THE UNIVERSITY OF TENNESSEE KNOXVILLE

The Journal of the Assembly for Expanded Perspectives on Learning

Volume 28 *JAEPL Volume 28* Article 12

12-2023

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Recommended Citation

Silver, Adina; Adeel, Zoya; Li, Tim; Siddiqui, Abeer; Hall, Alexander; Symons, Sarah L.; and Moisse, Katie (2023) "Weaving Science Communication Training through an Undergraduate Science Program with a Focus on Accessibility and Inclusion," *The Journal of the Assembly for Expanded Perspectives on Learning*: Vol. 28 , Article 12.
https://doi.org/10.7290/jaepl28BHeE
Available at: https://trace.tennessee.edu/jaepl/vol28/iss1/12

Weaving Science Communication Training through an Undergraduate Science Program with a Focus on Accessibility and Inclusion

Adina Silver, Zoya Adeel, Tim Li, Abeer Siddiqui, Alexander Hall, Sarah Symons, and Katie Moisse

Abstract: *Science communication training can help scientists engage diverse audiences with the promise and process of science, helping to strengthen science literacy and preserve public trust in science. But not all scientists have access to such training. To address this shortfall, we have embedded a suite of science communication courses in the Life Sciences Program, the largest undergraduate science program at McMaster University in Hamilton, Ontario. A foundational course focuses on making science accessible through inclusive language and media, while more advanced courses emphasize the importance of understanding and centering the values, beliefs, questions, and critiques of audiences, and using narratives and rhetoric to inform, inspire, and ignite change. Throughout the curriculum, students engage with and contribute to the scholarship of science communication. They graduate with skills that serve them in diverse careers. In this article, we outline the structure of our curriculum and detail key components of our science communication courses. We also describe a student-led assessment of our curriculum that highlights strengths and opportunities for improvement. Ultimately, we strive to provide a compelling rationale for teaching science communication at the undergraduate level by sharing a framework of replicable pedagogical practices for engaging large cohorts of students with both the theory and practice of science communication.*

Introduction

We have more *access* to scientific information than ever, and that access brings great promise and peril. There is an assumption that open science will foster public dialogue, improve understanding, and grow confidence in science (Nemer). But *access* alone does not make science *accessible*. If we, as citizens, cannot decipher open science articles, we cannot enjoy them, critique them, or confidently apply their knowledge within our lives. Even when science is made more accessible, citizens must still look for it and identify it in a growing sea of misinformation. We are then challenged with whether and how to act upon it.

Science communication training is helping to address this challenge. There are approaches, backed by evidence, for engaging diverse audiences—the young and the old; the skeptics and the "sciencephiles"—with the promise and process of science (Jensen and Gerber; Schäfer et al.). Importantly, there is now empirical evidence refuting the deficit model of science communication, which posits that one merely needs *access* to scientific information to make science-based decisions (Simis et al.). It is now widely accepted that our beliefs, values, self-identity, and social contexts influence how we seek out, scrutinize, and apply information (Nadkarni et al.).

Science communication training within higher education can help scientists reject the deficit model and engage more intentionally with diverse audiences in varied forums and genres. Indeed, 85% of the general population say they trust scientists and 82% say they want to hear more from scientists about their work (3M State of Science). Yet, in Canada few institutions provide formal training in science communication (Brownell et al.). While there is one Canadian graduate program in science communication at Laurentian University, there remains a need for wider access to science communication training for scientists at all career stages (Laurentian University; Akin et al.) Embedding science communication training into undergraduate programs is ideal because students can gain transferable skills relevant to a wide range of traditional and non-traditional careers in science, not to mention exposure to the latter (Rosenzweig et al.)

Science communication training also provides opportunities for students to examine how science shapes society and vice versa. No longer can educators separate science from its social contexts in our curriculum. The COVID-19 pandemic made clear the extent to which personal beliefs and values, as well as societal histories and politics, affect how we make sense of science and apply it in our lives. Other recent events, such as the racist attack that killed 10 Black people in Buffalo, highlight the power of science to shape beliefs and values—the shooter used genetics research to justify his hate crimes. Students should have opportunities to explore how science can be dismissed or misused to fuel agendas, as this affects public trust in science.

In this article, we describe the successful integration of science communication training into the Life Sciences program at McMaster University. We outline the structure of our curriculum and detail key components of our science communication courses. We also describe a student-led assessment of our curriculum that highlights strengths and important areas for improvement. Ultimately, we strive to provide a compelling rationale for teaching science communication at the undergraduate level by sharing a framework of replicable pedagogical practices for engaging large cohorts of students with both the theory and practice of science communication.

Connecting Science and Society

The Life Sciences Program at McMaster University is the largest undergraduate program in the Faculty of Science, with 1,619 students. Instructors in the program value innovative pedagogies, interdisciplinary perspectives, and experiential learning. The program is distinct from a biology program in its emphasis on the societal contexts of science. Many of our courses feature community-informed or -partnered projects. For instance, students have worked with municipal staff and non-profit organizations to co-create solutions for real-life community challenges. These partnerships provide opportunities for students to build relationships and prioritize reciprocity, equity, and sustainability—core tenets of community engagement ("Principles of Community Engagement").

Many of our courses include written, oral, and multimedia communication assessments, which serve several important purposes. For instance, they require students to demonstrate higher order learning (Armstrong), invite students to practice transferable skills, adopt a creative mindset, connect course content to contemporary challenges and their own lived experiences, and take a critical stance on science. However, in many science courses with a disciplinary focus there is little room for students to learn best practices in communication. For this reason, in 2018 we sought to codify our commitment to communication in the form of a science communication curriculum. We now have four science communication courses in the Life Sciences Program. Students taking these courses practice communicating scientific concepts and findings for different audiences and purposes using varied media and communication strategies. They also critically analyze examples of science communication and engage with the growing field of science communication research, which aims to identify barriers to science literacy and opportunities to engage underserved or skeptical audiences. Scaffolded activities encourage students to connect theory and practice via consistent reflection on their work.

Over the years, our science communication courses have provided a forum for students to view science through a social justice lens. The introduction of "inclusive science communication" as a concept in the science communication literature in 2020 helped to formalize this focus (Canfield et al.). The core traits of inclusive science communication—intentionality, reciprocity, and reflexivity—now form the backbone of our curriculum. We encourage students to communicate with purpose, actively listen, and routinely check their assumptions. Course discussions and activities push students to reject deficit models, practice humility, and embrace difficult conversations (Canfield and Menezes). Students are encouraged to recognize historical oppressions, discrimination, and inequities, and value the knowledge, experiences, questions, and criticisms that audiences—particularly marginalized audiences—bring to conversations about science.

Science Communication Curriculum

Our science communication curriculum spans the second-, third- and fourth- year of the Honours Life Sciences Program (students enter the program their second year). Currently, only our second-year course is required. But beginning in Fall 2023, Life Sciences students will also be required to take one of two third-year science communication courses. Our fourth-year science communication courses are electives. Life Sciences students are also required to take a number of discipline-specific science courses, many of which have communication assessments (papers, presentations, creative projects, etc.) accounting for at least 20% of the final grade.

Within our core science communication courses, we've designed our instructional approaches and assessments to minimize grade-based motivation and encourage students to take ownership of their own learning. We view our curriculum as an inclusive community of practice, wherein students connect theory to practice, take creative risks, and reflect on the process together. We incentivize students to value and incorporate instructor and peer feedback by providing opportunities to reflect on and in some cases resubmit work. Most importantly, we strive to build community in the classroom and foster a sense of belonging in science.

We designed our second-year course to prepare students for science communication activities that are common in upper-level courses, graduate science programs, and careers in science. In each of these scenarios, one is tasked with making science accessible to non-experts. For instance, upper-year undergraduate students may need to create text or video content for a community partner; graduate students may need to create a 3-minute thesis for peers in other labs or disciplines; and scientists often need to write lay summaries for journals and funding agencies. Students enter our second-year course with a desire to make science accessible, but realize through activities and discussions the limitations of the deficit model mindset. Ultimately, they propose ways to move beyond information-sharing, which keeps the onus on audiences to seek out information, and toward more intentional and reciprocal engagement.

In their third year, students work to actively dismantle the deficit communication model. They become increasingly focused on specific goals and audiences, as well as the biases we all bring to conversations about science. They reflect on the assumption they made at the start of second year, that making science accessible will result in meaningful engagement. They must now make sense of science while applying the science of sense-making—considering how people notice information, find meaning within it, and act on it (Weick). Activities challenge students to practice intentionality, reciprocity, and reflexivity, and assessments privilege measurement of the strategic development process over the final product.

In their fourth year, students apply their knowledge and skills in the context of narrative storytelling, a form of science communication that can nurture comprehension, interest, and engagement (Dahlstrom). Here, students practice humility and empathy as they connect directly with audiences to inform their communications. Through iterative, independent work, they recognize storytelling as a powerful way of knowing and a promising avenue for reaching disengaged and passive audiences for science communication.

We acknowledge that our curriculum is a work in progress. We think about our students as audiences and continue to practice the intentionality, reciprocity and reflexivity that we preach. Below, we summarize the learning outcomes for each of our core science communication courses (Table 1). We then highlight select pedagogical practices in each course. We choose to focus on practices that scaffold across our curriculum, though each course has multiple unique learning activities and assessments. Importantly, our instructional approaches and assessments have been developed and refined through meaningful partnerships with students.

Table 1. Core science communication course learning outcomes. Our science communication courses are intentionally scaffolded across second, third, and fourth-year to introduce key competencies in science communication and provide opportunities for students to practice and master these competencies.

Year	Course Name	Learning Outcomes
2	Foundations in Science Communication	1. Critically evaluate scientific papers and articulate the most salient information using accessible language 2. Communicate scientific concepts and data in different formats for different audiences of purposes 3. Critically analyze examples of science communication in the context of misinformation and politicization of science 4. Read, apply, and contribute to the scholarship of science communication 5. Describe alternative careers in science, including careers in science communication
3	Communicating Science for Public Audiences	1. Critically evaluate primary research in science and science communication 2. Apply principles of inclusive science communication to create text and visuals that inform, inspire and ignite positive change 3. Center equity, diversity and inclusion in discussions about how knowledge is created and shared 4. Merge creative and analytical skills to communicate complex ideas 5. Prioritize the process of science and science communication over the final product
4	Science & Storytelling	1. Explore a diverse range of science stories and discuss how they educate and inspire their target audiences 2. Identify neglected narratives and audiences and create new opportunities for inclusion through storytelling 3. Develop fundamental storytelling skills and apply them to different mediums 4. Shed jargon and formulaic writing in favor of creative, engaging prose without sacrificing accuracy

		5. Share our science stories with the community
	Science Communication in the Media	1. Critique diverse examples of science journalism and consider their potential to shape public opinion and policy 2. Discuss opportunities for science to be misconstrued and think proactively about the social and political contexts of science 3. Extend and apply our toolkit for communicating science through popular media 4. Seek out and integrate diverse expert perspectives into our communications 5. Read, apply, and contribute to the scholarship of science communication

Year Two: Foundations in Science Communication

In this foundational course, students practice critically reading research articles and summarizing the most salient information using inclusive language—avoiding jargon and the use of the passive voice, for instance. They do this in the context of scholarly articles that support best practices in science communication (Shulman et al.; Chan and Maglio). One important activity is the "lay summary," a plain-language distillation of a scientific paper for a non-expert audience. Lay summaries (also known as lay abstracts, plain-language summaries, digests, and more) have grown more common—and more important—with the rise of open access to scientific research. In this course, we call them "inclusive summaries" to better reflect their intention, which is to welcome non-scientists into research.

We created an inclusive summary rubric [see Appendix A] based on existing author guidelines for lay summaries and traits of inclusive science communication. We use this rubric in two activities. In one activity, students write an inclusive summary (first with peers and then independently) and receive a grade and feedback through the rubric. In the other activity, the students use our rubric to assess the quality of published lay summaries from four different journals. In winter 2022, 323 students assessed 200 lay summaries (50 from each journal with three independent scorers per summary). We pooled our data and used an ANOVA (Analysis of Variance) to compare scores between the journals (Figure 1).

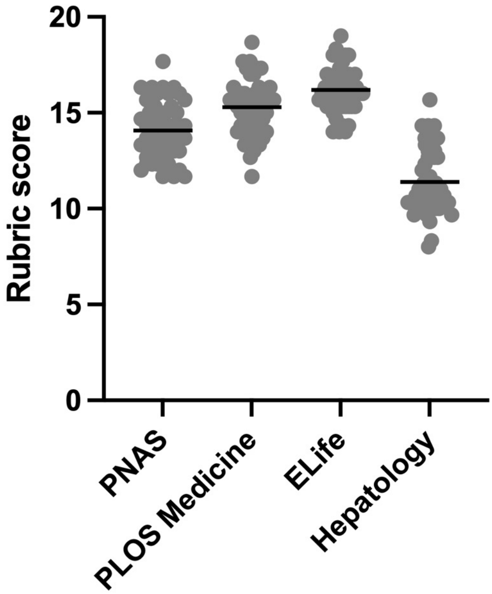

Figure 1: Overall lay summary rubric scores for four selected journals (n=200 lay summaries per journal with n=3 independent raters per lay summary).

The journals eLife and PLOS Medicine score significantly higher on the rubric than PNAS and the Journal of Hepatology ($p<0.0001$; ANOVA with Tukey post-hoc). All data were collected by students in our second-year science communication course.

This activity has four goals: It exposes students to a wide range of lay summaries, helping to inform their own writing; it requires students to understand and critically apply the rubric that will be used to assess their writing; it provides data from which students can draw conclusions about the usefulness of lay summaries and whether they serve their intended purpose; and it provides us, as instructors, with valuable insight on the inter-rater reliability of our rubric (this is important as we strive to make our expectations explicit and our grading equitable).

Through their research, students learn that the quality of published lay summaries varies greatly across journals. They also realize that the guidelines for authors vary, as do the levels of editing support. The students describe their research findings in an accessibly-written manuscript that includes a review of the relevant literature, including literature on inclusive best practices. They then propose a knowledge mobilization initiative, aimed at transforming their findings into positive change. Proposals have included universal lay summary guidelines for authors, lay summary workshops for researchers, and future explorations into the audiences for—and impact of—lay summaries. (For instance, does a well-written lay summary lead to better comprehension and more positive perceptions of science/scientists than a poorly-written one? Are there better formats and forums for welcoming non-scientists into research?) Students share their research and their proposals with their peers at an end-of-term showcase.

Year Three: Communicating Science for Public Audiences

Our third-year course builds on the activities and discoveries of our foundational course. Students reflect on lay summaries and how, even when done well, they require audiences to look for and find them. Students realize that the traditional structure of scientific communication—leading with the background and ending with what's new and why anyone ought to care—does not align with how non-scientists search for, vet, and share information today. They realize that less is often more, that visuals can be more impactful than text, and that effective communication respects the values, knowledge, experience, questions, and critiques of audiences.

One important activity in our level three course is the research translation which, unlike a lay summary, leads with the most salient information for a given audience. In about 300 words, students must describe the main takeaway or conclusions of a study (what's new), the implications of the work (why an audience ought to care), the approach, the specific findings, and the limitations. They are assessed using a research translation rubric [Appendix B], which prioritizes clarity, conciseness, accessibility, and engagement. Many students assume the research translation will be easy, given their experience with lay summaries, and are surprised by how awkward the new format feels. But after multiple attempts and feedback, their communications become increasingly creative, inclusive, and tailored to their audience.

Students realize through required readings that the format of their research translation aligns with the format of science news articles. One of the first research studies they 'translate' is a randomized controlled trial exploring the effects of spin in health news articles. The study concludes that audiences who read science news articles that do not accurately capture the methods and limitations of research are more likely to believe the research will help them or a loved one than are those who read more accurate, nuanced articles. Students go on to critique published science news articles that are guilty of spin and reflect on how this affects public trust in science.

In the fall of the 2023-24 academic year, students in our third-year course will build on the research they started in level two and run their own randomized controlled trial. They will identify a poorly written lay summary in medical literature, revise it to score better on our inclusive summary rubric, and then rewrite it again as a research translation. We will then recruit students in a large first-year science course to read one of the three summaries and answer survey questions gauging their comprehension, ease of reading, and perceptions of the authors (are they elitist, for instance). Our third-year students will describe their findings in a commentary written in the style of *The Conversation,* an online network for researchers and journalists to publish research commentaries.

Students in our third-year course are also asked to think critically about different audiences for science communication and, importantly, the expertise, lived experiences, questions, and critiques these audiences bring to conversations about science. We review the traits of inclusive science communication—intentionality, reciprocity and reflexivity—and reflect on how they apply in different scenarios. For instance, students read a commentary by Ty Fletcher-Beals titled "How I advocate the importance of vaccines to my Black family" and analyze how the author applies traits of inclusive science communication. We also reflect on our own privilege, as science students, and recognize that the mentors, museums, courses, camps, and clubs that engaged us with science are not universally accessible. Finally, we work with a community partner to address a science communication challenge in our community. Students share their work with their peers and our community partner at an end-of-term showcase.

Year Four: Communicating Science Through Stories

We have two elective fourth-year science communication courses, both of which have a focus on storytelling. Students are only eligible to take one of these courses.

4E03: Science & Storytelling. "Science & Storytelling" is a 30-student seminar course built around the premise that effective science communication concurrently considers audience, purpose, and narrative structure. This course continues the conversations that began in "3P03: Communicating Science for Public Audiences," centering relationship- and trust-building as necessary components for effective science communication. Students engage with dialogic science communication practices, rather than models built on a unidirectional flow of information. Additionally, students learn the importance of communicating science both as a process and as a product; building trust with their audiences by inviting them into the messy, behind-the-scenes parts of scientific knowledge production.

Students engage in a term-long project to create a science story for a particular audience. Past projects have included children's books, documentary films, and interactive narrative-based games. To encourage students to take creative risks and take ownership of their learning, students develop their own rubrics for their final projects in collaboration with the instructor. Grading criteria is tailored to the student's selected story, medium, genre, and audience. For example, an art installation about the health impacts of solitary confinement was assessed on its ability to make the audience feel anxious in a confined space.

To incentivise students to value and incorporate instructor and peer feedback, we have established a resubmission/regrading policy for key formative assessments. Students also meet weekly with their peer check-in groups to share rough drafts and solicit feedback on the final project. While this component is ungraded, students keep track of their discussions in an online notebook. The notebook also allows instructors to catch up on students' progress over the course of the semester. Furthermore, peer check-in groups help create a sense of community within the class–students can work together to troubleshoot problems, share resources, and celebrate successes without the incentive (or indeed, the threat) of being graded. Students in check-in groups are often working on drastically different final projects, ranging from short stories to documentaries to board games, and can therefore apply key principles of science communication to various formats and contexts.

In another assessment, students interview a member from their own respective communities about a specific topic and create a photo essay to share their story. A recent topic was science misinformation; students interviewed community members, friends, family members, etc., about whether they trust science, and why. Here, students practiced listening with empathy to understand where their interviewees' hesitations and misconceptions originate, and subsequently reflected on how we, as science communicators, can (re)build trust.

4J03: Science Communication in the Media. "Science Communication in the Media" is another 30-student seminar course in which students bring the science communication skills and theory they've amassed in years two and three to the practice and critique of science journalism. They engage with professionals who have different roles in the media: public information officers, journalists, and scientists with media experience. They compare and contrast the parallel roles of these science communicators in terms of their audiences and goals. Through engaging in these activities, they come to realize how divergent pressures and priorities create the potential for messages about science to get distorted.

An important focus in this course is the reported article, which combines elements of research translations and explanatory writing, and further integrates the perspectives of credible subject matter experts. Students engage with weekly activities focusing on each of these elements and have the semester to integrate them into a 1,000-word article for a non-scientist audience. There are many opportunities for one-on-one consultation with the instructor, just as there are in a writer-editor relationship. We publish exceptional student work on *The Macroscope*, a website featuring reported articles and commentaries by our science communication students.

Students in this course also engage in science communication research with a focus on media representations of science and scientists. They work in groups of five to come up with a research question that they can answer during the semester using existing data, such as online news articles (accessible through the online database Factiva), public funding databases, and more. They first submit a proposal, on which they receive feedback. They later submit a manuscript and present their findings to the class. In winter 2022, groups focused on topics including media representations of psilocybin research and coverage of men's mental health. The investigations revealed interesting differences between right- and left-leaning media organizations in terms of depictions of evidence and sources of expertise. In winter 2021, one group published their paper on media representations of postpartum depression (Benepal et al.).

Beyond the Classroom

To supplement our classroom offerings, we also create opportunities for students to participate in science communication activities through applied work placements and participate in research through independent studies and thesis experiences. These for-credit experiences, offered during third- and fourth-year, allow students to build their portfolios under the mentorship of an individual or community organization or contribute to the science communication literature under the mentorship of a faculty member.

One of our instructors, Dr. Katie Moisse, has supervised students in experiential placements engaging in a wide range of science communication activities, including writing science news articles, co-creating projects for science communication courses, illustrating pathogens, and painting portraits of women to spotlight women's health issues. Dr. Moisse has also supervised research practicum, independent study, and thesis students doing science communication research, including explorations of media coverage of preprints, comparisons of print and visual media for communicating epidemiological concepts, assessments of the impact of science communication workshops, and investigations of gender and racial bias in science news coverage. These independent projects allow students to dive deeper into the science communication literature and apply the research and data analysis skills they've learned in new ways. Many of these projects use surveys, providing students with the opportunity to engage in the ethics review process and learn qualitative analysis techniques. Students have presented their work at conferences, such as the Science Writers and Communicators of Canada annual conference (Adeel and Moisse) and published in peer-reviewed undergraduate science journals (Wadie).

Student Experience

In July 2020, Dr. Moisse received a Leadership in Teaching & Learning Grant from the MacPherson Institute for Leadership, Innovation and Excellence in Teaching and Learning at McMaster University. The grant provided funds to partner with current and former students (Adeel, Silver, and Li) to map our course offerings against core competencies in science communication (Mercer-Mapstone and Kuchel) and assess student perceptions of our science communication training (Table 2).

In April 2021, we invited students who had taken one of our core undergraduate science communication courses during the 2020-21 academic year to participate in a survey co-designed by students and science communication instructors. The exit survey invited students to reflect on their experiences with the curriculum and their comfort with various science communication activities (n=93). Our results suggest our curriculum provides transferable skills and gives students the confidence to communicate with diverse audiences for a range of purposes. Most students reported they were more comfortable applying oral, written, and multimedia science communication skills as a result of taking a science communication or communication-intensive course. For example, students were more comfortable completing certain communication-focused assessments for non-expert audiences, commentaries/opinion pieces (90%), social media posts (95%), and research translations (94%) in particular. Confidence levels for completing communication assessments almost always increased with each academic year. Our students' self-perceived ability to communicate science to non-expert audiences also increased with each academic year — confirming that our curriculum scaffolds its learning objectives as intended (Figure 2).

Table 2. Integration of the 12 core competencies of science communication in core courses and experiential electives. As students progress through our science communication curriculum, they are introduced to (light gray), actively apply (dark gray), and master (black) the 12 core competencies of science communication.

Core competencies	**Year 2**	**Year 3**	**Year 4**	**Experiential electives**
Identify and understand a suitable target audience				
Use language that is appropriate for your target audience				
Identify the purpose and intended outcome of the communication				
Consider the levels of prior knowledge in the target audience				
Separate essential from non-essential factual content in a context that is relevant to the target audience				
Consider the social, political, and cultural context of the scientific information				
Use a suitable mode and platform to communicate with the target audience				

Use/consider style elements appropriate for the mode of communication (such as humor, anecdotes, analogy, metaphors, rhetoric, images, body language, eye contact, and diagrams)				
Understand the underlying theories leading to the development of science communication and why it is important				
Promote audience engagement with the science				
Encourage a two-way dialogue with the audience				

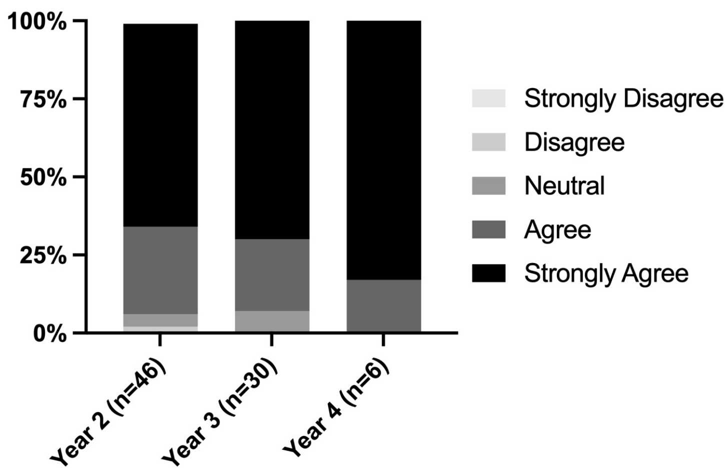

Figure 2: Students report their level of agreement with the statement, "My ability to communicate science to non-expert audiences has improved as a result of this course." At all undergraduate years, the majority of students strongly agreed that their science communication skills improved by taking a science communication course.

Our results also identified some curricular gaps. Students reported discomfort with performing a debate (55%), being interviewed by the media (46%), and engaging in policy communication (33%). We intend to fill these gaps through curriculum revisions such that students have an opportunity to develop these skills, which were affirmed as critical during the COVID-19 pandemic (Caulfield et al.; Gross).

We further captured student perceptions of the importance and relevance of science communication training at the undergraduate level. Many students shared that they believe science communication training should be mandatory for all undergraduate scientists (80%), expressing their recognition of the necessity of accurate and accessible communication in the field of science. They also agreed that it's important to include activities that develop science literacy and science communication in the curriculum (95%) and that it highly applies to their future careers (90%). When students have the opportunity to formally engage with science communication training, they recognize its importance and develop an interest in actively pursuing future opportunities to learn/practice science communication both informally and formally.

The Life Sciences Program encourages students to explore career paths beyond the traditional sciences. We found that the experience our students gain from these courses impacts their interest and willingness to pursue employment in science communication. Almost half (47%) of the student respondents reported that they are open to a career in science communication, while almost one-third (31%) said they would consider pursuing a Master of Science Communication degree. By embedding science communication training in our undergraduate program, we are addressing the need for students with training in both science and science communication to enter sectors outside of research and academia, from public policy and health communications to outreach and advocacy (Brownell et al.; Davies and Horst). Below are some excerpts from our qualitative survey that highlight positive student experiences with the science communication curriculum.

> "I never liked writing... But once I took [the third-year science communication course], my mind completely flipped. That course made writing fun and engaging for me. I have realized that I prefer writing for non-academic audiences because I want to simplify explanations of things and make it more accessible for everyone to understand. After the course, I felt accomplished and proud of my abilities... I think [science communication training] should be mandatory because, being in the science field, it is vital to be able to make science available and accessible to everyone, not just academic audiences." —Fourth-year student

> "I start medical school soon and I can't stress the importance of the skills I've learned over the last four years. I can only imagine the crucial role science communication will play in explaining complicated medical knowledge in easy to understand terms for my patients." —Fourth-year student

> "The science communication courses I took, and the pandemic and global warming, have shown me the importance of knowing how to explain science. That's why I wish to engage in science communication activities." —Third-year student

This evaluative survey has been key in refining our curriculum, within each course and across our offerings. Our students tell us they're learning transferable skills they can confidently apply in varied contexts. This survey was sent out again in April 2022, providing us with a growing longitudinal dataset of student perspectives that we can use to further refine our curriculum.

Looking to the Future

We are proud of the science communication curriculum we have built over the past four years and the ways our students are applying what they have learned. But we must continue to be intentional, reciprocal, and reflexive in our pedagogies. This coming fall, we will add a second third-year course, "Communicating Science for Professional Audiences" (see Figure 3). In this new course, students will practice communicating for clinicians, investors, regulatory bodies, and policymakers. They will debate solutions to climate change and outbreaks with other professionals, such as economists, and practice media interviews to address curricular gaps. We will also open up our science communication courses to undergraduate students across campus—not just science students—and further open up to graduate students our fourth-year experiential courses, in which students can engage with the theory or practice of science communication with an academic or community supervisor.

We will also introduce a concurrent Certificate in Science Communication open to students in any undergraduate program. Students can complete the certificate by taking our second-year course, one of our third-year courses, one of our fourth-year courses and three electives from an interdisciplinary course list. The list includes courses from all faculties that have a focus on bioethics, education, persuasion, policy, advocacy, media studies, or the sociology of science.

Finally, we are in the process of developing a new course-based Master of Science Communication graduate program. This 14-month program aims to engage students from the sciences, social sciences, and humanities with the theory and practice of science communication. Instructors are an interdisciplinary team of science communication scholars and practitioners. Students will practice evidence-based strategies for communicating a range of concepts, findings, and lines of inquiry to diverse audiences—public and professional. Here, too, the traits of inclusive science communication will provide the framework within which students collaborate, create, critique, and reflect.

We hope that by sharing some of our pedagogical practices and reflections on our curriculum, we can inspire others to embed science communication training and opportunities for students to connect theory to practice in their courses and programs. We are eager to engage with other instructors and contribute to a community of practice in Canada and beyond. We welcome all comments, questions, and critiques, and thank the editors for the opportunity to share our practice and process.

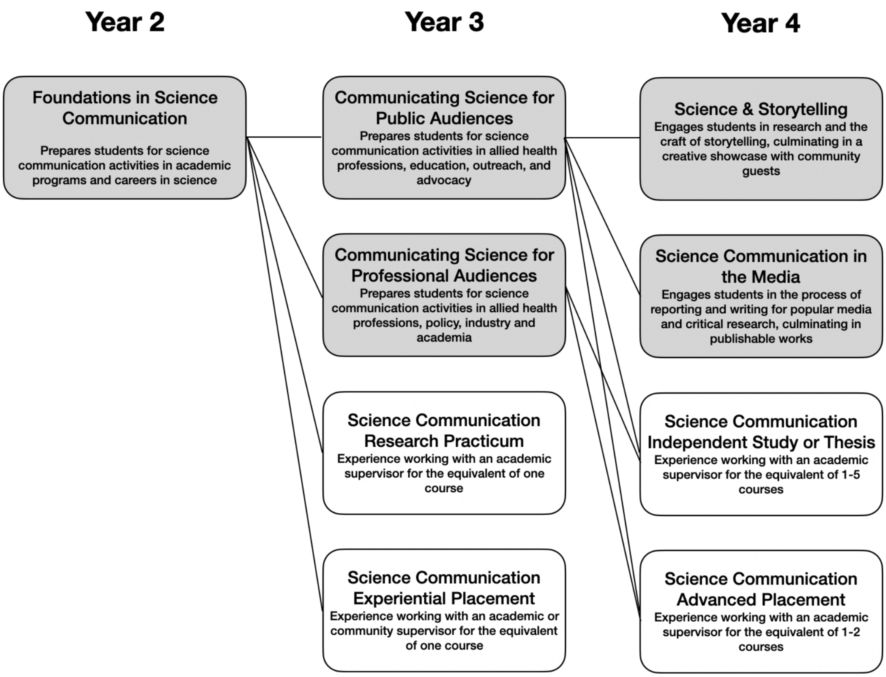

Figure 3: Flowchart schematic of the science communication curriculum with existing and forthcoming courses. Our updated curriculum will have five science communication courses (gray) and four experiential courses (white) through which students can engage in science communication activities or research.

Acknowledgments

The research described was funded by a Leadership in Teaching and Learning Fellowship from the Paul R. MacPherson Institute for Leadership, Innovation and Excellence in Teaching and Learning. Curriculum development was supported by an IDEAS (Inclusion, Diversity, Equity, Accessibility, and Sustainability) Grant from the MacPherson Institute.

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Appendix A: Inclusive Summary Rubric

Content	Level 5 5 points	Level 4 4 points	Level 3 3 points	Level 2 2 points	Level 1 1 point	Criterion Score
Did you accurately summarize the study methods, results and conclusions?	You excelled at this task, providing information that was consistently on-point.	Your summary is mostly accurate but sometimes ambiguous.	Your summary is mostly accurate but incomplete, introducing the potential for confusion.	Your summary raises multiple questions or lacks focus and was difficult to unpack.	Your summary contains multiple inaccuracies.	/ 5
Did you accurately summarize the study rationale, implications and limitations?	You excelled at this task, providing information that was consistently on-point.	Your summary is mostly accurate but sometimes ambiguous.	Your summary is mostly accurate but incomplete, introducing the potential for confusion.	Your summary raises multiple questions or lacks focus and was difficult to unpack.	Your summary is off-point.	/ 5

Style	Level 5 5 points	Level 4 4 points	Level 3 3 points	Level 2 2 points	Level 1 1 point	Criterion Score
Is your writing clean, clear and logically organized?	Your writing is free of typos and grammatical errors and easy to follow, with smooth transitions that carry your reader from one thought to the next.	Your writing is clean and your sentences are strong, but the overall organization could be improved.	Your writing contains one typo, grammatical error, confusing sentence or awkward transition or it lacks some clarity in terms of sentence structure and organization.	Your writing contains more than one typo, grammatical error, confusing sentence or awkward transition.	Your writing has multiple mistakes or minimal flow.	/ 5
Is your writing tailored to its audience and purpose?	Your writing is a joy to read. You make complex concepts relatable and consider your audience from start to finish, in terms of the language you use and the organization of your thoughts.	Your writing is accessible and contains elements that will engage your audience.	Your writing is generally accessible and contains at least one element aimed at engaging your audience, but some parts fall flat.	Your writing is generally accessible but it lacks elements that will engage your audience and keep them reading from start to finish.	Your writing contains words or descriptions that are inaccessible to your audience or may bore them.	/ 5

Total	/ 20

Appendix B: Research Translation Rubric

Content	Level 5 5 points	Level 4 4 points	Level 3 3 points	Level 2 2 points	Level 1 1 point	Criterion Score
Did you accurately convey the main takeaway and implications?	You excelled at this task, providing accurate information that was consistently on-point.	Your descriptions were accurate but buried or hard to identify.	Your descriptions were accurate but incomplete or raised new questions that went unanswered.	Your descriptions lacked focus or were difficult to unpack.	Your descriptions were inaccurate or missing.	/ 5
Did you accurately describe the methods and results?	You excelled at this task, providing accurate information that was consistently on-point.	Your descriptions were accurate but raised new questions that went unanswered.	Your descriptions were accurate but incomplete, creating confusion.	Your descriptions lacked focus or were difficult to unpack.	Your descriptions were inaccurate or missing.	/ 5
Did you accurately capture the limitations and indicate appropriate next steps?	You excelled at this task, providing accurate information that was consistently on-point.	Your descriptions were accurate but raised new questions that went unanswered.	Your descriptions were accurate but incomplete, creating confusion.	Your descriptions lacked focus or were difficult to unpack.	Your descriptions were inaccurate or missing.	/ 5

Style	Level 5 5 points	Level 4 4 points	Level 3 3 points	Level 2 2 points	Level 1 1 point	Criterion Score
Is your writing clean and clear with a logical flow?	Your writing is free from typos and grammatical errors and easy to follow, with smooth transitions that carry your reader from one thought to the next.	Your writing is clean and your sentences are strong, but the overall organization could be improved.	Your writing is clean, but lacks some clarity in terms of sentence structure and organization.	Your writing has multiple typos, grammatical errors, confusing sentences or awkward transitions.	Your writing has multiple mistakes or minimal flow.	/ 5
Is your writing accessible and engaging?	Your writing is a joy to read. You make complex concepts relatable and consider your audience from start to finish, in terms of the language you use and the organization of your thoughts.	Your writing is accessible and contains elements that will engage your audience.	Your writing is generally accessible and contains at least one element aimed at engaging your audience, but some parts fall flat.	Your writing is generally accessible but it lacks elements that will engage your audience and keep them reading from start to finish.	Your writing contains words or descriptions that are inaccessible to your audience or may bore them.	/ 5

Total	/ 25