Pitching STEM: A Communicative Approach to Entrepreneurship in STEM Classrooms

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When we are selling our ideas, the audience must first buy us.

Peter Coughter

Abstract

This chapter examines a group of undergraduate science students' oral performances and perceptions of a STEM pitching activity designed to enhance their entrepreneurial mindset. Drawing on scholarly literature from the fields of STEM education and business communication, it is argued that that communication can serve as a source of synergy that educators can strategically capitalize upon as part of their interdisciplinary efforts to teach entrepreneurship in STEM classrooms. In practice, such an approach entails providing STEM students with an opportunity to engage in instructional activities such as making a STEM pitch to a hypothetical funder about an innovative technology. In theory, integration of this form of business communication into the STEM curriculum is hypothesized as a source of entrepreneurial cognition for STEM learners (i.e., it can give rise to entrepreneurial thinking and mindset). Moreover, its reliance on communicative action is consistent with approaches to entrepreneurial education wherein the STEM entrepreneur seeks to actively create entrepreneurial opportunities. To illustrate how this interdisciplinary approach may look in practice, we examine and analyze the classroom

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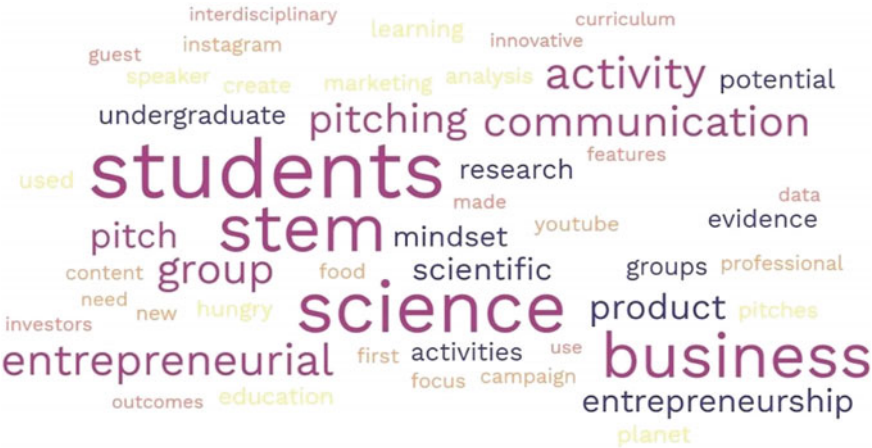
implementation of a STEM entrepreneurship activity at a Canadian university. In this activity, a group of undergraduate science students were given a seminar on the interface between science and business marketing, followed by a group activity in which they had to create and perform a promotional pitch for a plant-based meat substitute product. This chapter analytically scrutinizes an interdisciplinary curriculum designed to create entrepreneurial mindset, students' oral performance when pitching STEM, and their perceived learning outcomes.

Graphical Abstract



Keywords

STEM entrepreneurship · Entrepreneurial mindset · STEM pitching · Undergraduate science education

1 Introduction

At the higher education level, there is growing interest in preparing the next generation of STEM entrepreneurs. Such an interest is evident in the widespread proliferation of educational efforts aimed at providing university students in the STEM fields with opportunities to learn about technology commercialization and develop business and entrepreneurial skills [1]. As part of these efforts to prepare future STEM entrepreneurs, university educators have resorted to a variety of instructional pedagogies [2], including business simulation programs, actual startup

activities, entrepreneurial tasks that are infused into a STEM content course, and free-standing courses (e.g., e-commerce course for science majors). Emphasis is placed in creating authentic learning environments for students to explore the nature of technology commercialization, to practice entrepreneurship, to experience the creation of a STEM business (from ideation to implementation), to acquire entrepreneurial skills such as being able to identify an entrepreneurial opportunity, and to gain knowledge about the process used by entrepreneurs to transform an innovative product idea into a successful and commercially viable business.

Educational programs in STEM entrepreneurship vary not only in terms of format but also in their conceptualization of entrepreneurship itself. While some programs emphasize new business creation (producing start-up founders), others prioritize development of entrepreneurial mindset. Among the latter programs are those that aim to produce STEM professionals who have entrepreneurial ways of thinking and working that can be applied to existing organizations [3]. This distinction is particularly evident in the mission statement of the Kern Entrepreneurship Education Network: "our vision is not just to teach students how to start their own businesses, but to prepare them to think entrepreneurially, particularly more broadly and deeply about how their ideas fit into their environments" [4, p. 13.265.9]. Originally coined by McGrath and MacMillan [5] and further elaborated by others, the term *entrepreneurial mindset* has been defined in varied ways. Haynie et al. define entrepreneurial mindset as "cognitive adaptability… the ability to be dynamic, flexible, and self-regulating in one's cognitions given dynamic and uncertain task environments" [6, p. 218]. More than just acquiring a set of soft skills, developing an entrepreneurial mindset also entails learning dispositions and attitudes. Hill [7] breaks down entrepreneurial mindset into eleven salient elements that students must learn: (1) action orientation; (2) creativity; (3) independence; (4) internal locus of control; (5) leadership; (6) need for achievement; (7) opportunity recognition; (8) perseverance; (9) risk taking propensity; (10) self-efficacy; and, (11) tolerance to ambiguity. From this perspective, being a STEM entrepreneur is more than just learning how to start an entrepreneurial venture or commercialize a technological innovation, it also entails becoming a type of person who generally thinks and behaves entrepreneurially. As elaborated below, we believe that such a mindset can be effectively fostered through interdisciplinary pedagogies wherein business and science communication are infused together such as STEM pitching classroom activities.

Teaching science through entrepreneurial classroom activities remains an unknown educational phenomenon in the field of science education. While some studies have recently examined science teacher development of educational entrepreneurship in the context of professional preparation [8, 9], the pedagogical use of entrepreneurial activities for science instruction is yet to receive analytical scrutiny. To address this gap in the science education literature, this chapter examines and analyzes the classroom implementation of a STEM entrepreneurship activity at a Canadian university. In this activity, a group of undergraduate science students had to create and perform a promotional pitch for a plant-based meat substitute product. Throughout the chapter we use the term *entrepreneurship* in

reference to a subfield of academic business concerned with opportunity, strategy, and innovation. Our specific research questions (RQs) are:

1. What were the main design features (i.e., curricular attributes) of the STEM entrepreneurship activity?
2. What were the main communicative features of science students' oral performance when pitching a STEM business for the first time?
3. What did students perceive to be the learning outcomes of such activity?

2 Communication in Science and Business

Professional success in both science and business is contingent upon communicative ability. In both academic fields, recent scholarship has consistently identified communication training as a vital component of professional growth and an area of undergraduate education in need of improvement. Below, we first review educational scholarship centered on science communication and business communication, separately. An argument is then made that such shared concern with communication development across the two academic fields can serve as a source of synergy that can be strategically capitalized upon to enhance entrepreneurial mindsets through STEM education.

2.1 Science Communication

Science communication has been traditionally considered a secondary aspect or non-integral component to the STEM disciplines. However, recent years have seen increased recognition of the importance of public science communications to benefit society as well as the endeavors of science itself. This recognition is described rather emphatically by Gregory and Miller, who point out that "in the last decade or so, scientists have been delivered a new commandment from on high: *thou shalt communicate*" [10, p. 1]. As communication has been increasingly seen as an essential part of a scientist's professional responsibilities, infusing it into undergraduate science education has become a priority among university educators [11, 12]. The ability to effectively communicate scientific information in society at large is critical for political decision-making, regulation of science, and funding. For example, 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 [13, 14]. Therefore, development of effective science communication skills in undergraduate classrooms is crucial for preparing the next generation of scientists for successful public engagement, education, and influence.

However, at an undergraduate level, this important "soft" skill is not sufficiently taught to students. Brownell et al. [11] indicates that generalized science

communication is a valuable skill that not many scientists or aspiring scientists have been taught sufficiently. Gray et al. [15] surveyed 50 employers of graduates from Massey University, New Zealand, and found a significant trend of students only "occasionally" or "sometimes" being up to par with the written communication skills required for their employment. Likewise, Chan [16] emphasizes that the level of communication education offered to students during their undergraduate degrees is not adequate for the expectations of employers. Such research findings highlight the urgency of teaching science communication in tandem with science learning to increase undergraduate students' employability and ensure that they can achieve the highest level of success possible.

In an effort to address the above issue, university educators have resorted to a wide variety of activities for teaching science communication to undergraduate science students [16]. In addition, more specialized scientific communication activities offered to undergraduate students include oral presentations, written reports, lab reports, written responses on tests/exams, and group discussions. Across these latter activities, emphasis is placed on communicating science to scientific audiences (i.e., academic communication). However, such a narrow focus is inconsistent with the fact that professional scientists also have to communicate with nonscientific audiences in the workplace [17], 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. This can be accomplished, we argue, through integration of business communication activities such as pitching into the undergraduate science curriculum.

2.2 Business Communication

Communication is also of central importance to the world of business, where it is the focus of an entire field of scholarship, namely business communication. Emphasized in this field is the centrality and near omnipresence of the *entrepreneurial pitch*, a communicative practice in which entrepreneurs attempt to sell their innovative ideas to collaborators, investors, or clients [18]. 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 [19]. This act is often conceived in terms of a baseball metaphor [20] wherein the entrepreneur (pitcher) is viewed as throwing (pitching) an idea to a potential stakeholder (catcher) in a very short period of time loosely equivalent to an elevator ride from the first to the tenth floor [21]. Pitching, as theorized in the field of business communication, is a professional genre centered on a value proposition [22]. At its core is a proposition or 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.

Entrepreneurial pitches are characterized by specific discursive structures and linguistic features. For Smith and Viceiza [19], a pitch consists of three basic parts:

introduction of concept/idea followed by an *initial ask* (amount and percent of investment being requested) and then *negotiation* (e.g., questions and answers about the enterprise). Moreau [23] identifies two additional parts, namely to *establish a niche* (the entrepreneur creates a market space by criticizing an existing industry or specific product), and to *occupy the niche* (the entrepreneur presents a new product as a "better" option in comparison to pre-existing ones). Nelson [24] adds that an entrepreneurial pitch may include a business plan; a description of potential markets, competitors, and obstacles; company qualifications, characteristics, and milestones; and/or an account of current funding sources.

Particularly relevant to this chapter is the body of research focused specifically on pitching innovative technologies. This research emphasizes that, to become successful entrepreneurs, STEM innovators need to learn to effectively pitch their technological innovations to appropriate audiences [25]. Considered as part of the rhetorical dimension of technological entrepreneurship [26], the business pitch is seen as an attempt to persuade a stakeholder of the value of an *innovative product,* 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 be able to effectively speak to the needs of catchers and persuasively make claims that can convince them of the business value of the new product (i.e., 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 STEM domains, novice innovators often need training in professional communication, particularly in how to effectively pitch their ideas/products [27]. To attend to such a need, education programs in entrepreneurship that offer training in effective pitch communication have become increasingly available [28, 29]. In these programs, technology innovators are provided with instruction and guidance on topics such as rhetorical strategies (e.g., making presentations more compelling by including evidence), engagement tactics (e.g., performing demonstrations, telling stories, asking questions, etc.). 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.

2.3 Pitching STEM

As emphasized throughout the above literature review, persuasive argumentation and rhetorical influence are an important part of professional communication in both STEM and business fields. Whether through writing research proposals or orally presenting business propositions, professionals in both fields need to be 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, the ability to persuade or influence others (e.g., peers, other professionals, and/or the lay public) is an essential feature of

professional communication in both STEM and business. Such a trend points to the pedagogical value of *STEM pitching competitions*—classroom activities in which students are challenged to convincingly communicate technological innovations to potential investors (real or simulated) as they compete for funding. Such activities, we believe, can serve as powerful interdisciplinary springboards for enhancing entrepreneurial mindsets through STEM education. This belief is subjected to empirical scrutiny in this study, which examines a STEM entrepreneurship activity in which a group of undergraduate biology students had to create a promotional pitch for a plant-based meat substitute product. Our methodology is described next.

3 Methodology

Exploratory in nature, the present study adopts a flexible and emergent methodology partially aligned with the tradition of grounded theory [30]. As part of this ethics-board-approved study, descriptive data were systematically collected through open-ended research methods (survey and video-recorded classroom observations). Data was analyzed inductively to build a naturalistic account [31] of the pedagogical nature and perceived learning outcomes of an interdisciplinary classroom activity (STEM pitching) designed to foster entrepreneurial mindset in science students at the undergraduate level.

3.1 Participants and Intervention

Participants in this study consisted of a group of science undergraduate students taking a third-year course called *The Public Communication of Science*, aimed at developing science communication skills among undergraduate science students. 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 sessions. The course was structured as a series of seminars with guest speakers—specialists in communicating science to the public from various sectors of society, followed by a student activity based on the learnings from the specific expertise of each guest speaker. Over the course of the single semester (15 weeks) it covered topics such as public speaking, talking to the media, and government policy reports and briefings. The focus of this study is limited to the third week of the course. During this week, the focus was *Pitching Science to 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 and used to articulate a communication-based approach to enhancing entrepreneurial mindsets through STEM education that holds promise. The STEM 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).

On the first day, 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., bars and 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 first day began with a talk, in which the guest speaker used a PowerPoint slideshow to present three exemplars of highly successful STEM business pitches currently in the market. These exemplars dealt with the following commercial products: (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 STEM 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 STEM 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 demographic), hence making

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 a 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 percent wild-caught Atlantic haddock	• Partner with "industry expert" • Pilot project (use the scientific method) • Clear and concise message

Source SCI 3101 The Public Communication of Science [32]

headlines, producing a substantial boost of sales, and even winning 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 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.

These three business strategies are discussed at length in marketing books such as 33 Million People in the Room: How to Create, Influence, and Run a Successful Business with Social Networking [33].

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 and burgers. Such a product is consistent with recent calls for more *sustainable diets*, that is, food whose production strives to reduce its ecological footprint, and that can hence help mitigate human impact on the environment (e.g., off-setting global warming, minimizing losses of habitat and biodiversity). Other benefits include higher nutritional content (healthier compared to animal products) and an ethical treatment of animals.

The specific aim of this assignment was for each group to prepare to make a 5-min STEM 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 pitch use (video, press release, a FAQ (Frequently Asked Questions), 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 group work 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, a spokesperson from each group made a business pitch (10 pitches were made overall) and received feedback from classmates as well as the professor and guest speaker.

3.2 Data Collection

Our main data sources were the curriculum developed by the instructor, video-recordings and the survey data. First, curricular materials (assigned readings, handouts, PowerPoint slideshows, course syllabus, student work) were systematically collected and used to determine the main curricular design features (e.g., structure, sequence of activity, and content) of the interdisciplinary intervention (Responding to RQ 1), Secondly, video-recordings were made of the entire STEM Entrepreneurship Activity implemented in the third week. These data were used to identify engagement tactics and rhetorical strategies deployed by students, and communicative features of their pitching presentations (Responding to RQ 2).

Lastly, a written survey served as the main source of data used to determine students' perceived learning outcomes of the STEM Entrepreneurship Activity (Responding to RQ 3). Designed originally for the purpose of providing the students with an opportunity for targeted reflection on the activity, the survey 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?

3.3 Data Analysis

Qualitative in nature, our analysis had a tripartite focus that took into account the curricular intervention itself, students' oral performance, and learning outcomes. More specifically, we adopted elements of a "grounded theory" approach to data analysis [30] 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. This analytical approach was aimed simply at the production of emerging interpretations grounded in our data, not a summary theory or model as often done in full-blown, formal grounded theory analyses.

3.3.1 Curriculum Analysis

Curricular characterization of the STEM Entrepreneurship Activity (RQ 1) was accomplished by means of document-based analysis of the curricular materials [34]. Attention was given specifically to the following features of the curriculum: content (what is the instructor teaching?), activities (how is the content structured?), teacher role (how is the instructor facilitating learning?), time (for how long is he teaching?), and materials and resources (with what are students learning?).

3.3.2 Video Analysis of Students' Pitches

Transcribed recordings of oral presentations were carefully examined to assess students' oral performances (RQ 2) in light of the design features identified through our curriculum analysis. This examination was also informed by previous studies of business pitch communication [19, 23, 24]. More specifically, we sought to assess the extent to which students' entrepreneurial pitches were consistent with previously reported discursive structures and linguistic features (e.g., engagement tactics, and rhetorical strategies).

3.3.3 Post Presentation Surveys

Student responses to our open-ended probes were analyzed to determine their perceived learning outcomes, that is, the extent to which students felt that participation in the STEM Entrepreneurship Activity allowed them to acquire entrepreneurial mindset (RQ 3). Also, taken into account was how the students felt about their experience after the activity and how they evaluated its effectiveness (strengths and weaknesses) at promoting their learning of an entrepreneurial application of science communication. Theoretical definitions of entrepreneurial mindset proposed by McGrath and MacMillan [5], as well as Haynie et al. [6] informed this analysis.

4 Results

This section is organized according to our three RQs.

4.1 STEM Pitch Curriculum

Regarding RQ 1, our curriculum analysis revealed that, as designed, our STEM entrepreneurship activity had a good degree of alignment with the *Guiding Framework for Enterprise and Entrepreneurship Education* [35], which contains a list of specific learning outcomes to be targeted in entrepreneurship education. Our activity targeted the outcomes included 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, such as the need for students to learn to protect intellectual property, identify supply chains, assess policy, and regulatory issues. As emphasized by the guest speaker, the goal was simply to come up with an execution plan to launch Hungry Planet® nationally and articulate a rationale to justify their proposed plan.

Compared to similar educational interventions in previous studies, several design features set our STEM 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.

4.2 Students' Pitch Performance

With respect to RQ 2, our video analysis revealed several trends across the students' pitches. Particularly noticeable was the prevalence of discursive structures (organizational patterns) that differed, at times quite considerably, from those reported by previous studies. For instance, the two monetary components of *initial ask* and *negotiation* were completely absent. Students' execution plans for launching Hungry Planet® in Canada did not attend to financial aspects of their proposed ventures such as costs and profits. The financial viability of their STEM business proposals was simply overlooked as students tended to assume that the necessary investors were already on board and that funding was not an issue that needed to be carefully considered. Several contextual factors seemed to contribute to the emergence of such a trend. First, none of the guiding questions provided by the guest speaker focused on financial matters. The goal of pitching assignment was not to literally sell an idea to potential 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). Second, no one in the audience was explicitly identified as a potential investor. Instead, it was entirely made up of other pitchers, an expert marketer, and the course instructor. In this instructional context, the financial aspect was not treated as an essential part of successfully pitching a STEM business idea.

On the other hand, student-pitchers provided fairly detailed descriptions of their potential markets, competitors (their target audiences), potential partners (online platforms, local businesses, etc.), marketing strategies, campaign format and content, and evidence to justify their choices. For example, 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 plant-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:

…GoodFood prides itself on using locally sourced and sustainable food products, so that really aligns with our goal for sustainability and the environment. … 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… 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 for STEM communications. Due to space constraints, other student pitches are just summarized on Table 2.

The marketing strategy most commonly pitched by students was to leverage existing social media platforms and online communities (used by all 10 groups). 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. Relatively fewer groups emphasized empowerment (Groups 4, 8, 9 and 10) or attempted 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 conscious millennials to be able to actually do something 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 an opportunity to act, thus our campaign slogan is 'start here'.

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.

Table 2 Summaries of students' STEM business pitches

Group	Partner(s)	Rationale	Marketing strategies
2	*Elgin Street Diner* + YouTube	– A local business that is family friendly and well known in the community for their meat products – Appeal to cultural knowledge (no evidence)	– Free samples to parents and kids to familiarize with taste – Create recipes and give them to social media influencers
3	UOttawa + Instagram	– Local university regularly hosts public events that are attended by large numbers of students (e.g., Frosh Party, Poutine Fest) – Appeal to cultural knowledge (no evidence)	– Set up pop-up shops at UOttawa events like games and campus parties – Instagram ad campaign
4	YouTube + Instagram influencers	– Excite, Engage and Empower youth – 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") – No slide deck	– Create videos ("Hungry Planet®, not rabbit food" and using famous athletes eating Hungry Planet®) for a media campaign – The videos would pre roll health and fitness videos on YouTube
5	Meat-focused, local restaurants (*The Keg*, and *East Side Mario's*) + YouTube	– Target people "who are on the fence about" adopting a vegan/vegetarian lifestyle (not vegetarians) – Evidence: graph bar showing amount of greenhouse gases emissions per kilogram of meat for beef, lamb, pork, and chicken; analysis of restaurant menus	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

(continued)

Table 2 (continued)

Group	Partner(s)	Rationale	Marketing strategies
6	Small, trendy, nice restaurants in Vancouver and Toronto + YouTube	– Smaller restaurants that are "Instagram destinations" (unlike corporate, fast food chains) in large cities – Bar graph of "projected sales increase" (not actual evidence) – Getting people to talk about Hungry Planet® (creating a "buzz")	– For younger audience (millennials): short YouTube ads (5–6 s) targeted to animal and environmental activists – For older audience: scientist talk (educational) – Free samples at restaurants
7	*Health Canada* (government agency) + YouTube/Instagram	– Health Canada has a new food guide that recommends large increase in the amounts of vegetables and fruits; – Hungry Planet® can help achieve the recommended amount of veggie intake – Evidence: Pie chart of new food guide + demographics	– Partner with barbecue YouTubers and Instagram recipe content creators – Use wLink (influencers receive digital currency per clicks) – Target 17–30 y.o. who are meat-eaters and climate conscious ("on the fence")
8	YouTubers with larger numbers of subscriptions (*Tasty*, *Binging with Babish*, *The Burger Show*)	– YouTube is very popular among millennials – Empower YouTubers and leverage their popularity – Evidence: statistics about the millennial demographics (size, buy power, etc.) + number of subscriptions of popular YouTube channels	– Send packages with samples to popular YouTubers who will use it to create videos – Give YouTubers a cut of orders – Send out coupon codes (measure of campaign effectiveness and impact)
9	Instagram + *Skip the Dishes* (online food delivery company in Canada)	– Instagram is popular among younger demographics – Evidence: statistics about adults	– Instagram ads + hashtags – Empower younger, progressive, environmentally

(continued)

Table 2 (continued)

Group	Partner(s)	Rationale	Marketing strategies
		wanting to reduce meat consumption, and the number of Canadians who use apps to order food delivery to the door – No slide decks (notes on cell phones)	conscious people (millennials) who are more open to change – Send free samples to culinary influencers
10	YouTube + Instagram	– Empower environmentalists (e.g., Instagram activists) and health-conscious people – Evidence: protein content of Hungry Planet® (23 g/burger), number of people who attended "climate strikes"	– YouTube videos – Traditional posters (place "Start Here" posters in restaurants, community centers, gyms, etc.) – Sampling events

Groups 2, 5, and 6 favored partnerships with local businesses (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.

Overall, students were able to demonstrate having effective pitch communication skills. Among their commonly used engagement tactics were use of slideshows with colorful and creative imagery and ending their pitches with a memorable closing statement—a tactic previously identified as effective earlier in the course. These closing statements took various forms, including humorous comments and motivational/inspirational phrases:

> Group 3: "And, if we can get a Tik Tok challenge trending, we are golden".
> Group 4: "So, what are you waiting for? Partner with Hungry Planet® for a better future."
> Group 5: "Given all of that, who is hungry and who is ready to make some money?".
> Group 6: "If you don't know where to start, you should start with us."
> Group 7: "Eat a burger, save the planet. Satisfy your cravings with a guilt free solution delivered to your doorstep."

On the other hand, it should be noted that slide decks were not always used: Group 9 had their notes on cell phones, and Groups 3 and 4 memorized their pitching lines. Moreover, no demonstrations were performed nor were any stories told.

Another common feature shared by the students' STEM 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.

4.3 Students' Perceived Learning Outcomes

In regard to RQ 3, many students emphasized in their survey comments how participation in the STEM Entrepreneurship Activity allowed them to experience a new way of thinking about science and consider scientific ideas and findings from a novel perspective:

> 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. (Group 9)
>
> 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. (Group 1)
>
> Ways to ***integrate an investigative mindset into business ventures***, such as applying the scientific method to advertising campaigns. (Group 7)
>
> Taught me to really try to think about ***science from the perspective of a business***. (Group 5)
>
> In creating an advertising campaign, I had to ***think about different target audiences*** and why this type of presentation might appeal to them. (Group 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. (Group 2)
>
> This assignment required ***holistic thinking***… ***big-picture thinking***, and attempts to consider ***perspectives beyond my own***. (Group 4)

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, unfamiliar and sometimes even uncomfortable (e.g., Group 9's statement as "took us out of our comfort zone in a more unknown environment"). 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.

Despite widespread recognition of gain in entrepreneurial mindset among students, some felt that a stronger focus on science and scientific content would have improved the activity. These students were surprised by the lack of detailed scientific information in the final product. As students in science majors who were used to focus their learning exclusively on advanced scientific content, it was a challenge for them to participate for the first time in an interdisciplinary activity whose focus extended beyond the scientific domain:

> I personally found that ***this activity didn't have a lot to do with science***… very little of the research was actually ***science oriented***. (Group 5)
> I feel that ***there wasn't as much of a science*** focus as I had hoped for. (Group 8)
> The pitch itself ***wasn't really about science*** even though the product was, so I had to take off my scientist hat and put on a businessman hat, which was a really weird experience. (Group 5)
> It surprised me how the research that went into this assignment was ***very little about the actual science***, and much more about getting a message out there, about building a business, about marketing. (Group 3)
> I was surprised at ***how little research really mattered*** in this assignment and how more so than the others, it was very much based upon delivery and stylistic elements instead. (Group 10)
> It surprised me that so ***little of the research*** I did for this assignment was ***centered around the actual scientific information*** we would be presenting. (Group 1)

For the above students, the STEM entrepreneurial activity could have been more strongly focused on the scientific aspects of the technological innovation (i.e., the science behind it) being marketed. These students wished to have spent more time exploring the scientific research that informed the development of Hungry Planet®. Such a desire to become more knowledgeable about the science behind innovative product development was consistent with these students' strong interest in science (i.e., it was reflective of these students' disciplinary bias). This personal interest in

science seemed to create the expectation that the activity was going to be science-dominated and that little attention would be given to the business/communicative aspect of science-based entrepreneurship.

5 Discussion

Student communicative performance of STEM pitches constitutes an effective means to enhance entrepreneurial mindset in undergraduate science. Pitching a technological innovation provides 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 STEM 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.

Yet, despite such promising outcomes, some students called for a stronger focus on science and scientific content. Their comments can be taken as indicative of a common problem in teaching approaches that integrate multiple academic disciplines, namely lack of balance. As our previous work showed [36], STEM curricula often give primacy to the knowledge and skills of one specific discipline (domain of enquiry) while integrating parts from others (instrumental domains), hence giving rise to imbalance. From this perspective, one could simply conclude that the examined STEM pitching activity provided another example of an integrated lesson that showed an imbalance between integrated disciplines. However, it would be hasty to reach such a conclusion without more careful consideration of other important factors. One such factor is the possibility of disciplinary bias on the part of the students. Students' strong interest in and commitment to science could have created the expectation that the activity would be science-dominated. Put differently, students expected the scientific dimension of science-based entrepreneurship to receive more attention relative to the business/communicative dimension (as opposed to equal attention). Therefore, these students' tendency to experience the STEM pitching activity as requiring a stronger scientific focus could alternatively be linked to biased expectations favoring science rather than a lack of appropriate balance between science and business in the activity's design. Nonetheless, students' comments highlight the need for careful consideration to be given to what constitutes an appropriate balance when it comes to integrating science and business.

Finding effective ways to strike a productive balance will be essential for future interdisciplinary efforts to teach for entrepreneurship in STEM classrooms. However, a 50–50 balance may not necessarily be the most appropriate and effective approach for STEM business pitching activities in the science classrooms. Engaging in this type of interdisciplinary activity inevitably means a lessening of focus on one's own academic discipline and also attending to important content and research from other fields. As such, it is possible that, at least in some occasions, science may become an instrumental domain (a secondary domain) from which parts are strategically borrowed and integrated into business communication (the primary domain).

Our curriculum analysis also revealed a need for a higher degree of authenticity. As described above, several design features of our STEM entrepreneurial activity set it apart from an authentic pitching competition [18]. First, the activity was framed as a "collaborative simulation" without winners or losers. Second, all teams pitched the same innovative product, which had been previously developed by other science experts. This is in sharp contrast to "real pitching" wherein participants pitch their own products after having dedicated a considerable amount of time and effort to its design and development [19]. Third, financial matters were largely overlooked—there was no initial ask, negotiation or discussion of costs and profits. The financial viability of their STEM business proposals was simply overlooked as students tended to assume that the necessary investors were already on board and that funding was not an issue that needed to be carefully considered. The goal of our pitching assignment was not to literally sell an idea to potential 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 potential investors, the audience was made up of other pitchers, an expert marketer, and the course instructor.

Such design features seemed to constrain students' pitching performances as evident in the prevalence of discursive structures (organizational patterns) that differed, at times quite considerably, from those reported by previous studies [19, 23, 24]. On the one hand, students' pitches included a business plan with detailed descriptions of potential markets, target audiences, potential partners, marketing strategies, campaign format and content, etc. On the other hand, the two monetary components of *initial ask* and *negotiation* were completely absent, and students did not attend to financial aspects of their proposed ventures such as costs, profits, and investors. Moreover, slide decks were not always used, no demonstrations were performed, and no stories told. Several groups did not provide any evidence to justify their marketing decisions, at times simply appealing to shared cultural knowledge or backing up their decisions with seemingly "pseudo" evidence.

The above findings invite us to reflectively consider possible ways of increasing the authenticity of the examined STEM pitching experience. Among these, we would suggest incorporating an engineering phase in which students had a chance to design their own innovative technology prior to setting out to pitch it. Additionally, encouraging students to carefully consider the financial viability of their product and including actual investors in the audience could render their STEM

pitching experiences more realistic. Lastly, students might also benefit from guidance on what constitutes actual evidence when it comes to justifying their business plans. Doing so, we believe, is likely to increase the chances that educational efforts aimed at enhancing entrepreneurial mindsets will be as effective as intended by curriculum developers.

6 Conclusion

As posited at the onset of the paper, interdisciplinary pedagogies wherein business and science communication are infused together can help prepare the next generation of STEM entrepreneurs. One such pedagogy is classroom performance of STEM pitching activities wherein classroom activities in which students are challenged to communicate science informally and persuasively as they attempt to sell technological innovations to potential investors. As the reported findings have shown, this pedagogy can encourage undergraduate science students to go beyond a strictly scientific/investigative mindset (analytical and thing-oriented) and adopt an entrepreneurial mindset that is more people-oriented, holistic, big-picture focused, and comprising of multiplicity of perspectives. Nonetheless, questions remain regarding what constitutes an appropriate balance when it comes to integrating science and business. Should STEM pitching activities pay equal attention to science and business communication (i.e., be 50–50)? Or should science be given more attention and remain the primary field (as opposed to becoming an instrumental field)? Should students' potential disciplinary biases be taken into account in the design of such activities? If so, how? It will be critical for future research to find answers to these complex questions if science educators are to succeed in their efforts to expand scientist training beyond cumulative acquisition of facts, and effectively help science novices become a type of person who (like professional entrepreneurs) are creative, independent, resilient, willing to take risks, and tolerant to ambiguity. It is our hope that the present chapter will provide educators with some initial insight in this direction.

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