slightly rolls his head back, and uses a skeptical tone of voice as he turns to makes eye contact with the audience like a disappointed parent reacting

> incredulously to mischief that their child has partaken in], when NASA is lying to us? Every photograph that they have given to us has been photoshopped [employs a vocal tone indicative of disbelief]. The creator of the Blue Marble [a photo of the Earth taken from space] … yes, the creator, not the photographer … because he created this. When you pull out your brand-new iPhone, your back screen is the picture of the [takes a dramatic pause] Earth [uses fingers to mimic quotation marks], of the globe. No, that photo was actually photoshopped.

Yet, despite his team's verbal aggression, both the audience (who, by virtue of being upper-level science undergraduates can be assumed to be biased towards the scientists being disparaged by Frank) and his opponents frequently laughed at Frank's attacks. This is especially apparent when he responded to his opponents' argument that one can literally use their eyes to see that the Earth is not flat:

> Frank: Alright, the ship goes over the edge [which means] there's no edge there? That is because of optics. Our eyes are not the best things in the world, we accept that … I'm wearing glasses [grabs onto his own glasses] … so are these two [points to his opponents].

Whether due to the farfetchedness of Frank's argument or how he had wildly gesticulated towards his opponents, the audience subsequently launched into a cacophony of claps, cheers, and laughs – the loudest audience reaction that would occur in any of the students' debates. Likewise, his opponents (also smiling and apparently understanding the humour of the situation despite having just been insulted) made a point to immediately and dramatically/exaggeratedly remove their glasses from their face, provoking an even stronger audience reaction. Through continued use of exaggerated markers of emotional intensity (exclamatory sentences, rhetorical questions, body movement, and face expressions), Frank and his opponents continued to frame the debate as a playful/humorous exchange that resembled a comedy roast.

An emotional climate of amusement persisted through the debate despite the recurrent verbal aggressions and back-and-forth reputational attacks. This aggression was particularly evident towards the end of the closing arguments when Frank's opponent launched a final attack while matching his tongue-in-cheek nature:

> Frank's Opponent: The Flat Earthers are a group of impressionable people who would do anything to ignore the fact that they have been proven wrong time and time again … *To all Flat Earthers out there, it's okay! You can admit that you're wrong* [uses a tone of a caring yet slightly condescending mother] [audience laughs]. We won't say that we told you so, but we think that it's time to FLATTEN [forcefully slams her palm against the table and smiles] [audience laughs] this theory, come around, and realise that this ridiculous theory should've died a long time ago [smirks].

With the way she delivered this emphatic yet tropey catchphrase, Frank's opponent acknowledged the humour surrounding the debate, adopting a persona of her own – that of a concerned-yet-condescending interlocutor. The resulting atmosphere throughout the debate was characterized by relatively low levels of stress and nervousness, with Frank and his opponents making no noticeable mistakes. Namely, they all spoke in a relaxed yet confident and firm pace; engaged in consistent eye contact with one another and the audience; did not stumble over any words; and did not have any distracting body language. Frank and his opponents remained visibly poised and at-ease even amid heightened verbal aggression such as Frank's characterization of astronomers as hypocritical and smug fake scientists who unfairly refuse to entertain the possibility that they are incorrect, and Frank's opponent framing of Flat Earth Theory supporters as cultists with an intelligence comparable to those who would willingly ingest laundry detergent.

Gary's performance

Gary had a much different experience. Unlike Frank, his team was tasked with arguing in favour of a science-oriented stance: 'GMOs are not detrimental to human health.' Accordingly, he had noted in his post-activity survey the ease with which he was able to find scientific evidence corroborating the safety of GMOs and how familiar he was with anti-GMO arguments, thus being prepared for them:

> Gary: Before doing any research on this topic, I have always thought that GMOs are a contentious topic, and people standing on both sides of the argument should all have plenty of scientific arguments to support them. However, after researching this topic, I realized that the opponents of GMOs do not really have much science to back them up, and there is general consensus in the scientific community that GMO are safe. The reason why so many people do not trust GMO is that anti-GMO arguments use conspiracy theories that can easily convince the general public who lack a strong scientific background … The strong aspect of our team is that our arguments were all drawn from the scientific literature. I felt confident in presenting our evidence to the audience with a solid scientific background.

Unfortunately, Gary's confidence and preparation would subsequently be undermined by his public-speaking anxiety, leading to an error-filled performance that went against his expectations:

> Gary: This activity made me realize that I am still far from being a good science communicator, and I still need more practice. Although I had prepared for lots of arguments for the debate, the moment when I spoke to the audience, my mind just went blank, I was too nervous to recall some information that I prepared before the debate. I should practice more and be more familiar with the content next time.

This inability to recall was apparent in how Gary spent most of his recorded performance reading from a script. This nervousness was further evident in the fact that, when not reading from the laptop, Gary rarely established eye contact with his audience or opponents (his gaze was usually downwards).

Likewise, he attributed the rapid pace at which he had spoken to his inability to feel relaxed. Furthermore, while he did not touch upon this in his reflections, other manifestations of his anxiety included his vocal monotony and lack of audible emotion. This was especially apparent in the following excerpt from the debate:

> Gary: [The GMO crop Golden Rice] would help us solve malnutrition issues around the world, especially in underdeveloped countries in Asia and Africa where vitamin A deficiency [which Golden Rice has been genetically modified to address] are a big problem and can cause blindness and even death in young children. And because some activist groups are constantly opposing this crop, it still has not been produced in developing countries. This has caused an estimate of 2,000 children to die [Gary unceremoniously and abruptly stops talking].

Despite discussing a topic as emotional as the death of children, Gary chose to employ a flat tone for the entirety of the previous quote, never changing the inflection or volume of his voice. Instead of acting out sadness or anger (i.e. over the needless child deaths that he implied his opponents have had a hand in causing), Gary chose to simply read his script aloud, giving rise to a performance characterized by low levels of emotional energy (Davis & Bellocchi, 2020). Such a low-intensity performance drew considerable scrutiny from audience members:

> Audience Member: Some of [Gary and his partner's] points weren't as forceful … like 'two thousand children dying [from malnutrition abetted by lack of access to GMOs]' … like it was almost like a whisper in my ear. If you had brought out that a little bit more it would've been more impactful.

> Audience Member: [Watching the debate was] so hard because you're like 'I want to agree with you [Gary and his partner]; start dancing or something … do something like … watch these guys [Gary's opponents who had spoken with emotion and energy] … like come on!

This latter recommendation stemmed from how one of Gary's opponents presented his arguments with a confident and passionate tone. For example, the opponent had also referred to the deaths of children, using them as sentimental examples of how, from his perspective, genetic modifications are dangerous. Yet, unlike Gary, the opponent was able to present with emotion (specifically one of feigned anger over how supporters of GMOs were being reckless with the public's health). In addition, Gary's opponent was able to follow-up and capitalize on his anecdote, having turned to face the audience before subjecting them to a barrage of personal questions while gesticulating emotionally:

> Gary's opponent: A seventeen-year-old had a condition called OTC which means he basically can't process proteins. He, at *seventeen* [emphatic tone] was healthy. He lived a healthy life. He volunteered for a clinical trial on this new gene therapy experimental thing … at the age of seventeen [switches to a more somber

> tone], Jesse died [pauses dramatically], four days after his treatment … How many more children need to die? How many more parents? [dramatic pause] How many more people do we need to lose before we say 'no'? I'm saying zero [dramatic pause] that's something we do, we shut it down today. There's a better way, people had treatments that allowed them to live, but we took that away from them. I rest my case.

As can be seen above, Gary's opponent strategically resorted to a series of rhetorical questions and exclamations (dramatic pauses) that effectively fostered a collective emotional climate of moral indignation. Such linguistic features indicated high involvement and strong commitment, giving rise to a tense argument (Plantin, 2019), that is, an argument with a high intensity of emotional energy. Relative to Gary's messages, the above anecdote received much more praise from the audience, who had found it to be rhetorically powerful:

> Audience Member: That [story] … somehow, like, I just got chills because it was so … it felt personal that he died … that death … and at the end of the day you can say all the facts you want, but if you appeal to the audience emotionally (which you did to me) then I think you will have convinced me … you've done a very good job.

In sum, the audience's reception drastically differed between Gary and his opponent. Subsequently, the negative audience feedback that Gary had received was one contributor to his perception that he was still far from being a 'good' science communicator, an unfortunate conclusion to have drawn from his already-stressful experience.

Larry's performance

Larry, whose team was assigned to argue in favour of the statement 'human population must be limited in growth' also indicated that his debating experience had been particularly negative. Like Gary, Larry came into the activity feeling confident thanks to his preparation. Yet, despite such planning, Larry unexpectedly found heavy resistance from his debate opponents in terms of their arguments:

> Larry: Our team did a good job of choosing salient and relevant points based on scientific concepts and leveraging them through metaphors and examples to appeal to the audience's emotion and logic … I felt very confident about my understanding of the topic going into the debate, but I was surprised by how deftly the opponents were able to brush off points or squeeze in their own, relying heavily on adept communication skills … having a good knowledge of the subject on both sides of the argument is not enough to convey the information effectively to convince an audience or an opposing view.

Verbal aggression from Larry's opponents came about in the form of direct attacks and attempts to straw-man Larry's arguments (i.e. misrepresenting Larry's points so that he could be more easily rebutted):

> Larry's Opponent: Our opponent has argued that the only way to secure a habitable Earth for the future is to sharply reduce the human population. This WRONGLY [strong, emphatic tone] focuses on one symptom of an irrational polluting system and does not deal with the root causes.

Like Gary, Larry was faced with a tense emotional climate wherein his opponents made radicalized rebuttals ('all or nothing') that left no room for compromise or negotiation (Plantin, 2019). As can be seen above, his opponent's rebuttal included the verdictive marker ('WRONGLY'). Larry's argument was dismissed as being completely wrong – a non-negotiable verdict highly resistant to refutation. This manner of counterattacking was commented upon by an audience member after the debate:

> Audience Member: There were a couple of points that [Larry's opponents] made in their opening remarks that I just … like, they [Larry's opponents] said something like … '*they* [Larry's team] *said this,*' but it wasn't quite right, it wasn't quite what [Larry's team] had said … and I was like '*Wait, did I miss something?*'

Another obstacle for Larry was his own anxiety surrounding public speaking:

> Larry: I was looking down at my sheet, and had my body folded tight in a ball with my legs up. This probably represented a lack of adequate preparation and memorization, and part of a reaction to a fight or flight response, where muscles are tense.

This 'ball-folding' was a particular point of contention for him. After reviewing the video footage of his performance, he reported:

> Larry: Watching myself mumble to the floor and huddle in a ball made me cringe, and I felt that if I saw someone with that posture in a real televised debate, they would not be very convincing to me. I was surprised by how much this detracted from the passion and understanding I had in the topic. This passion barely showed when my body was held this way. If I could do it again, I would ensure the audience knew my passion by being much more aware of the physical part of my communication.

Such self-flagellating language is particularly notable given that most of the other students had relayed instances of their own errors without an equivalent level of intensity. What made Larry's self-criticality even more unusual was how, as our review of the video recording of the debate showed, his references to a supposed 'ball' behaviour were nothing more than a hyperbole, a highly exaggerated description from our third-party perspectives. While he had demonstrated body language indicative of stress – his foot periodically jittered intensely and he constantly fidgeted by shuffling his feet, swivelling his chair, changing his sitting position, and even moving himself to and from the table – this huddling behaviour he described was never apparent. The actual source of Larry's self-critical comment about his alleged 'huddling' was an audience member who, while offering feedback, brought Larry's attention to the supposed existence of this body movement ('You [Larry] were doing this [folds his body into a ball] the entire time and moving'), stating that it was distracting to the audience.

Discussion

Anxiety and student performance

Reviewing the students' video-recorded debate performances in tandem with their post-activity reflections revealed how feelings of stress and nervousness were common among the students, having been experienced by more than half of the students (16/28). These students invariably displayed behaviours indicative of anxiety/distress, including avoidance of eye contact; looking downward; speaking at a heightened pace and/or monotonously; stumbling through what they are saying (e.g. word mispronouncing, awkward pauses, and overuse of filling words like 'umm' or 'like'); and/or exhibiting distracting body language. Although some were able to manage these emotions, others were unable to feel relaxed, which negatively influenced their debate performance. For example, Gary unexpectedly found himself unable to recall from memory the information he had learned in preparation for the debate (his mind went blank), consequently being forced to read from a script. Meanwhile, Larry froze up when faced with the verbal aggression of his opponents, being unable to rebut their attempts to straw-man his arguments. These students' initial confidence and preparation were undermined by their felt anxiety, unexpectedly leading to rhetorically weak and error-filled performances.

The above finding is consistent with literature highlighting the anxiety commonly experienced by students during public speaking (Arnsten et al., 2012; Lacy et al., 1995). The adversarial nature of debates can itself be a source of additional stress for students when such activities are employed as educational tools (Goodwin, 2003; Hartin et al., 2017). Such stress stems from students' fear or apprehension that their self-image as competent communicators may be publicly undermined while debating (Howe & Cionea, 2021; Oliveira et al., 2021). Debating anxiety can serve as an 'emotional filter,' precluding students from achieving their full potential (Hopârtean, 2016). Rudland et al. (2020) describes how stress can impede memory functioning as well as decision-making, cautioning that too much stress can inhibit academic ability. Such detrimental effects were observed in the performance of Gary, Larry, and other students.

As a result of his participation in the debate activity, Gary admitted in his reflections that he felt as if he was 'still far from being a good science communicator.' In other words, his perceived self-efficacy in being able to communicate science was low. This learning outcome is concerning for two

reasons. First, past literature (e.g. Besley et al., 2018; Besley et al., 2019; Rodgers et al., 2020) has pointed to an inverse relationship between one's self-efficacy and willingness to partake in future public science communication endeavours. Moreover, self-efficacy has also been associated with a motivation to learn (Wang et al., 2008). In a worst-case scenario, this could potentially mean that students who came away from the practice debates with lower perceptions of science communication self-efficacy, like Gary and Larry, might be discouraged from continuing along their path to becoming a capable public communicator or seek assistance/training to improve on their weaknesses.

Nonetheless, our analysis also revealed that not all students were negatively impacted by feelings of anxiety/stress. A case in point was Frank who seemed able to capitalize on his feelings of nervousness, subsequently delivering a particularly effective oral performance steeped in style, charisma, and stage presence. His silly words, farfetched arguments, and exaggerated gesticulation elicited a cacophony of claps and cheers from the audience, causing even his opponents to laugh. This positive reaction boosted his self-confidence, transforming what he initially experienced as a 'stressful situation' into a 'fun experience.'

This finding is consistent with previous research showing that, in certain situations, stress can alternatively have positive impacts on student performance. Accounting for how some students effectively communicated their arguments (i.e. without any errors and in an engaging manner), stress can be associated with enhanced motivation (Rudland et al., 2020) and mental functioning (e.g. Cahill et al., 2003; Kaiseler et al., 2009; LeBlanc, 2009) rather than anxiety. These researchers emphasize how 'eustress' (stress that aids those experiencing it, as opposed to distress which hampers those it afflicts) can be conducive for learning, regardless of whether it occurs in a high – or low-pressure environment.

Further insight into the significance of the above findings can be gained by examining it from the perspective of the Expectancy Value Theory (EVT) (e.g. Pintrich & De Groot, 1990), which seeks to explain how students approach a particular task from a standpoint of personal experience, confidence, and background as well as how they view such a task in terms of its efficacy to them as learners (i.e. how it fits their unique needs, style, and personality traits). From this perspective, one may argue that how well students handle stress is direct a reflection of personality traits such as extroversion (arguably a predictor of natural performativity). Though reasonable, such an argument should be considered with caution as it runs the risk of reducing emotional management and adversarial science communication ability to innate qualities possessed by a lucky few who are born or raised with them. As emphasized by epigenetic perspectives on talent/skill development (Weaver, 2019), human ability is socio-ecologically emergent phenomenon that is not simply determined by internal factors (e.g. personality) as it is also affected by external factors (e.g. exposure to training). As such, it is likely more productive for university instructors to approach communication and emotional handling as skills that all students can develop over time through guided instruction and practice.

The implication here is that instructors wishing to conduct a practice debate series should ensure that their class is comfortable and that less confident or extroverted students (who may have less natural performativity) are provided with the necessary means to adapt to the stresses of the activity. A possible avenue for this can be found in Reis et al. (2015), who investigated the anxiety faced by students participating in science fair competitions. These authors observed that students who had had positive experiences in previous science fairs were more capable of adapting to the stresses of later science fairs. As such, instructors could consider conducting smaller-scale 'dry runs' (rehearsals) with even lower stakes (e.g. no grades/assessment, no expectations) beforehand, allowing their students to comfortably acclimate to the actual activity of adversarial debates.

Theatricality and emotionality

Another noteworthy finding was an apparent link between theatricality (performance of highly animated/dramatized arguments) and emotionality (how participants emotionally experienced the

classroom debates). This was particularly evident in Frank's adoption of a comical 'persona' through continued use of exaggerated markers of emotional intensity (exclamatory sentences, rhetorical questions, body movement, and face expressions), giving rise to an emotional climate that resembled a comedy roast. This theatrical approach not only provided Frank with an effective means to manage his own nervousness/stress but was also positively evaluated by his audience. In sharp contrast, the reduced theatricality of Gary's script reading and the associated low levels of emotional energy that resulted made it difficult for him to manage his own nervousness, leading to negative peer feedback and class experience. Likewise, Larry's performance seemed to have been negatively impacted by his opponents' highly theatrical debate delivery style.

The above finding underscores the value of acting skills to science communication education. The pedagogical value of drama activities in science has been highlighted by previous research (Aubusson & Fogwill, 2006; Dorion, 2009; Varelas et al., 2010). These studies consistently point out that acting instruction and practice constitutes an important source of richer meaning-making and deeper scientific knowledge. The present study adds to this literature by showing how, at the university level, drama training can also help prepare future scientists to engage in adversarial forms of science communication like debates. As the reported findings indicate, being able to argue theatrically can be a powerful tool of both persuasion and emotional management. Such findings provide empirical support for training programs such as those currently offered by the Alan Alda Center at Stony Brook University (USA), which combine communication strategies with improvisational theatre exercises to help science experts learn to connect, engage, and empower others (Basken, 2013). Further corroboration is provided by recent neuroscience research showing that the benefits of acting skills can include improvements in emotional control, stability, and self-regulation (McDonald et al., 2020).

Emotional management

Another important finding was that many students (12/28) were able to manage their feelings of anxiety and stress during adversarial argumentation. These students attributed their emotional management ability to their extensive preparation and practice prior to the activity. Having researched the topic under deliberation comprehensively, having become familiar with effective rhetorical strategies, and having practiced these strategies extensively, these students were able to comfortably anticipate their opponents' messages and avoid being caught off-guard by any unexpected arguments/rebuttals. These students were better able to adapt to the stressful nature of the debate and deal with the unpredictability/spontaneity of debating. Additionally, at least one student (Frank) made strategic use of humour. His comic demeanour allowed him to effectively manage the anxiety he initially felt when faced with the daunting task of having to bring down his adversaries, transforming the nature of the debate from a tense confrontation into a relaxed exchange filled with laughter.

The above finding is consistent with previous research about the social functions of humour. Researchers like Meyer (2000) emphasize that humour provides participants with a socially acceptable outlet through which to release tension and reduce uncertainty related to controversial issues. Seizer (1997) adds that humour serves an important liberating social function. Talking about serious, sensitive, and controversial topics in unserious or joking ways allows speakers to escape discursive constraints and at the same time protect themselves against criticism. Likewise, Franks' comical demeanour had tension-relieving, liberating effects. His humorous argumentative style fostered a playful mood – a less tense, less threatening, less formal, and more enjoyable classroom atmosphere wherein students could casually and comfortably argue about Flat Earth Theory.

Despite its novel insights into student anxiety in the context of adversarial argumentation, it should be acknowledged that this study is not without limitations. For instance, the scope of our examination was limited to an isolated activity in a single classroom setting with its own unique culture, set of students, course instructor, and other characteristics. Implementing the same debate activity in another classroom may result in different outcomes with anxiety. Additionally, our methodological design did not include follow-up interviews that could have allowed students to reveal

more about their emotional management while debating. Another limitation was the gender-based foci of our students; closer attention will need to be given to female students in future studies. Lastly, it should be acknowledged that the prompts in the questionnaires used to gather data did not focus specifically on ways students were feeling at the time of debate, which may have biased our findings to students who were most forthcoming in stating how they felt about the adversarial debating contexts and their performances.

Moving forward, research in this area might benefit from the use medical equipment to track various physiological states (e.g. stress hormones), emotion sensors, face recognition software, and eye-tracking technology (unavailable to us at the time of the study). These cutting-edge technologies have been shown to have the potential to advance research on student emotionality by enabling analyses that go beyond self-reported data, such as by tracking the physical manifestations of anxiety (e.g. Arroyo et al., 2009; Azevedo et al., 2013; Terzis et al., 2010). Additionally, longitudinal examination of students' sense of self-efficacy in science communication over longer periods of time might also prove to be a productive venue for further research. Future studies can also examine the extent to which science students' emotions and emotive resources during classroom debates are directed towards discourse objects rather than participants (Grize, 1981).

Conclusion

Our study sought to examine the emotionality experienced by students taking part in an in-class practice debate activity meant to provide them a platform to improve their competency in adversarial public science communication. It was found that students generally felt stressed and anxious, despite the fact that this was an ostensibly low-stakes activity for practicing adversarial argumentation – that is, one where (1) any verbal aggression was role-played and (2) participants were amongst acquaintances. While some students were able to adapt to the activity and even to thrive amid their negative emotions, others were not able to cope with the stresses of the adversarial debate activity. Consequently, the performances of these latter students suffered, and their reflective commentary was filled with lamentations on how they could and should have done better. This was not seen as being an optimal outcome because their comments suggested a drop in their perceived self-efficacy in science communication, raising questions as to whether they might simply give up on future public science communication endeavours or not. Such findings highlight the complex nature of promoting student pedagogical development of rhetorical competence in adversarial social contexts. It is our hope that the present study can help science communication instructors recognize the importance of emotional management and find ways to effectively prepare the next generation of scientists to face the heat of adversarial communication.

Ethical statement

This study was reviewed and approved by the University of Ottawa's Institutional Review Board (Approval # H-08-21-6969). To protect the anonymity of all participants, pseudonyms were used and student faces were blurred out of still frames from video-recordings, thus meeting the ethics requirements for human subjects research at our university.

Disclosure statement

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

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Appendix

Debate Guidelines

Procedure:

At the end of the term, you will debate in teams of 3 students on a topic of relevance to science in society. To make this experience equitable to both teams (as well as to maximize the science communication learning from this experience … . and the fun!), you will not know whether you will argue FOR or AGAINST the issue until the time of the debate. Because of this, you will need to prepare both sides of the argument, which will allow you to develop a complete view of the issue in question.

You must have your teams and a list of 3 preferred topics to debate by the end of September.

The process during the debates will follow typical debate formats: the team arguing FOR the issue will present their opening arguments for 5 min, followed by the AGAINST opening arguments for the same duration. After the opening arguments, each team will have 5 min each to offer a rebuttal to the arguments presented by the other's opening remarks. Finally, there will be a 2 min allotment for each team to present their concluding remarks on the subject.

Potential topics for debates:

- GMO food is toxic to human health
- GMOs are bad for the environment
- Human populations must be limited in growth
- Vaccines cause autism
- Nuclear power is too dangerous to be a viable energy option
- The earth is flat
- Glyphosate (Round-up) pesticide use is dangerous to human health
- Human-caused climate change is a real threat to humanity
- Homeopathy is a valid 'alternative' medicine
- Veganism is healthier than omnivory in humans
- Farmed fisheries are more sustainable than wild caught fish
- Humans should colonize Mars
- Capitalism is bad for the environment
- All remaining oil stocks should remain in the ground
- The economy is more important than the environment
- Water fluoridation is bad for our health
- Mining for precious metals is unsustainable
- Artificial intelligence is a threat to human civilization
- Social media algorithms are a threat to democracy
- Social media is a cause of mental illness in youth
- All drugs should be legalized in Canada
- GMO mosquitos will increase the spread of infectious diseases like Zika or West Nile Virus
- or you may make other suggestions