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Experiencing the entrepreneurial side of science: undergraduate students pitching science-based businesses

Alandeom W. Oliveira[1] · **Adam O. Brown**[2]

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Abstract

Despite increased recognition of the need to expose students to the entrepreneurial side of science, few actually have the chance to experience the process whereby advances in science become commercialized as technological innovation and give rise to business opportunities. To address this issue, the present study examines the implementation of a classroom activity wherein undergraduate biology students orally pitched a science-based business to trade a new plant-based meat product. Through a primarily qualitative design that combined video-recordings and survey data analysis, we explore student argumentation (claims, evidence) as well as the impact of orally pitching on students' professional mindset and professional identities. Our findings revealed that evidence-based argumentation was prominent across students' entrepreneurial pitches. Six out of ten groups included scientific evidence in their pitches, presenting their products as both commercially and scientifically valuable. The remaining four groups resorted to strictly commercial value propositions. Moreover, sociocultural impact on students was mixed. Although for many students pitching a science-based business led to entrepreneurial mindset and expanded their science career options, for others it was an uncomfortable experience perceived to be inconsistent with their scientific values and academic identities. Only the former students opened themselves up to the possibility of embracing a new identity as science entrepreneurs in their future career choices. This study highlights the pedagogical potential of science-based business pitching to serve as a transdisciplinary curricular space where students can authentically and productively experience the entrepreneurial side of science.

Keywords Science entrepreneurship education · Undergraduate science curriculum · Science-business integration · Science-based business pitching · Evidence-based argumentation

✉ Alandeom W. Oliveira
aoliveira@albany.edu

Extended author information available on the last page of the article

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Introduction

There is increased recognition among educators of the importance of exposing students to the entrepreneurial side of science and creating authentic learning environments for the exploration of the science-business interface. Students in the scientific fields, it is argued, need opportunities to learn about technology commercialization and to develop business and entrepreneurial skills (Blessing et al., 2008; Rae & Melton, 2017; Shekhar & Huang-Saad, 2021; Warhuus & Basaiawmoit, 2014). Learners need to be able to explore the nature of technology commercialization, to practice science-based entrepreneurship, to experience the creation of a science business (from ideation to implementation), to acquire entrepreneurial skills such as the ability to identify an entrepreneurial opportunity, and to gain knowledge about the process whereby entrepreneurs transform an innovative product idea into a successful and commercially viable business. Offering students such learning opportunities is critical as it can allow them to experience science in more expansive ways, develop expanded notions of what it means to be a scientist, and recognize the wide range of professional possibilities available to them beyond the academic sphere (Letovsky & Banschbach, 2011).

Despite this recognition, student experience in the business of science and in the pursuit of profit from science is relatively infrequent. Few students have the chance to experience the process whereby advances in science become commercialized as technological innovation and give rise to business opportunities (Winkler et al., 2015). Reasons behind such state of affairs include lack of teacher training and curricular absences (Deveci, 2016; Deveci & Çepni, 2014; Deveci et al., 2016; Deveci & Seikkula-Leino, 2018). Nonetheless, initial studies suggest that this business-based approach to science teaching can promote student development of improved scientific and entrepreneurial skills (Lester & Rodgers, 2012; Levin & Montvilo, 1998; Radday et al., 2019), particularly in the area of communication. Participation in entrepreneurial science activities such as developing "green" business plans (Letovsky & Banschbach, 2011) and making a rocket pitch to "sell" renewable energy (Rodgers, 2014) has been shown to provide students with an engaging and personally relevant space to discuss and argue, effectively promoting argumentation skills such as the ability to make convincing claims based on scientific and/or commercial evidence.

The above suggests that the pedagogical power of science-based entrepreneurship is not well understood and is yet to be fully capitalized upon by higher educators. This is particularly important given the fact that entrepreneurship is a critical and potent societal force shown to drive innovation, productivity, and overall economic growth (Kedrosky, 2013). Advances in the sciences of life, energy, and materials come with the promise of technological innovation that can drive economic growth and welfare improvement. Therefore, entrepreneurship integration into the science curriculum warrants closer analytical scrutiny. To this end, the present study examines the implementation of an interdisciplinary classroom activity in which undergraduate biology students researched, planned, and orally

pitched a science-based business to trade a new plant-based meat product. Our specific research questions are:

1. What kinds of value claims (commercial, scientific, personal, etc.) did students make during their oral pitches and what types of evidence (if any) did they use to support such claims?
2. How did the experience of pitching a science-based business impact students' professional mindset and professional identities?

Theorizing entrepreneurship

Our theoretical stance combines cognitive and socio-cultural perspectives on entrepreneurship. Informed by Blessing et al. (2008), we conceive of entrepreneurship as a professional mindset, that is, a way of thinking that is shared by the members of a professional community. Originally coined by McGrath and MacMillan (2000) and further elaborated by others (e.g., Haynie et al., 2010; Hill, 2016), the term *entrepreneurial mindset* has been defined as a set of expert cognitive abilities that that novices are expected to develop overtime. One such ability is persuasive argumentation. Entrepreneurs must be able to think of effective ways of convincing stakeholders of the value of a new product (Spinuzzi et al., 2015a; Spinuzzi et al., 2015b; Spinuzzi et al., 2016) such as making compelling claims based on evidence (e.g., market research).

However, cognitive development is only one side of the coin as there is also a sociocultural dimension to the teaching and learning of entrepreneurship. Exposing students to entrepreneurship entails more than just teaching them how to think like an entrepreneur, it also involves inviting pupils to experiment with being a particular type of person/professional. As students learn how to start an entrepreneurial venture and practice how to commercialize a technological innovation, they inevitably experience a novel professional positioning or way of being as business entrepreneurs. Such experience has the potential to influence students' emergent sense of self and can lead to their development of expanded professional identities. Engaging in business or trade inevitably involve negotiation of a new professional identity. Such a point is eloquently made by Magee (2019) who calls on researchers not to overlook entrepreneurial personhood in their analytical accounts: "caution [should be taken] not to let what exactly is being sold slide out of view of estimations of such personhood… asking 'what will I sell?' is tantamount to asking 'who shall I be'? (p.22)". As such, it stands to reason that pitching a new science-based business also entails pitching a new professional self. The extent to which this business personhood is experienced as compatible with and becomes integrated into students' science identities is part of our analysis.

In an entrepreneurial pedagogical setting, science students have the chance (many for the first time) to try on a new professional identity as a *science entrepreneur*. Hybrid in nature, such a professional identity sits in what can be considered a social ecotone—a transitional zone between two social ecosystems (professional communities), namely science and business. The significance of such social boundaries

as generative places is highlighted by Leggo (1998) who describes how the place where different spaces intersect (called an "ecotone") tend to be full of possibilities and fecund. Likewise, we consider the science-business interface to be such an in-between space. Its interdiscursivity (Bhatia, 2010) constitutes fertile ground for learning that is both generative and transformative.

During entrepreneurial activities, novices are also socialized into the cultural values of the world of business, including preferred ways of communicating. Pitching, as theorized in the field of business communication, is a professional genre centered on a value proposition (Kowalkowski et al., 2012). At its core this proposition is a claim about the commercial value of a new product to investors and customers. This claim can be either accepted or dismissed depending on the pitcher's rhetorical performance. Acceptance is contingent upon technology innovators' effective deployment of rhetorical strategies (e.g., making presentations more compelling by including evidence), engagement tactics (e.g., performing demonstrations, telling stories, asking questions, etc.) (Cofrancesco et al., 2017; Spinuzzi et al., 2015b; Spinuzzi, Jakobs, & Pogue, 2016). More than mere "tricks of trade," these preferred ways of communicating to an audience constitute cultural values to which novices must be socialized to succeed in the business world. The present also attends to this sociocultural aspect of science-based entrepreneurship.

Straddling two worlds

Science and business

In early scholarship, science and business were treated as two separate worlds (Pisano, 2010), that is, completely distinct human enterprises governed by different sociocultural norms. The world of science was seen as being inhabited by academics whose main concerns included research projects, publication of findings in academic journals, and sharing of knowledge with the general public. As "disinterested professionals", scientists were assumed to be driven by their intrinsic motivation to advance knowledge and to share it with peers and the broader public (Peters, 1999) as opposed to money or status. Being driven by profane reasons such as publicity, raising funds, political influence or financial gain was considered unscientific and culturally discouraged (DiBella et al., 1991; Nelkin, 1987). In contrast, the world of business was considered to be dominated by managers, industrial scientists, and engineers concerned mainly with profitability, capital, and markets. In this highly competitive world inhabited by "ruthless sharks," self-interest was culturally accepted as the norm, and technological advancements were surrounded by secrecy.

However, more recent scholarship has progressed beyond such a dichotomous view, showing that it was too simplistic as the scientific and business worlds in fact have much in common and actually overlap to a significant degree (Shapin, 2008). Contemporary accounts highlight how scientists have become increasingly active in competing for funds and seeking to capture financial returns on intellectual property through patenting, licensing, etc. Likewise, scientific research is now pervasive in the business world (e.g., corporate industrial laboratories). The increasing

convergence of these two worlds in recent years has led to rise of the *science-based business* (Pisano, 2006a), entrepreneurial firms and organizations that are deeply immersed in science. In the present paper, we align ourselves with this later perspective, conceiving of science and business as two overlapping worlds, that is, two distinct yet interconnected human endeavors which we defined as follows:

Science is the study of the natural world, including the laws of nature associated with physics, chemistry, and biology and the treatment or application of facts, principles, concepts, or conventions associated with these disciplines. Science is both a body of knowledge that has been accumulated over time and a process—scientific inquiry—that generates new knowledge. Knowledge from science informs the engineering design process (p. 14, Honey et al., 2014).

Business refers to the efforts and activities undertaken by individuals to produce and sell goods and services for profit (Hayes, 2022).

Science business refers to science-based commercial enterprises that use scientific knowledge to create innovative [technological] products that satisfy human needs and wants (p.2; Pisano, 2006b).

Far from straightforward, this convergence of science and business has led to philosophical tension, raising questions such as: "Can science be a business?" (Pisano, 2006a). As Pisano (2010) adds, "science-based businesses face unique challenges as they straddle two worlds with very different time horizons, risks, expectations, and norms" (p. 4). For instance, professional communication practices can differ considerably across these two worlds, making it difficult for novices to grasp the precise nature of expert communicative performance about science-based business. To illuminate the complexities of this issue, we review scholarship centered on science communication and business communication next.

Science communication

Communication is an essential part of a scientist's professional responsibilities, the ability to effectively communicate scientific information, it has been argued, is critical for political decision-making, regulation of science, and funding (Brownell et al., 2013; Greenwood & Riordan, 2001). To secure funding for their research, scientists must be able to produce compelling proposals that clearly convey the value and applicability of the ideas being proposed as well as the potential broader impact that the proposed discoveries may have on society (Feliú-Mojer, 2015; McNutt, 2013). Put differently, scientists need to be able to convince reviewers that their ideas have intellectual merit and can engender broader social impact (i.e., "sell" their ideas to funders). As such, it can be argued that, from a communicative perspective, scientists can be considered "intellectual salespeople"; they are in many ways sellers of science. This highly competitive review process exemplifies well the socially embedded nature of science, an abstract and elusive concept that students often find challenging to grasp (Akerson & Abd-El-Khalick, 2005).

Beyond grantsmanship, scientists also need to be effective oral communicators. Rather than simply expecting the data to speak for itself, they must be able to persuade their peers of the validity of their claims and importance of their scientific

work. Recent research on oral presentations in academic settings has revealed a wide variety of strategies commonly used by effective oral communicators to achieve such a goal. For instance, rather than reading the text verbatim with both eyes fixed on the PowerPoint slide, effective speakers tend to read the text *extemporaneously* by making eye contact with the audience, using gestures, and uttering elaborations and parenthetical remarks to create the illusion of spontaneity (Tannen, 1988; Tracy, 1997). Other strategies attended to include speaking rate, timing, social skill (handing difficult questions from the audience), and rhetorical style (Hincks, 2010). Also examined are retrieval strategies used to call up language and recollect information (e.g., memorizing the text, using notes), and rehearsal strategies such as practicing before presenting (Chou, 2011). This literature emphasizes the culturally embedded nature of oral communication in science in the sense that effective performance is contingent on the presenter's familiarity with the communicative values of the culture of science (e.g., orally creating the impression of objectivity).

To teach science communication to undergraduate science students, university educators have traditionally used oral presentation assignments (Oliveira et al., 2021; Chan, 2011). In these classroom activities, undergraduate students practice how to formally communicate science to scientific audiences and effectively perform academic communication. However, such a narrow focus is inconsistent with the fact that professional scientists also have to communicate with a variety of non-scientific audiences (Rodrigues et al., 2007), including investors, funders, and commercial partners. To increase their chances of professional success, students also need to develop a strong foundation in informal science communication during their undergraduate degree.

Business communication

Of central importance in the world of business is the *entrepreneurial pitch*, a communicative practice in which entrepreneurs attempt to sell their innovative ideas to collaborators, investors, or clients (Sabaj et al., 2020). Epitomized by the TV show *Shark Tank*, the act of making a pitch is aimed at securing investment for an innovative product in a competitive business context (Smith & Viceisza, 2017; Teague et al., 2020). This act is often conceived in terms of a baseball metaphor wherein the entrepreneur (pitcher) is viewed as throwing (pitching) an idea to a potential stakeholder (catcher; Belinsky & Gogan, 2016) in a very short period of time loosely equivalent to an elevator ride from the first to the tenth floor (Denning & Dew, 2012).

Considered as part of the rhetorical dimension of technological entrepreneurship (Spinuzzi et al., 2015a), the business pitch is seen as an attempt to persuade a stakeholder of the value of an *innovative product* (new technology), often with the support of a slide deck (e.g., PowerPoint slideshow). To this end, the pitcher has to be able to present the new product in a manner that is compelling and engaging (i.e., promote it), and that can create interest in the audience. Moreover, the pitcher has to effectively speak to the needs of catchers and help the audience envision how the

technological innovation could meet the needs of potential buyers and be profitably adopted by the market.

Despite their technical expertise in the scientific domains, novice innovators often need training in professional communication, particularly in how to effectively pitch their ideas/products (Spinuzzi, Jakobs, & Pogue, 2016). To attend to such a need, education programs in entrepreneurship that offer training in effective pitch communication have become increasingly available (e.g., Cofrancesco et al., 2017; Spinuzzi et al., 2015b). In these programs, participants hone their pitching skills as they take part in educational activities such as Shark-Tank style pitching competitions and pitch redesign based on feedback from a trainer or mentor.

Communication at the science-business intersection

As can be gathered from the above literature, persuasive argumentation and rhetorical influence are an important part of professional communication in both science and business worlds. Whether through writing research proposals or orally presenting business propositions, professionals in both fields need to able to make a compelling case and convince an audience of the value of their work in order to secure the funds required to advance one's research agenda or start a new entrepreneurial business. In other words, ability to persuade or influence others (peers, other professionals, and/or the lay public) is an essential feature of professional communication in both the science and business worlds. Such a shared concern with professional communication, we believe, can serve as a productive source of synergy for the integration of entrepreneurship into university science curricula.

One way that university educators can capitalize on this area of synergy is through implementation of interdiscursive classroom activities such as *science-based business pitching competitions* wherein students are challenged to communicate technological innovations to potential investors (real or simulated) as they compete for funding. This is precisely the focus of the present study, which examines a science entrepreneurship activity in which a group of undergraduate biology students set out to create and present a promotional pitch for a plant-based meat product.

Research design

Exploratory in nature, the present study adopts a flexible and emergent research design aligned with the tradition of grounded theory (Glaser & Strauss, 1967). As part of this study, descriptive data were systematically collected through open-ended research methods (survey and video-recorded classroom observations) and then analyzed inductively to build a naturalistic account (Lincoln & Guba, 1985) of the argumentative nature and pedagogical impact of a classroom activity that integrated business entrepreneurship into science at the undergraduate level, namely oral pitch presentations.

Participants and intervention

Participants in this study included a group of biology students taking a third-year course called *The public communication of science* Enrollment consisted of a total of 40 students. Designed to prepare future scientists to communicate science to various non-specialist audiences, the class met twice a week for 1.5-h lectures. The course was structured as a seminar with regular guests 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 third week, the focus was on *Pitching a Science Business*. Spanning two entire lectures and a recitation session (total of 4.5 h), the set of classroom activities implemented during this particular week were subjected to analytical scrutiny.

The guest speaker for the week was the owner of a local marketing company who worked with small- to medium-sized brands in the food industry (e.g., restaurants) providing communication advisement. With a background in environmental science, he had experience working with non-profit groups, science research and policy communication, and marketing in both the public and private sectors. As a former science student now in the marketing field, he was knowledgeable about science as well as social media and digital advertising.

The Science Entrepreneurship Activity was structured as follows:

Day 1 (Lecture): 30-min presentation by guest speaker + Group Work (1 h).
Day 2 (Recitation): Group Work 1.5 h.
Day 3 (Lecture): Student Pitches (1.5 h).

The first day began with a talk, in which the guest speaker used a PowerPoint slideshow to present three exemplars of highly successful science business pitches currently in the market. These exemplars dealt with the following technological innovations: (1) *Reefertilizer*, (2) *Instant Pot,* and (3) *Macdonald's fish and chips*. During the presentation, he introduced students to the inventors behind these technological innovations, discussed features that made their science business pitches successful (e.g., use of digital and social media strategies), identified many platforms and methods used to sell the products (e.g., YouTube, Instagram, fast food chains, home meal care services etc.), showed videos developed to market the products (e.g., the award-winning reefertilizer jingle at https://vimeo.com/374944262), and introduced basic principles of pitching a science business idea (Table 1).

During his presentation, the speaker emphasized how the creators of reefertilizer used their jingle video (a catchy, creative and simple pitch unlike other fertilizer ads) as a YouTube ad targeted at gamers (a key demographics), hence making headlines, producing a substantial boost of sales, and even wining marketing awards. He also emphasized the unique nature of the "grassroot approach" used by the Instant Pot creator where he sought to empower chefs by sending them free Instant Pots and encouraging them to publish new books and recipes using it, ultimately making Instant Pot a huge success, particularly with Amazon. The speaker also described how the creators of Macdonald's Fish and Chips took a scientific approach by first

Table 1 Guest speaker's examples of successful STEM business pitches

Product and Ad description	Key takeaway points
Reefertilizer–grow good weed Cannabis needs 3 things to grow: Light, Air, and Nutrients. The first two are easy, nutrients should be too. This is what Reefertilizer was made for	Adapt message to popular platform; Target specific demographic; Push the envelope creatively
Instant pot–dinner. done The product was developed with an advanced microprocessor and incorporated the functions of five cooking appliances into one: pressure cooker, slow cooker, rice cooker, steamer and warmer	Leverage already existing popular communities online; Empower people to empower yourself; Find strong strategic partner (Amazon)
MacDonald's–fish and chips With the Fish and Chips Meal, we've brought something unique to the table—not just made for Atlantic Canadians, but made by Atlantic Canadians. The new meal is described as a two-piece serving made with 100 per cent wild-caught Atlantic haddock	Partner with "industry expert" Pilot project (use the scientific method) Clear and concise message (i.e., no BS)

piloting their product in Atlantic Canada prior to launching it nationally (described as an experiment). He then summed up his presentation as follows:

> So, I've given examples of different ways to create an engaging type of campaign to launch in Canada. One way is leveraging an existing platform, one way is empowering a community, the third way that we looked at was kind of using the scientific method with an industry expert, the McDonald's one.

At the end of his presentation, the speaker introduced students to their pitching assignment. Working in small groups (four members each), students were to create an engaging campaign to launch an innovative product called *Hungry Planet*® in Canada. Developed by Todd and Jody Boyman, this plant-based meat was designed to serve as an analog and potential substitute for conventional animal meat (see official website at https://www.hungryplanetfoods.com/about/). Proteins from plants such as soy and pea were used to create a product that shares the aesthetic qualities (e.g., texture, flavor, appearance) and approximated the nutritional profile of conventional animal food items such as beef. Such a product is consistent with recent calls for more *sustainable diets*, that is, food whose production requires reduced emission of greenhouse gases, and that can hence help mitigate human impact on the environment (global warming). Other benefits include healthier nutritional content (compared to animal products) and ethical treatment of animals.

The specific aim of this assignment was for each group to prepare to make a 5-min science business pitch that addressed the following questions:

1. Who is your audience?
2. What is the best platform that you can launch on?
3. What format should it be (video, press release, a FAQ, social media campaign, influencer survey, etc.)?
4. What's the key message for the product?

5. How do you excite, engage, and empower your audience?

For the remainder of the lecture (Day 1) and the entire recitation session (Day 2), students worked in small groups. This groupwork time was devoted to background research and pitch preparation. Using notebooks, students were instructed to research the Hungry Planet product, find scientific research related to the product (evidence that could be used to sell their product and/or justify aspects of their campaign), explore potential platforms/commercial partners, and research a target audience. Then, on Day 3 each group made their business pitch and received feedback from classmates as well as the guest speaker. A total of 10 pitches were made overall.

As designed, our science-based entrepreneurship activity had a good degree of alignment with the *Guiding framework for enterprise and entrepreneurship education* (QAA, 2012), which contains a list of specific learning outcomes to be targeted in entrepreneurship education. Among the outcomes targeted by our activity were the need for students to learn to: (1) identify an opportunity; (2) define benefit and value; (3) investigate a market; (4) create a preliminary business model; (5) evaluate feasibility, viability, and desirability; (5) communicate in terms of societal benefits; (6) identify distribution channels; and (7) build teams. However, other recommended outcomes were not addressed in this activity, including the need for students to learn to protect intellectual property, identify supply chains, assess policy and regulatory issues, etc. As emphasized by the guest speaker the goal was simply to come up with an execution plan to launch *Hungry Plant* nationally and articulate a rationale to justify their proposed plan based on a review of the relevant scientific literature. Instructor guidelines were open-ended, granting students some freedom in deciding exactly how to position themselves during the communicative assignment; traditionally as a science or business person (as someone who belonged to either world), or in a more hybrid manner as a science-based business person (as someone who belonged to both worlds).

Other adaptations were also made. Compared to similar educational interventions in previous studies, several design features set out our science entrepreneurial activity apart. First, it was not framed as a "real pitching competition" wherein the team who makes the most compelling pitch wins. Instead, the activity was framed as a "collaborative simulation" meant to simply provide science students with an opportunity to experience and explore the business world for the first time and apply their newly acquired knowledge about entrepreneurship by making a pitch and then receiving feedback from an expert. Another distinctive feature of this activity was that all teams pitched the same innovative product (*Hungry Planet*), which had been previously developed by other science experts. This technological innovation was simply selected by the guest speaker without any student input and presented as the only product choice for students to pitch. This is in sharp contrast to pitching competitions wherein participants pitch their own products after having dedicated a considerable amount of time and effort to its design and development. Lastly, there was no initial ask or negotiation of specific costs and profits (i.e., detailed discussion of finances was seen as unnecessary and beyond the scope of the activity). The goal of the pitching assignment was not to literally sell an idea to real investors, but rather to

metaphorically "sell" a marketing plan to peers and instructors (i.e., to present a plan that was compelling and somehow justifiable). Instead of "real" investors, the audience was made up of other pitchers, the course instructor, and the guest speaker—an expert marketer who played the role of a "business angel" (Teague et al., 2020).

Data collection

Our main data sources were video-recordings and survey data. Video-recordings were made of the entire Science Entrepreneurship Activity, including students' oral pitches. This data was used to identify the specific kinds of value claims (commercial, scientific, personal, etc.) students made during their oral pitches and the types of evidence students used to support their claims (Question 1). In contrast, the written survey was the main source of data used to determine how the experience of orally pitching a science-based business impacted students' professional mindset and professional identities (Question 2). Taken by students at the end of the Science Entrepreneurship Activity, it was comprised of the following open-ended probes:

1. What did I learn most from doing this activity?
2. How will this skill help me progress towards my professional goals?
3. What was something that surprised me about this assignment?
4. What potential weakness did this activity highlight in me that I would like to improve upon?

Data processing

Our qualitative analysis had a tripartite focus specifically on students' oral argumentation, and impact (cognitive and sociocultural) on students. More specifically, we adopted a "grounded theory" approach to data analysis (Glaser & Strauss, 1967). that called for the iterative and combined use of interpretative and flexible methods of analysis. There were no a priori hypotheses or codes. Instead, analytical categories emerged and were gradually refined based on close examination of meanings and patterns in the collected data.

Video analysis of students' pitches Transcribed recordings of oral presentations were carefully examined to assess students' oral performances in light of recent studies of business pitch communication (Moreau, 2018; Nelson, 2016; Smith & Viceiza, 2017). Our specific analytical focus was on the argumentative practice of value proposition (Kowalkowski et al., 2012). To this end, we examined the kinds of value claims (commercial, scientific, personal, etc.) students made during their oral pitches and the types of evidence (if any) used to support such claims. In other words, we analyzed how the value of a new product was constructed in discourse by students through a process of linguistic evaluation—explicit and implicit communication of values of varied nature.

Post presentation surveys Student responses to our open-ended probes were assessed for perceived impacts in students' professional mindset and professional identities (i.e., the extent to which students felt that participation in the science

entrepreneurship activity allowed them to acquire a new ways of thinking as well as a new ways of being a science professional). The former analysis focused specifically on students' thinking process, whereas the later centered on emotionality (feelings about their professional selves, science, entrepreneurship, and professional future) that resulted from their oral pitching experiences.

Various measures were taken to ensure the validity and trustworthiness of our analysis. First, we combined systematic examination of transcribed recordings and sequential analysis and playback of video-recorded interaction. Second, we held peer debriefing sessions where we worked to triangulate our individual interpretations of the data. As emphasized by Lesh and Lehrer (2000), the cross-checking of particular episodes is of paramount importance to videotape analysis. And third, we reflectively considered our emergent patterns in light of student responses to the survey.

Results

Our main findings are presented in this section, focusing first on the students' value claims and supporting evidence (Question 1). Attention then shifts to how the experience of pitching a science-based business impacted students' professional mindset and professional identities (Question 2). Throughout the section, underlining is used to identify key terms and phrases in our participants' quotations that were central to our analysis.

Students' value claims and supporting evidence

Overall Student-pitchers provided detailed descriptions of marketing strategies, potential partners and markets, and competitors (Table 2). By far, the marketing strategy most commonly deployed by students was to leverage existing social media platforms and online communities. As part of their proposed approaches to launch Hungry Planet in Canada, all groups sought to harness the power of platforms such as YouTube and Instagram to influence youth and younger audiences, especially millennials. In addition to online platforms, many groups also pitched parallel campaign strategies (e.g., food sampling) with a variety of local partners—another form of leveraging focusing on existing local communities and face-to-face interaction. Groups 2, 5, and 6 favored partnerships with local business (popular restaurants that catered to their targeted audiences), whereas Groups 3 and 7 opted for a partnership with an educational institution (UOttawa itself) and a government agency, respectively.

Four groups emphasized empowerment (Groups 4, 8, 9 and 10) and one proposed a scientific experiment (Group 6)—the other two marketing strategies introduced by the guest speaker. The former groups presented purchase and consumption of *Hungry Planet* as a potential source of empowerment for everyday consumers (acts of power). As the speaker for Group 8 stated, "we would like to empower the youth and our environmentally consciously millennials to be able to actually do something

Table 2 Summaries of students' STEM business pitches

Group	Partner(s)	Marketing strategies	Rationale	Type of value claim	Type of evidence
1	*GoodFood*	1. Send a coupon to customers for a free meal kit with the plan-based meat 2. Provide original recipes to subscribers	1. Canadian online meal-kit company with a large number of subscribers 2 Rapidly growing demand for meal-kit services 3. Alignment of values (culinary excellence, environment, health, justice)	Commercial claim	Statistical evidence (a bar graph showing the industry's annual sales between the years 2013 and 2020)
2	*Elgin street diner* + YouTube	1. Free samples to parents and kids to familiarize with taste 2. Create recipes and give them to social media influencers	1. A local business that is family friendly and well known in the community for their meat products 2. Appeal to cultural knowledge	Commercial claim	No evidence provided
3	UOttawa + Instagram	1. Set up pop-up shops at UOttawa events like games and campus parties 2. Instagram ad campaign	1. Local university hosts public events that are attended by large numbers of students (e.g., Frosh Party, Poutine Fest) 2. Appeal to cultural knowledge	Commercial claim	No evidence provided
4	YouTube + Instagram influencers	1. Create videos ("Hungry Planet, not rabbit food" and using famous athletes eating Hungry Planet) for a media campaign 2. The videos would pre roll health and fitness videos on YouTube	1. Excite, Engage and Empower youth 2. Older generations (used to eating "steak and potatoes") are set in their ways. Instead, focus on increasing next generation's awareness of plant-based meat as an option worth trying (without labels such as "vegan food")	Commercial claim	No evidence provided

Table 2 (continued)

Group	Partner(s)	Marketing strategies	Rationale	Type of value claim	Type of evidence
5	Meat-focused, local restaurants (*The Keg*, and *East Side Mario's*) + YouTube	Ad campaign using YouTube's algorithm to target specific age groups: (1) 25 y.o. and under – emphasis on sustainability; and (2) 35 y.o. and up – emphasis on health benefits of product	1. Target people "who are on the fence about" adopting a vegan/ vegetarian lifestyle 2. Evidence: graph bar showing amount of greenhouse gases emissions per kilogram of meat for beef, lamb, pork, & chicken; analysis of restaurant menus	Commercial and scientific claims	Scientific evidence: a graph bar showing amount of greenhouse gases emissions per kilogram of meat for beef, lamb, pork, and chicken
6	Small, trendy, nice restaurants in Vancouver and Toronto + YouTube	1. For younger audience (millennials): short YouTube ads (5–6 s) targeted to animal and environmental activists 2. For older audience: scientist talk (educational) 3. Free samples at restaurants	1. Smaller restaurants that are "Instagram destinations" (unlike corporate, fast-food chains) in large cities 2. Getting people to talk about Hungry Planet (creating a "buzz")	Commercial claim	1. No evidence provided 2. Showed bar graph of "projected sales increase" (not actual evidence)
7	*Health Canada* (government agency) + YouTube/ Instagram	1. Partner with barbecue YouTubers and Instagram recipe content creators 2. Use wLink (influencers receive digital currency per clicks) 3. Target 17–30 y.o. who are meat-eaters and climate conscious ("on the fence")	1. Health Canada has a new food guide that recommends large increase in the amounts of vegetables and fruits; 2. Hungry Planet can help achieve recommended amount of veggie intake	Commercial and scientific claims	Scientific evidence: Pie chart of new food guide + demographics

Table 2 (continued)

Group	Partner(s)	Marketing strategies	Rationale	Type of value claim	Type of evidence
8	YouTubers with larger numbers of subscriptions (*Tasty*, *Binging with Babish*, *The Burger Show*)	1. Send packages with samples to popular YouTubers who will use it to create videos; 2. Give YouTubers a cut of orders; 3. Send out coupon codes (measure of campaign effectiveness and impact)	1. YouTube is very popular among millennials; 2. Empower YouTubers and leverage their popularity;	Commercial claim	Statistical evidence: statistics about the millennial demographics (size, buy power) + number of subscriptions of popular YouTube channels
9	Instagram + *Skip the Dishes*(online food delivery company in Canada)	1. Instagram ads + hashtags; 2. Empower younger, progressive, environment-ally conscious people (millennials) who are more open to change; 3. Send free samples to culinary influencers	1. Instagram is popular among younger demographics 2. No slide decks (notes on cell phones)	Commercial claim	Statistical evidence: statistics about adults wanting to reduce meat consumption, and number of Canadians who use apps to order food delivery to door
10	YouTube + Instagram	1. YouTube videos; 2. Traditional posters (place "Start Here" posters in restaurants, community centers, gyms, etc.) 3. Sampling events	1. Empower environmentalists (e.g., Instagram activists) and health-conscious people;	Scientific and commercial claims	Scientific evidence: protein content of Hungry Planet (23 g/burger), number of people who attended "climate strikes"

about the climate crisis in a delicious way and also to be able to use a bit of scientific foresight." Similarly, Group 10's speaker stated that "[When dealing with environmental issues and health]", people often feel that their impact as an individual is minimal it can be overwhelming and uncertain… so our strategy is to empower these people, give them opportunity to act, thus our campaign slogan 'start here'."

One noticeable feature of the students' business pitches was the inclusion of evidence in an effort to make their presentations more compelling. This rhetorical strategy was deployed by the majority of students (Groups 1, 5, 7, 8, 9, and 10), as recommended by the guest speaker during his talk. These groups showed graphs with a variety of data, shared research findings, and/or the results of their own analysis of selected partners. In sharp contrast, the remaining four groups did not provide evidence of any sort, instead resorting to alternative strategies. Groups 2 and 3 simply appealed to shared cultural knowledge through strategic reference to potential partners that were well-known locally, hence rendering their proposal more compelling by creating the impression of some degree of market familiarity and expertise. Group 4 made no attempt to provide any sort of evidence. Lastly, Group 6 included a bar graph of "projected sales increase" that did not actually constitute evidence, but simply groundless predictions.

Evidence-based pitching. To illustrate the themes described above, we now take a closer look at student oral performance within groups 1, 5 and 7, all of which made rhetorical use evidence in an effort to make their entrepreneurial pitches more compelling.

Group 1 pitched the idea of partnering with *GoodFood*, a very popular online meal kit company in Canada that delivers the ingredients for making meals selected by customers to their doorstep along with a recipe (https://www.makegoodfood.ca/en/home):

> From this partnership, we would be targeting the company itself, and by doing so, we would also be targeting their consumers… students, busy families, and seniors. To launch our product, our plan is to send to customers for a free meal kit which includes our plan-based burgers… original recipes will be provided to their subscribers and it's not gonna be only for the preference of vegetarians, we are going to try to cover a broad market so that includes those who are "carnivores," those who are vegetarians, and vegan.

This proposed partnership was justified with statistical evidence (a bar graph showing the industry's annual sales between the years 2013 and 2020) that meal-kit services is a rapidly growing industry. Another justification was close alignment with the company's values as evident in the statements and descriptions available on its website:

> We are committed to culinary excellence, environment, and education. Now, GoodFood, they pride themselves on creating new and exciting recipes, something that occurs very often with people who subscribe to these meal kits is that, when they have these recipes, they cook with ingredients that would never have cooked with before. Something else is that GoodFood prides itself on using locally sourced and sustainable food products, so that

really aligns with our goal for sustainability and the environment. Finally, one of the mottos of GoodFood is make cooking fun, so they really encourage people to get back in the kitchen and start cooking again, something that we are committed to also. On a final note, something great about GoodFood is that, for every box purchased, they send a nutritious meal to someone in need. Now, here at Hungry Planet, a project where we are trying to commit to improving human and planetary health. We decided to collaborate with GoodFood so for every Hungry Planet meal that is bought, we're going to be donating one of our products to a hungry child, that way they can get a nutritious meal. In conclusion, we hope that, through our partnership with GoodFood, we will be able to help the planet.

As can be seen above, selection of *GoodFood* as a partner is justified in terms of a value analysis as well as a market analysis. Their value proposition is that their product is personally valuable (i.e., is driven by lofty personal values) and commercially valuable (there is growing demand for it in the food market). Whether Hungry Planet may also have scientific value is not given any consideration. In other words, science is not used as a tactic to render their pitch more compelling or as grounds for selling their technological innovation. Noticing this absence, the guest speaker provided students with the following feedback comment: "science has a place in business."

Group 5's oral pitch included a slide deck with a graph bar showing amount of greenhouse gases emissions per kilogram of meat for beef, lamb, pork, and chicken (Fig. 1a):

- Student 1: Hello everyone, we are Hungry Planet, and we are here today to talk about a plant-powered alternative for meat. So, a couple of things that we are very proud of at Hungry Planet, for starters is that we proud ourselves on how our product is so close to actual meat in terms of the taste and the feeling, and what you are familiar with… another thing we are very proud of too is that our product is really made by chefs for chefs…
- Student 3: Using UTube's algorithm, we will have tailored advertisements for specific age groups, so those around the age of 25 and under we will really hammer on the point of sustainability and ethical practices, whereas ads that appear for people aged 35 and up will be more geared toward the health benefits of eating meal alternatives…
- Student 4: One of the benefits of incorporating this, um, plant-based alternative, into these, uh, industries, these restaurant industries, is the actual science behind it. So, currently, 100 of ground beef costs 24 thou, uh, hundred gallons of water, 74.5 square feet of land, and results in 4 pounds of carbon dioxide emissions, whereas just one day of plant-based diet can cut these numbers in half. To go with the environmental benefits of a plant-based diet, there is also numerous health benefits, mostly the availability of nutrients with less cholesterol, trans fats, and antibiotics in general, meats as well as, huh, a diet that supports the treatment of many heart diseases and diabetes, among others.

As can be seen above, in addition to discussing the commercial value of their new product (potential to appeal to a particular market and generate profit), members of Group 5's pitch also focuses on the "science behind it." The quantitative results of environmental studies visually displayed and orally mentioned serve as evidence for the claim of there being added environmental benefits to their product, namely reduced carbon dioxide emissions. However, no scientific evidence is actually provided to substantiate the claim that their product is also beneficial to consumer health. The core of their value proposition is that their product has not only commercial value but also scientific value (intellectual merit and potential for broader social impact). The guest speaker's feedback was that "empowering environmentalist with something they can do is a great idea."

Group 7 pitched the idea of partnering with *Health Canada*, which is the department of the Government of Canada responsible for national health policy. Based on extensive food science research, this department recently published a new food guide (available online at https://food-guide.canada.ca/en/). This publication was strategically treated by this group as a business opportunity:

- Student 1: Scientists show that the only way for us to meet our goals is to reduce our average meat consumption. That's why we as a company have the mission to provide these plant-based products that are more sustainable and environmentally friendly than animal products that you likely grew up with.
- Student 3: Just last year, Health Canada came out with a new food guide (Fig. 1b), and a lot of health-conscious communities were kind of shaken about the reduction in the amount of meat that was recommended in the diets, and the increase in the amount of veggies and fruits. So, we are hoping that maybe we can partner with Health Canada, with the people who created the new food guide to show that our products are a way of reducing your meat intake and increasing your veggie intake while still cooking and eating the foods that you have grown to love your whole life.
- Student 4: As a young person, with all the talk about climate change and our changing environment that we have going on, it can feel kind of a bit overwhelming, like "What can I as individual do to help?" and you feel a little lost. So, that's where we step in, if you don't know where to start, you should start with us.

Like Group 5, Group 7's pitch went beyond a discussion of the commercial value of their new product. The group also displayed a science infographic showing the food makeup of healthy diet according to current food science research. This infographic took the form of pizza-like plate in which each food type (meat products, fruits and vegetables, and grains) was represented as a "slice" whose size was proportional to the relative amount recommended by scientists. This infographic served as scientific evidence for the claim of there being health benefits to their product, namely increased vegetable consumption. However, no scientific evidence was provided to substantiate the claim that their product was also environmentally beneficial (such claim remained without any warrant). As result, the core of their value proposition was that their product had commercial value as well as scientific value. In

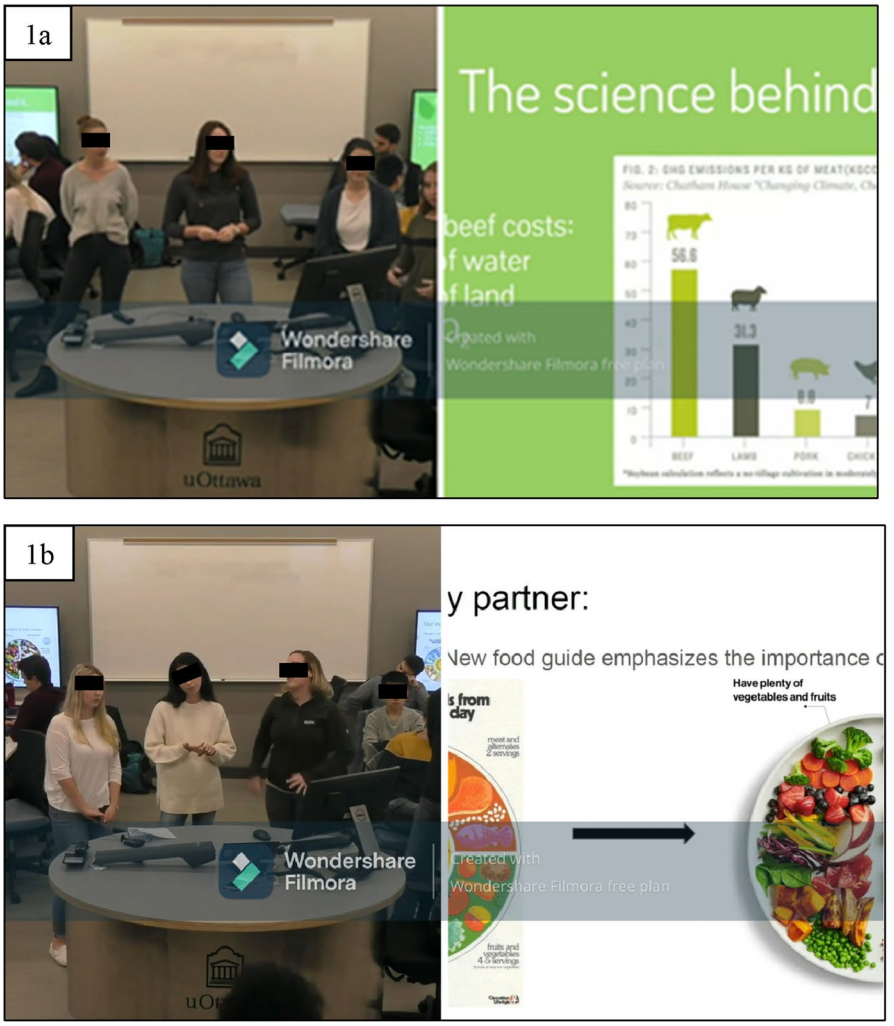

Fig. 1 Simultaneous view of students' oral pitches (left) and slide decks under discussion (right) for **a** Group 5 and **b** Group 7

this feedback to this group, the guest speaker wrote "GOC [Government of Canada] doesn't endorse would have to look for another partner… industry partner wouldn't be GOC".

In sum, student argumentation during their participation in Science Entrepreneurship Activity comprised of a variety of value claims, including scientific and/or commercial. For students who advanced scientific claims, the core of their value proposition was that their product had commercial as well as scientific value (intellectual merit and potential for broader social impact). These students invariably supported their claims with the findings of scientific research studies. In contrast, other

students refrained from making scientific claims, choosing instead to claim value strictly on commercial grounds. Although some of these commercial claims were supported with statistical evidence (market data), many of them remained unsupported by any credible evidence.

Impacts on students' mindset and identity

While participation in the Science Entrepreneurship Activity had an overall positive cognitive impact on students, its sociocultural impact was mixed. Evidence of these differential trends is provided below.

Professional mindset In their survey comments, many students emphasized how participation in the science entrepreneurship activity allowed them to experience a new way of thinking about science and consider scientific ideas and findings from a novel perspective. In response to the probe "What did I learn most from doing this activity?", students stated:

- Student 1: What I learned the most is that it takes different mindsets when communicating to a general public and this is a key aspect to being a good communicator. In this situation we had to think like marketers and business people which took us out of our comfort zone in a more unknown environment.
- Student 2: I learned a lot about how to think like a consumer. I found that in order to come up with an effective business pitch I had to step into the shoes of the different consumers in order to see what would seem the most effective.
- Student 3: Ways to integrate an investigative mindset into business ventures, such as applying the scientific method to advertising campaigns.
- Student 4: [This activity] taught me to really try to think about science from the perspective of a business.
- Student 5: In creating an advertising campaign, I had to think about different target audiences and why type of presentation might appeal to them.
- Student 6: The work was very people oriented, although I learned about the contents and nutritional value of the product and about the nutritional value for regular food.
- Student 7: This assignment required holistic thinking… big-picture thinking, and attempts to consider perspectives beyond my own.

In the above comments, students recurrently emphasize the transformative nature of their experiences making a business pitch for the first time. As described by the students themselves, such a learning experience gave rise to an alternative mindset that was novel and unfamiliar. In addition to thinking like a scientist, students also had an opportunity to think like an entrepreneur, marketer, salesperson, or consumer while considering scientific issues such as nutrition, health, and the environment. In other words, the pitching activity successfully encouraged students to go beyond a strictly *scientific/investigative mindset* (analytical and thing-oriented) and adopt *an entrepreneurial mindset* that was more people-oriented, required holistic and

big-picture thinking, and entailed a multiplicity of perspectives. It was clear from their comments that students became more entrepreneurially minded.

Feeling uncomfortable with an entrepreneurial identity Students' comments also revealed that pitching a science-based business was often a source of discomfort for them. Students recurrently described how uncomfortable they felt as novice scientists venturing into the familiar world of business for the first time. This was evident in students' responses to the probe "What was something that surprised me about this assignment?":

- Student 1: This project took me out of my comfort zone quite a bit, and forced me to use my background in science in a whole to way, to attack a challenge from a very different perspective…it allowed me to try my hand at communicating science to an audience that doesn't have much of a background or even interest in science, and to try and keep it interesting, to use it to get a message across.
- Student 2: I felt very much out of my comfort zone, and pretty disoriented when doing research for this assignment, and found it quite challenging.
- Student 3: I felt I needed to look off of my notes while speaking in order to get my point across given that I am not entirely comfortable with this subject matter.
- Student 4: In this situation we had to think like marketers and business people which took us out of our comfort zone in a more unknown environment.

The experience of making their first oral pitch left some students with a sense of discomfort and disorientation. Such feelings seemed associated with a degree of difficulty grasping their new speaker role, understanding the expectations of a business audience, and approaching the selection and structuring of content for their pitches. Students' comments are reflective of their strictly academic background. As members of an academic culture, performing on a business "stage" for the first can be challenging task due to a variety of cultural and cognitive differences (discussed later in the paper). These are particularly evident in the following student comments prompted by the probe "What potential weakness did this activity highlight in me that I would like to improve upon?":

- Student 1: It was challenging to present the topics and ideas in a way that stayed true to science and the scientific process while still remaining clear for the client.
- Student 2: I think that I don't have the peppy salesperson energy needed to be successful in marketing. I don't think that this will hold me back in my career, but I can of course work on being more energetic.

Both students above describe the challenges they faced while attempting to adopt a new style of professional communication more typical of business culture. The highly energetic and engaging speaker role (the "peppy salesperson") that successful pitching performance is perceived to entail is felt uncomfortable and in certain ways inconsistent with the scientific values. As Student 1 writes, communicating in this new way makes it difficult to "stay true to science and the scientific process." For this particular student, selling science came with the possibility of "selling out," that is, betraying the scientific values to which she was personally committed.

A couple of students also commented on how they perceived pitching science-based business as being tantamount to "selling science" and how such perception impacted their future professional selves as evident in their responses to the probe "What did I learn most from doing this activity?":

- Student 1: I love coming up with research ideas, research proposals, competing in science competitions. My dream is that someday, one of those ideas will come to fruition and lead to a viable business idea. However, no matter how good the idea or the product may be, I've learned that I need to sell it, both metaphorically and perhaps literally. Proper communication of my science/business idea is the only way I can even hope to receive enough funds or investments for my future ventures.
- Student 2: I think the biggest thing I learned from this activity was the ability to sell science in a way that is digestible for all audiences.

As underlined above, "selling science" was an emergent theme across many student comments. As a result of their participation in this activity, these students seem to view "science" as something that can be sold. Perhaps as an attempt to reconcile this seemingly counterintuitive notion, a distinction is made between literal and metaphoric selling. While entrepreneurs are viewed to literally sell science in the form of technological innovation, academic scientists are said to sell science only metaphorically in the form of academic projects for research funders. Each form of selling is linked to a particular professional identity. Such comments provide empirical support for Magee's (2019) argument that asking "what will I sell?' is tantamount to asking 'who shall I be'?

Embracing an entrepreneurial identity While some students remained committed to the professional identity of an academic scientist, others were more open to the possibility of embracing a new identity as science entrepreneurs in their future career choices. This was evident in students' comments in response to the prompt "How will this skill help me progress towards my professional goals?":

- Student 1: I believe that having this experience with a "sales pitch" format will be helpful. It is conceivable that in the future I might be in a position where I am trying to sell a technology or something that I have worked on to investors.
- Student 2: If I decide to pursue my career in something that involves sales, marketing, and advertising, I think this communication skill would be very beneficial as this skill would help me be more persuasive and effective in selling any product as well as being able to advertise the science of a product effectively.

Rather than struggling with cultural differences between science and business, the above students are able to reconcile the two worlds. For them, crossing the boundary into the business is unproblematic and appears to be experienced as a smooth transition (Aikenhead, 2001) because their personal values align with both the cultures of science and business. Since becoming a "professional science salesman" is embraced as a serious career option under consideration, these students are benefited with an expanded range of professional possibilities.

In sum, as reported by the participants themselves, the Science Entrepreneurship Activity effectively supported student development of entrepreneurial cognition (i.e., encouraged them to think like entrepreneurs). Nonetheless, as designed, its sociocultural impact seemed less effective. While some students embraced science entrepreneurship as an expanded professional identity and a new career option, others were left with a sense of discomfort and disorientation (i.e., struggled to navigate and reconcile what they experienced as incompatible worlds/professional identities).

Discussion

We now discuss the significance of the reported findings.

Evidence-based argumentation

One important aspect of students' oral performance of science-based entrepreneurial pitches was their use of evidence-based argumentation as a rhetorical strategy to persuade potential investors. As described above, six out of the ten groups included evidence in an effort to make their presentations more compelling. These groups resorted to graphs with a variety of data to back up their claims about the value of their product to investors and customers. Groups 5 and 7 shared findings of recent environmental and health science studies to advance value propositions that their product was commercially as well as scientific valuable (i.e., they used science to sell their product). In contrast, Group 1 shared the results of market/value analyses, putting forward a value proposition that their product was personally valuable (i.e., is driven by lofty personal values) and commercially valuable (there is growing demand for it in the food market)—whether it also had scientific value by virtue of being consistent with the latest scientific research was not given any consideration.

The above rhetorical practice of using science to sell an innovative technology is aligned with current emphasis on evidence-based argumentation in the field of science education. Among the *eight essential practices of science and engineering* that all students should learn, the Next Generation Science Standards (NGSS Lead States, 2013) include engaging in argumentation from evidence (Practice 7). According to this document, learning to orally present an argument based on data and evidence is a critical part of teaching for citizenship in science. Pedagogical practice in evidence-based argumentation can help produce citizens who are communicatively better prepared to join deliberations in different parts of society, and hence foster improved democratic participation (decision-making) informed by science. In practice, enactment of this educational goal usually entails facilitation of deliberative activities such as classroom debates and role-playing (town hall meeting, mock trials, etc.) in which students argue in response to a dilemma or scenario (e.g., Oliveira et al., 2012; Sadler et al., 2007). As our results show, this form of argumentation can also be fostered through student engagement in science-based business pitching. As such, the present study identifies a new pedagogical tool that can be added to the belt of science instructors.

Another noticeable aspect of students' evidence-based argumentation was their altruistic features. As described above, students frequently resorted to evidence to back up value claims (commercial and scientific) made during their oral pitches. However, students went beyond simply providing the evidence that their marketing plan was solid in terms of its potential to generate financial gain. Group 1 selected a business partner based on evidence of company values such as commitment to helping others. Group 5 provided scientific evidence that their market plan was sustainable, that is, supported eating habits that were beneficial to the environment and the planet. And, Group 7 provided scientific evidence that their marketing plan promoted eating habits that were beneficial to consumers' personal health. The evidence presented by the students was characterized by a degree of altruism, suggesting that their business plans were not entirely driven by self-interest (a selfish desire for profitability at any expense). Although aimed at profitability, the science-based businesses pitched by students also aimed at lofty/selfless goals such as environmental sustainability and personal health.

This altruistic orientation of students' science-based business pitches is in stark contrast to traditional views of science and business as culturally incompatible enterprises, one disinterested and altruistic in nature and the other selfish and self-centered (Pisano, 2006a, 2010). As emphasized by recent scholarship, the business world has recently witnessed the rise of *social entrepreneurship* (Dees, 2001), the process whereby an entrepreneur recognizes and pursues opportunities to promote social change or societal transformation. The social entrepreneur leverages current technologies to craft innovative approaches that address critical social needs and create both social and economic value. Rather than a non-profit organization, a social enterprise is a for-profit business whose mission also includes social/environmental impact. As Briar-Lawson et al., (2020) point out, it is a myth to think that the difference between business and social entrepreneurship is greed as all business entrepreneurs are greedy, and none are philanthropic.

The businesses pitched by students in the present study fit the above definition of social entrepreneurship. Their proposed enterprises were situated in between for-profit and non-profit organizations. While profit remained a goal, its pursuit was socially and environmentally responsible as informed by current scientific research. As such, students pitched what can in fact be considered *socio-scientific enterprises* in the sense that their social/environmental missions were informed by science with social ramifications; they addressed socio-scientific issues or SSIs (Zeidler, 2003). Profitability did not preclude these enterprises from having a scientific and altruistic orientation. Reflective and explicit discussion about such philosophical issues with students may help students develop a clearer sense of the complexities that science-based entrepreneurship as interstitial practice situated at the nexus of multiple worlds (science and business, profits and nonprofits) that are often characterized as having competing cultural values (altruism vs. self-interest, knowledge vs. action, theory vs. application).

Impact on student mindset and identity

One important way that communicative performance of science-based business pitching impacted the undergraduate science students was by supporting their development of entrepreneurial cognition (i.e., encouraged them to think like entrepreneurs). Pitching a technological innovation provided students who are a priori unfamiliar with the business world with a transformational opportunity to think like an entrepreneur, marketer, salesperson, or consumer while considering scientific issues such as nutrition, health, and the environment. As designed, our pitching science activity successfully encouraged students to go beyond a strictly scientific/investigative mindset (analytical and thing-oriented) and adopt an entrepreneurial mindset that was more people-oriented, required holistic and big-picture thinking, and entailed a multiplicity of perspectives. Although the activity did not produce professional entrepreneurs (e.g., start-up founders), students who participated in the activity became more familiar with the business world and skillful in thinking and communicating entrepreneurially.

The above findings are consistent with research emphasizing the benefits of incorporating entrepreneurship into students' scientific training (Shekhar & Huang-Saad, 2021). Science-based entrepreneurship learning has been shown boost students' entrepreneurial self-efficacy, entrepreneurial attitudes (e.g., viewing entrepreneurship as a valuable and desirable alternative to academic careers), and entrepreneurial intent (interest in becoming an entrepreneur). It can also place students in a position to better handle life transitions (e.g., losing a job, having to relocate, etc.) since entrepreneurially minded individuals tend to be open to a wider range of career pathways and professional options.

In contrast, on a sociocultural level, participation in the Science Entrepreneurship Activity seemed to be less impactful. While some students embraced science entrepreneurship as an expanded professional identity and a new career option, others were left with a sense of discomfort and disorientation (i.e., struggled to navigate and reconcile what they experienced as incompatible worlds/professional identities). As reported, science students frequently described feeling "out of their comfort zone" while pitching a science-based business for the first Student discomfort was in many cases communicatively rooted. One important source of discomfort was having to present in the unfamiliar business English rather than in the more traditional scientific English.

The above finding is consistent with linguistic research showing that, like scientific communication, entrepreneurial communication is highly specialized and can be considered a specific professional register (variation of English) that is unique to business settings (Evans, 2013; Thill & Bovée, 2013). As a result, presentations in academic and business settings differ significantly in terms of purpose, source and structuring of content, speaker roles and audience expectations. Academic presentations are formal, content-focused, and aimed at epistemic goals like demonstrating understanding of a topic and sharing empirical findings. In contrast, business presentations tend to be less formal, more engaging, client-focused, and aimed at expediting business in some way (e.g., by reporting progress, proposing solutions to a problem) or persuading a skeptical audience to purchase their product or accept

their approach (Clark, 2008). The latter can feel uncomfortable for students who, due to their academic background, may require guidance to overcome the challenge of adopting a new style of professional communication. Such a possibility underscores the need for instructional support of students' linguistics needs; instructors need to help their science students feel more comfortable with the specialized jargon of the field of business.

Student discomfort is consistent with research showing that novices commonly experience a degree of social anxiety when giving oral presentations due to concerns with public image and social evaluation (Oliveira et al., 2021). Social anxiety has been shown to arise in social situations in which people set out to make a favorable impression on others but are uncertain about their ability to do so (Alden & Regambal, 2010; Leary et al., 2015). Moreover, social anxiety is often linked to personal concerns over negative self-perception and feelings of insecurity (Rapee & Hayman, 1996). Making a science-based entrepreneurial pitch for the first time can give to these feelings among science students concerned that may fall short of conveying the desired impression, and hence be met with disapproval from peers and instructors. Nonetheless, it has been argued that novices can learn from these uncomfortable experiences (Kennedy, 2005). As Paley (1986) asserts, "real change comes about only through the painful recognition of one's own vulnerability." The discomfort that science-based pitching may cause in science students can in fact provide impetus for professional growth and development and become a powerful motivator for improving one's communicative performance if accompanied by constructive feedback (from instructor and peers) in a positive and support social context characterized by a growth mindset (Limeri et al., 2020).

As described earlier, the traditional view is that of scientists as disinterested professional whose epistemic activity is unbiased by financial matters and personal interest. However, as scholarship in this area has revealed, such a view is at best naïve (Pisano, 2006a, 2010; Shapin, 2008). Moreover, as our findings have shown, viewing science in this manner can lead to feelings of discomfort during entrepreneurial activities wherein science is suddenly approached from a profit-driven perspective. Such an approach can be felt as fundamentally inconsistent with the value of objective disinterest assumed to be shared by scientists. As a possible way that educators can mitigate students' feelings of discomfort, we suggest reflective and explicit discussion about the nature of science (Clough, 2006; Khishfe et al., 2002). Honest and thoughtful deliberation about this issue can help students develop more sophisticated views of the financial/business of side science (i.e., its societal and cultural embeddedness) and ease students' cultural border crossing (Aikenhead, 2001) into the world of business.

Conclusion

There is clear educational value in providing undergraduate science students with opportunities to authentically experience the entrepreneurial side of science. It is invaluable for novice scientists have access to transdisciplinary curricular spaces where they can think, argue, and feel like an entrepreneur. One way of effectively

accomplished this is through integration of oral pitching activities into undergraduate science courses. As our results have shown, oral pitching of science-based business can have multiple pedagogical benefits for science students, including engagement in evidence-based argumentation, skill in communicating science to non-specialized audiences (other than peers), familiarity with expanded the range of science career choices, knowledge about science entrepreneurship, and development of more sophisticated views of science and business fields.

Nonetheless, the feelings of discomfort and disorientation experienced by some of our students should be taken as a word of caution. Such an unexpected instructional complication points to a need for additional research on how the pedagogical design of entrepreneurial science activities can be further improved. For instance, future studies can examine whether more authentic design formats (making the activity more like "real" pitching competitions) might be more beneficial for science students. Additionally, future research will benefit from the incorporation of existing research instruments such as questionnaires and interview protocols (e.g., Clark, 2008; Shekhar & Huang-Saad, 2021). Incorporation of interviews into the research design of future studies (an important methodological limitation of the present study) will allow for closer examination of whether and how differences in the individual characteristics of students may interact with curricular features in shaping business-based science learning. Such additional research is likely to lead to an improved, theory-based understanding of the pedagogical potential of oral pitching as a means to integrate entrepreneurship into science education. It is our hope that the present study as a helpful first step in this direction.

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Authors and Affiliations

Alandeom W. Oliveira[1] · **Adam O. Brown**[2]

Adam O. Brown
abrown@uottawa.ca

[1] Educational Theory and Practice Department, State University of New York at Albany, 1400 Washington Ave., Catskill Bdg., 227, Albany, NY 12222, USA

[2] Department of Biology, University of Ottawa, Ottawa, ON K1N 6N5, Canada