What They Really Think: A Qualitative Analysis of Graduate-Level Science Students' Views on Science Journalism

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Abstract

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This thesis examines how graduate-level science students view science journalism, investigating how discussions in formal or informal pedagogical settings with professors and peers intersect with one's likelihood to participate in science journalism activities. Through the use of semi-structured interviews, twelve graduate-level science students shared their thoughts on various topics related to science journalism. Grounded theory using thematic analysis resulted in the development of a framework for considering how this largely unstudied group of future scientists perceive science journalism: The Four T's of Science Journalism. The research posits that graduate-level science students employ normalized behaviors fostered in science programs when consuming news, wherein they become critical analyzers of news stories, actively seeking discrepancies in the news stories they read. Regardless of the nature of conversations around science journalism in classroom or casual settings, and the news consumption habits of students, the research argues that the scientists of tomorrow are eager to learn about and participate in the creation of science journalism, pointing to the critical necessity to further assess how science journalism is woven into graduate-level science programs today and the urgency to which the disparate literatures of science communication and science journalism should be bridged in the pursuit of creating meaningful science journalism for public audiences.

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Chapter 1: Introduction

The relationship between science and the media is complex and multilayered. It has been a focal point for researchers studying science communication and journalism for decades, and many discussions are anchored in the role and purpose of the "science journalist." Science journalists are a group of professionals that can broadly be described as "the most visible actors in the interplay between science and the media" (Lewenstein 2011). Today, science journalists investigate various science-related topics and hold a critical lens to science on an institutional and practical level. As Deborah Blum puts it:

> Science journalists now readily cover contentious areas of science—from climate change to vaccines to the long-standing culture warts around evolution—with clarity and, in turn, detail with furious pushback from skeptics on social media and other platforms (Blum 2021).

Meanwhile, scientists globally are sharpening their communications skills to promote their work, whether their goal is to generate awareness and increase funding for their projects, or ensure that the public has access to facts about various topics, or a mix of both. This practice is more commonly referred to as "science communication", which Blum comparatively describes as "work to foster a positive view of science" (2021).

Science journalism cannot be adequately investigated without examining the intersections of scientists as communicators and journalists as professional storytellers, resulting in a field that is both broad and ripe for exploration from multiple points of view. Through examination, seemingly endless complexities emerge when considering global, national and local nuances of the media, as well as the emerging trends in both the sciences and journalism that are invariably impacted by rapid technological development. In 2014, late scholar Sharon Dunwoody published

Science Journalism, looking at how emerging trends for producing and consuming news on the internet was ushering in a potentially new era of science journalism, wherein the role of the modern science communicator put the role of the science journalist at risk. She asks, "Have we entered an era in which science journalists gradually lose their media platforms and find themselves increasingly eclipsed by savvy scientists keen to promote their *brands*?" (p. 35). Dunwoody ultimately concluded that the "commitment and passion" of science journalists still plays a pivotal role in telling compelling stories about science, and their survival requires new ways of looking at the decline of legacy media, and a renewed understanding of the core definition of a science journalist in the 21st century (p. 37).

The Coronavirus Pandemic and Science Journalism

A few short years after Dunwoody published *Science Journalism*, the COVID-19 pandemic put science journalism and science communication to the test as communities across the world searched and consumed countless hours of news coverage related to coronavirus. According to Statista, in March 2020, 38% of the global population was searching for information about coronavirus. As the pandemic raged, citizens interacted across digital platforms to share, question and interrogate the information they were receiving. Tweets about coronavirus reached 600M on twitter by May 2020 (Broniatowski et. al. 2022). Without question, the unprecedented global impact of the pandemic was reflected in the insatiable appetite for consuming and sharing information about the coronavirus, serving as the ultimate litmus test for how science and journalism intersect, a relationship already fraught with challenges in the digital age.

While interest in science journalism generally rose with the pandemic (Schäfer 2021), many of the questions that science journalism scholars have been asking for decades were

crystallized: who is responsible for communicating scientific information to the public? And furthermore, how can we ensure that what's delivered en masse is both truthful and easily understood? To answer these questions, one might pose a simple solution: if journalists know how to communicate to the public, and scientists have the answers, can't they work together to get the job done?

But, as predicted by Dunwoody in 2014, the emergence of digital platforms have collapsed the traditional boundaries of the media and the public, thus creating a maelstrom of scientific information: journalists, scientific experts, politicians, and misinformation converged to create global confusion, uncertainty, and ultimately the spread of misinformation. In "Objectives and Objects of Science Journalism Research During the Coronavirus Pandemic" (2020), Seth Lewis argues that a renewed look at the purpose of science journalism research is required, even if the well-established tensions already explored by scholars are unchanged. He writes:

> The present pandemic makes our absence in public and policy discourse all the more painfully apparent. There is a heightened need to understand the nature of public trust in expertise (journalistic as well as scientific, medical, political, etc.), just as there is to puzzle through what it means to designate journalism as an "essential service" or journalists as "essential workers" who may need additional support during a crisis. Journalism scholars have much to say about these issues, but perhaps our ways of working or our inability to get people to take our work more seriously preclude us from making a more robust contribution (p. 686).

Here, Lewis suggests that journalism studies are lagging in comparison to other academic institutions, rooted in "academic exclusivity" in comparison to other disciplines (p. 685). This is exacerbated by the fact that journalism research often fails to look at the "unique value proposition" of the news—in other words, how the business of news and the audiences' desire to consume it make it an indispensable and "economically-viable fixture" in everyday life (p. 684). This results in limited visibility in public discourse, with journalism studies lacking a presence on key debates around media and information. While this thesis was not inspired by the coronavirus pandemic and does not focus on it as a key topic, Lewis' critical examination of journalism studies in the wake of the pandemic will be mobilized to think about how meaningful connections can be made between the institutions of science, media and academia.

Science Meets Journalism: Credibility, Change, and "Communication" vs. "Journalism"

While some scholars have argued that scientists should expand their communications toolbox to participate in the creation of science journalism (Besley 2021; David et al. 2020; Secko & Amend 2013; Felt & Folcher 2012; Wilkes 2002), others contend experienced journalists are better fit to deliver important science-related stories to the public (Dunwoody 2021). Yet both paradigms are challenged by the fact that rapid change and transformation is pervasive: the ways in which publics produce, disseminate and consume information is shifting at an unprecedented speed, thus today's solution may be tomorrow's conflict.

The complexity of how these two fields collide is evident when listening to an advertisement currently running on *The Daily,* a podcast by the *New York Times*, that captures 4 million listeners a day (Schneier 2020). Like most major newspapers, *The Times* relies on digital subscriptions as a key revenue source (Myllylhati 2016), and capitalizes on the reach of *The Daily* to prompt listeners to become paying subscribers. In this particular ad, the professional

processes of "a scientist" and "a journalist" are contrasted to give weight to the importance of funding journalism. It consists of audio clips of Brian Rosenthal, Pulitzer Prize-winning investigative journalist, and his father, a research scientist, speaking about their careers. Brian Rosenthal first describes what he does at *The Times,* and briefly introduces his father, who says, "My career has been devoted to scientific training and research." To which Rosenthal responds, "I remember growing up—I didn't fully understand what he was doing every day. But, now that I work as an investigative journalist, I do understand." Rosenthal's father continues: "You have to start with facts. With those facts, a hypothesis appears, and then you work on trying to test that hypothesis." Following, Rosenthal says:

> I do the same thing. Obtaining documents, crunching the numbers, and I talk to as many people as possible to get to the bottom of the story. The *New York Times* does not publish until we can prove that something is true. The best scientists are able to do deep work because they receive funding from their university or government. We as journalists depend on funding from subscribers. You can support that type of work by subscribing to the *New York Times.* (Barbaro 10:41)

On the surface, the ad evokes a warm and human tone, with a well-known reporter talking about his profession in the frame of his father's influence. However, analyzing the content of this clip from the perspective of journalism studies, critical questions about science and journalism come to light: how does the perceived notion of science as a credible, fact-based field contrast with the role of the journalist? Why is this leveraged to communicate the value of investigative reporting at *The Times* to an audience of 4 million people? In other words, why is Rosenthal, a Pulitzer-Prize winner, using his father's processes as a scientist to give credibility to his work as

a reporter by outlining the "scientific" nature of his processes? Ultimately, the call to action for listeners of *The Daily* is to subscribe as a paying customer to *The Times*, so reporters with scientific-like methodologies like Rosenthal can continue to do their deep journalistic work.

While the ad on *The Daily* sparks a host of questions that give weight to the conflicts that emerge from the interplay of science and journalism, it is just a window into the vast and varied tensions that have connected and fractured the communities for decades (Shäfer & Metag 2021). These tensions have been explored at length. Science communication scholar Bruce Lewenstein (2011) describes the literature on science and the media as disparate and complex, an accurate representation of the palimpsest of problems ripe for analysis (p. 14). But in this complexity lies opportunity, and Lewenstein suggests "the best way to resolve the problem is to treat science and the media as a subset of issues in a more general model that describes science communication as an interactive, multidirectional activity occurring in many contexts" (p. 14).

While Lewenstein illustrates the breadth of research on science and the media, Shäfer (2010) suggests that employing science communications models is a useful approach when attempting to elucidate new ways to examine this topic. Shäfer describes the "traditional model" of science communication, focusing on the popularization of science through the diffusion of information from the science community to the public via the media (p. 400). Shäfer argues that this model, although useful when considering the importance of science literacy programs, is limiting. The traditional model assumes scientific knowledge is "superior to other forms of knowledge" and it unfairly assumes protests, dissent and conflicts around science arise from a lack of knowledge (p. 401). On the other hand, the medialisation model is much more useful in its ability to capture the complexities of the science-media relationship, positing a "loss of distance between science and other subsystems of society." In the medialisation model, science

and the media are intricately connected rather than two opposing entities, both actively participating in the science communication process. As a result, both entities adapt to one another which "results in changes on both sides" (p. 401).

Medialisation gives shared ownership and responsibility to both the science and media realms, opening the door for productive discourse that considers the interwoven communication complexities arising from both fields today. While some studies point to the increased appetite and professional obligations for scientists to participate in the media (Felt & Folcher 2010; Larsson 2019), others suggest scientists have hesitation, characterized by the potential for losing professional credibility among fellow scientists, risk of research findings being sensationalized, and lack of public understanding of the intricacies of the scientific process (Dijkstra, Roefs and Drossaert 2014). In parallel, research on the role of the science journalist today illustrates the various obstacles a journalist must overcome when reporting on science: from the decline in the value of specialized reporting to difficult working conditions and new professional norms that journalists must adopt (Dunwoody 2014; Nisbet & Fahey 2012; Molyneux & Holton 2015) the chasms that divide scientists, journalists, and the media institutions are multilayered, made all the more fraught by the fact that the pressures on each profession today are unique.

Context & Research Inspiration: The iSCOPE project with University of Bergen, Concordia University and UC Berkeley

I first became interested in this topic while completing my coursework for the Master of Arts in Journalism Studies program. In 2017, I worked as a research assistant for an interdisciplinary project focused on sciences, communication and education. The project, entitled Integrating Science of Oceans, Physics and Education (iSCOPE), was initiated by University of Bergen's Center of Excellence in Biology and Education (bioCEED). iSCOPE involved

graduate-level science students completing their Masters of Science or Doctorate degrees in a range of science specializations, predominantly biology and physics. The project brought together professors and students from Norway (University of Bergen and University College of Stord and Haugesund), California (University of Berkeley) and Canada (Concordia University). As stated on the project's website, the project was "designed as a bridge between successful science educational methodologies and the goals which UiB aims to reach." Researchers from Concordia, Dr. Vivek Venkatesh and Kat Urbaniak, analyzed the educational efficacy of the alternative science education methods tested by the iSCOPE and BioCEED teams. One of the key objectives of the project was to analyze how alternative methods of science communication education improve the communication abilities of students.

My first task as a research assistant was to spark a meaningful conversation about science communication in the context of the mass media by leading an interactive workshop during a project summit at UC Berkeley. The workshop consisted of a short presentation and small group discussion, and the primary goal was to guide the students toward thinking about how to contextualize and communicate their science work and research interests to lay audiences via the media. While some of the students had taken elective coursework in science communication, others had not, and the majority were unfamiliar with key topics in journalism studies. The presentation highlighted some of the key topics within journalism studies, in an effort to give context to the complexities that arise from producing journalism, such as the challenges of professionalization (Zelitzer 2001) and journalistic objectivity (Deuze 2005; Shudson 2001). Equipped with introductory information on some of the current challenges of journalism at large, students were then asked to read a science news story and share their thoughts with the group.

The conversations that emerged from this workshop fueled the direction of this thesis project. I observed complicated opinions about the mass media shared among the group. Chief among them, and arguably the most influential observation I encountered, was the professors expressing their uncertainties, hesitation, and lack of confidence in the capabilities of journalists reporting on science. Indeed, the perception of journalists as individuals unable to adequately report on science stories is a common viewpoint shared among the science community (Wilkes 2002). Following this experience, I was eager to analyze how the opinions shared by the established science professors influence student trust in journalism, thereby impacting their likelihood to participate in science journalism in the future.

Thesis Focus and Research Questions

This thesis aims to analyze how graduate-level science students view science journalism with interviews that were completed from 2020 to 2021. Graduate-level science students' viewpoints have largely been ignored in science communication and science journalism research to date. The research asks two key questions: does a graduate-level science student's trust in science journalism impact their willingness to participate in the media? Furthermore, have these students been encouraged or discouraged to interact with, or produce, media by their mentors or peers? By gathering a more comprehensive understanding of these opinions on the news, the goal of this research is to uncover what factors–pedagogical or otherwise—influence if and how the scientists of tomorrow might engage with the media in the future.

Specialized science communications programs and courses have proliferated in many countries (Wilkes 2002; Dunwoody 2014), and yet many graduates in the sciences still feel ill prepared to engage with the media. Through an analysis of twelve interviews of graduate-level science students at Concordia University and University of Bergen, this thesis argues that the

institutional structures and the norms pervasive within science programs influence students' consumption habits of the news, opinions on the media, and appetites for producing journalism. As a result, graduate-level science students often become inspectors and analyzers of the news, actively seeking truth discrepancies in the stories they read by employing the practice of "critical thinking" encouraged in their programs. However, despite a significant amount of general interest in the media and a measured awareness of its importance for contextualizing the importance of science in societies, many students do not actively participate in the medialisation of their own work, in spite of being interested to do so. This points to the need to increase opportunities for adequate practical training at the graduate program level in universities, and suggests adopting a reimagined approach to formal and informal pedagogy around science journalism could not only have beneficial long-term implications for the relationship between scientists and journalists in the future, but better utilize the varied interests and appetites graduate-level science students have to contribute to science journalism.

This thesis is divided into five chapters. Following the introduction, the literature review provides a comprehensive examination at the key areas of research in science journalism studies, with a look at some key literature on science communication in tandem. Given the broadness of the field and its various perspectives, the literature is organized thematically in relation to key research questions (Creswell 2014). The methods chapter outlines the approach to the study, describing in detail the constructivist worldview, the selection of semi-structured interviews, as well as the use of thematic analysis in grounded theory to generate meaning in qualitative research. The findings chapter highlights four key themes emerging from the research, which are thematically organized as "The Four Ts of Science Journalism for Future Scientists:"

1. Training: The Why and How Behind Scientific Training For Journalists Reporting on Science
2. Trust: How Critical Thinking Influence Science Students' Media consumption Habits & Viewpoints
3. Tensions: Appetites and Barriers for Producing Science Journalism
4. Teaching: How Traditional Science Pedagogy Structures Create Barriers for Science Journalism Training

Lastly, the discussion chapter reflects on how the findings challenge or uphold current literature, and proposes new suggestions for future research on the topic.

Chapter 2: Literature Review

Science journalism and science communication scholars have been analyzing topics of professional responsibilities, trust, working conditions, and much more, at length, asking critical questions such as: (a) Can journalists adequately report on topics in which they have a limited understanding of the nuances, from both a scientific process and scientific language perspective? (b) Can scientists be trained as journalists, or journalists be trained as scientists? Should they be? (c) Can the respective institutional frameworks—and subsequent professional norms—of journalism and the media coalesce to create a productive, meaningful working relationship to ensure that the public has access to important information in a timely manner? If so, what might this formation look like?

These questions, among others, have influenced the direction of this research and will be unpacked in the literature review. The literature review is organized into five themes to align with areas of research in science journalism and science communication that are critical to this thesis. First, we will look at the foundational research on science journalism and its history that has served as a starting point to many of the frameworks, definitions and terms, and modes of analysis for thinking about the field. Following, an examination of the common tensions and complexities that have divided these communities and the extensive literature on this topic will be explored. Next, we will examine literature on the professional norms and responsibilities of scientists and journalists today, asking how these norms contribute to either deepening tensions or budding alliances. We will also look at the literature on one of the most commonly asked questions in the field: should scientists be trained as journalists, or vice versa? We will conclude the literature review by looking at recent publications on science communication and science

journalism in light of the coronavirus pandemic, and explore perspectives on epistemic communities.

Part One: Connections and Chasms: A Brief History of Science Journalism Research

One of the most influential pieces of literature in science journalism research is Dorothy Nelkin's *Selling Science: How the Press Covers Science and Technology* (1995). In this book, Nelkin traces the histories of science reporting, predominantly from the United States lens, drawing on evidence from countless examples of science journalism to suggest that the representation of science as superior to other forms of knowledge is deeply influenced by the media. While this is an idea that is increasingly challenged (Peters 2013; Ward 2019), Nelkin suggests that the complex interplay of the media, journalists, scientists and sociopolitical climates throughout time have allowed the institution of science to remain relatively protected from journalistic scrutiny. In Nelkin's view, science is often critically unquestioned, and sometimes blindly accepted as the truth. She notes "Even in reports of scientific fraud, scientists are often idealized as dispassionate, objective, and with values that must remain above those in other fields" (p. 29). Furthermore, Nelkin argues that the institution of science benefits from a privileged position, often benefiting from less comprehensive investigation than other sectors. Speaking on the benefits scientists get from the media, she writes, "In the coverage of science, the media has encouraged the widely held belief that science is distinct from politics and beyond the clash of conflicting social values… science as an institution is assumed to be a neutral source of authority, the engine of progress, the basis for just solutions in controversial public affairs" (p. 63).

Most interestingly, Nelkin argues that the American ideal of objectivity in journalism had a significant impact on how scientific knowledge was viewed. In her view, the norm of

objectivity "converged with the growing idea that scientific knowledge prevailed over all other forms of knowledge to shape the conventions in journalism" (p. 64). The notion of professional norms and ideals, and subsequent impacts on the scientists-journalist relationship tensions is explored further in part four of this literature review.

From another perspective, in Science Journalism: Prospects in a Digital Age (2014) Sharon Dunwoody illustrates the historical contexts that have influenced the division of the science and journalism communities. Whereas Nelkin's arguments are framed by looking specifically at the media, Dunwoody focuses on the intricacies of the science community and science as a profession. Specifically, speaking of both the United States and Britain, Dunwoody argues that although scientists placed an emphasis on sharing knowledge with the public, this was followed by a "retrenchment that moved scientists away from direct contact" (p. 27). She also speaks to the creation of a scientific community somewhat removed from other sects of society: "As knowledge became more specialized, creating their own languages and awards, communication with the outside world became less of a priority (p. 27)." Dunwoody also notes that some scientists were punished for popularization of their work, to the extent that they were not able to have access to awards.

While Nelkin and Dunwoody put forth useful ways of thinking about the nuances of science journalism, Hartz & Chappel speak to the impacts of the divide between these communities in *Worlds Apart: How the Distance Between Science and Journalism Threatens America's Future* (1997). The authors conducted a survey of scientists and journalists to assess attitudes and opinions towards one another. Many of the key findings are in-line with common tropes in the science-media relationship, including scientists claim that journalists need to better understand the scientific method, and journalists reporting that scientists are limited in their

ability to explain their work simply and clearly, among others (p. 41) Significantly, the survey found that journalists are more critical of their own professional norms and institutions, in comparison to their scientist counterparts, for whom journalists have a high degree of confidence in (p. 45). The confidence in scientists' abilities, despite clear professional differences, connects to Nelkin's assertion that the media has routinely elevated scientific knowledge and institutions to a different class.

Nelkin, Dunwoody and Hartz & Chapel have each provided a critical foundation for science journalism research at large, presenting viewpoints that illustrate a high degree of critical reflection among both communities. While each provides a starting point to thinking about science journalism conflicts, each has their gaze focused primarily on particular geographic locations: Hartz & Chapel and Nelkin are from an American lens, while Dunwoody's references cross the US, Britain and Canada. Indeed, examining the intersection of two disparate communities with two significantly different sets of professional norms, that may shift significantly depending on geography, is challenging. However, scholars such as Leweinstien (2011) provide a useful way of thinking about how to bridge the gaps in science journalism research, regardless of borders. Specifically, in his literature review featured in the *Handbook of Science and Technology*, Lewenstein casts a critical lens on the literature available within the science journalism field. He describes the landscape as complex and divided, asking: "How are we supposed to understand the disparate literatures that deal with science and the media?" He argues that critical questions need to be asked at the outset of contributing to research, writing:

> To bring these literatures together, we must ask: for what purpose are we trying to bring them together? To understand the structure of science? To understand the relations between science and society? To improve public

> understanding of science? To improve the technical flow of information? To improve science literacy?" (p. 14).

Indeed, the critical questions brought to light by Lewenstein represent the vastness of this field of research, and the subsequent need to have a clear approach to critically interpreting the various ways to approach these issues. He recommends creating a new model of science journalism that stresses its "interactive, contextual nature" (p. 9), by leveraging more holistic models for thinking about science journalism as a " multidirectional activity occurring in many contexts." (p. 14). He critiques the limiting models of thinking about science communication today, noting that current work on science literacy is limiting as it has "been interpreted to indicate that there is a single audience that enjoys science, while another, much larger audience poses a 'problem' for those committed to improving public understanding, knowledge or attitudes toward science" (p. 10).

Lewenstien's approach for looking at issues in science journalism research is supported further by the work of Schäfer (2011), who paints a picture of the literature available in science journalism. Noting the limitations in the methods available for critical analysis, he draws on two models of science communication: the traditional model and the medialisation model. In unpacking these models, Schäfer argues that the traditional model of science communication, which assumes the primary goal of communicating science is to ensure the public is scientifically literate, is limiting. Citing Wynne (1995), Schäfer notes this way of thinking about science in the media has its shortcomings:

> [Traditional model of science communication] conceptualized science and the public as being unequal, with science being superior to other forms of knowledge. This led to the assumption that every citizen who was

> adequately informed about science would inevitably support scientific developments, and that criticisms and protests against such developments were invariably to the critics' inadequate knowledge (p. 400).

In Schäfer's view, the medialisation model is a more effective way for thinking about science journalism today. Whereas the traditional model involves a top-down approach to communicating information, with the medialisation model, science and the media are "mutually interrelated" wherein innovations and evolutions within either field require adaptation on the other side. In this view, significant changes in the media would inherently create change within scientific communities, and innovations in science influence changes in the media. This prediction holds measurable weight, as evidenced by recent research that will be explored in part three of the literature review (see pages 22-27.)

Reviewing the historical work of Nelkin, Dunwoody and Hartz & Chappel provides a useful foundation for understanding the key tensions and conflicts that have historically divided the science and journalism communities. Nelkin's investigation argues that high regard for scientists in the United States has impacted the science-journalist relationship, whereas Dunwoody takes a deeper look at how the evolution of science as an institution and profession has deepened the science-journalism divide. These findings are supported by the 1990s work of Hartz & Chappel, whose research suggests that viewpoints of scientists versus journalists and the public, and journalists versus scientists, is a critical factor in creating tension, division, and ultimately conflict among both communities. Lewenstein and Schäfer, on the other hand, look at science journalism research from a much broader lens, urging science journalism scholars to revisit the questions they ask. They illustrate the limitations on science journalism research from the lens of an increasingly complex media landscape, pinpointing the need to evolve methods of

analysis to align with the professional communities and the interactions among them, while accounting for the state of constant change, innovation and evolution that affect both journalists and scientists.

Part Two: Relationship Tensions and Complexities: Unpacking The Conflicts Dividing the Science and Journalism Communities

At the center of much of the debate around science journalism and science in the media is the relationship between scientists and journalists, both from an institutional level and an individual level. The tensions among these fields are widely known, and have been alluded to in texts explored in this literature review (Baron 2010; Nelkin 1995; Hartz & Chappel 1997). Some scholars have made this tension a focus of their research, including Larsson et al. (2019), who undertook a massive study across North America and Europe that includes interviews, focus groups and surveys of 600 medical professionals who have previously been involved in creating science journalism related to their field. The study, titled "Medicine and the media: Medical experts' problems and solutions while working with journalists" found that medical experts willingness and appetite to interact with the media is strong, with 74% of respondents from the United States interacting with the media more than six times per year, with the majority of respondents considering this type of interaction was a professional duty (p. 5). Despite frequent interactions, respondents complained that the journalistic tendencies to create headlines in a rush and with limited space to tell complex stories impacted accuracy in final outcomes. Furthermore, respondents stated that stories that are important to overall health—on the topic of prevention, for example—were often ignored, although experts see these as critical information for the public. A key suggestion put forth by the researchers was to improve the basic medical knowledge of journalists reporting on medical issues, while at the same time increasing awareness and knowledge on the working conditions of journalists and the media marketplace (p.

9). From this perspective, Larsson et al. paint a picture of a medical community that sees value in a strong relationship with the media to ensure key pieces of medical information are disseminated to the public, despite pitfalls.

While the previous study provides useful data for interpreting the relationship between scientists and journalists, approaching the problem with a theoretical lens can also foster a meaningful way for thinking about the multiplicity of the challenges that face both scientists and journalists as they interact. In a European study focused on the Netherlands, A. Dijkstra employs the theory of planned behavior as a tool to analyze qualitative semi-structured interview data from interviews with both journalists and scientists. The study, entitled "The science-media interaction in biomedical research in the Netherlands: Opinions of scientists and journalists on the science-media relationship" (2015), suggests practical ways for fostering more meaningful interactions by highlighting the barriers of entry that divide each community. Interview data found that, in general, journalists perceive the relationship with scientists as more positive than scientists do. Scientists interviewed suggested that journalists should have some degree of scientific training to be effective, whereas journalists largely did not believe that scientists need to have specific skills to participate in interactions with journalists, though general media training is an asset (p. 11). Dijkstra also hones in on the pressures that scientists face when interacting with the media among their peers: while participating in the media activities can be positive for their career, many often fear facing criticism (p. 13).

Investigating the scientists' hesitation to participate in media more closely, Dijkstra identified a number of negative control beliefs from scientists that lead to not participating in the media. They include: previous negative experiences with the media, public and peer criticism, and involving oneself in controversial scientific topics with ethical considerations (p. 11). This is

further complicated by a scientists' own perceived abilities, including: lack of communication skills, perceived irrelevance of their research, lack of time, among others (p. 14). Dijkstra suggests that practical approaches to overcoming these barriers should be implemented, such as support from research communications departments, and working with a journalist with whom they have a trusting relationship. The identified barriers for journalists included finding the right scientist to interview due to lack of communication skills, managing their expectations for the final story, and dealing with journalistic norms such as tight deadlines (p. 14). Dijkstra asserts that both groups consider a lack of scientists' communication skills as a barrier to entry; focusing that shared barrier can empower both groups to find ways to overcome this challenge through both practical improvements through teaching and training.

While Larsson et al. and Dijkstra leveraged interview data to analyze the science-journalism relationship, a smaller study led by Soldovsky et al. (2017) looked in-depth at the perceived level of stakeholder expertise in science communication interactions, and how these perceptions impact likelihood and quality of communication. Soldovsky et al. surveyed scientists to better understand how perceptions of journalists influenced interactions. The authors argue that a project researcher was more likely to engage in communication if they believed an individual, such as a journalist, had similar levels of scientific expertise (p. 589). Drawing this conclusion, the authors point to a central tension that could significantly limit the effectiveness of research: "If perceptions about stakeholder expertise are a factor in shaping how researchers choose to engage with stakeholders, they may be limiting their ability to create research partnerships that would be required to achieve their transdisciplinary goals" (p. 590). From this perspective, the suggestion that scientists may be less inclined to discuss topics with journalists if they do not feel they have necessary knowledge not only limits interactions, but perhaps the

relevancy and overall effectiveness of specialized research at large intended to benefit general publics.

Whether mobilizing the works of Larrson, Dijkstra or Soldovsky, there are a number of consistent patterns that emerge when examining the complexities of the relationships between scientists and journalists. First, that working conditions can impact relationships negatively: while journalists might need to focus on topic relevance to fulfill their professional obligations, scientists might want journalists to portray more holistic nuances in their reporting. Second, expertise in each other's domain, whether perceived or real, can significantly impact both willingness to communicate and the effectiveness of the communication: scientists hope that a journalist will understand their field, whereas journalists seek to interview and work with scientists who can clearly articulate their research. Third, the tensions that divide both of these communities can have substantial impacts on what information is communicated to the public.

Despite these divisions, the need for an effective collaboration between scientists and journalists is well-understood. In "An uneasy relationship: the tensions between medicine and the media" (1997), Dorothy Nelkin describes that, as of the 1990s, journalists were becoming increasingly hesitant to always portray a positive image of science, asking critical questions around the social and ethical implications of science. Furthermore, Nelkin outlines the ways in which the media can drastically influence scientific fields: positive reports on a health product can send a company's stock skyrocketing (such as Prozac), while negative coverage on medication side effects can dramatically impact sales of consumer goods (1603). Most crucially, however, these media messages impact funding for research projects and therefore research priorities. Overall, Nelkin's examples of the 1990s demonstrate that science and the media have been enduring complex tensions consistently, across many borders, and challenges that existed

decades ago still exist, albeit in new forms. As such, this literature demonstrates that strained science-journalism relationships not only impacts the quality and breadth of topics of science journalism that the public receives, but also the science research that is focused on, funded, and produced.

Part Three: Role Evolutions: Present-Day Challenges and Professional Norms

While the previous section highlights the macro and micro-level tensions impacting the science and journalism communities, a look at how the individual roles of journalists and scientists have evolved provides critical insight into the daily realities and pressures these professionals face. The evolving role of the journalist, and the crisis of the professionalization of journalism, has been a topic explored at length in journalism studies (Bauer et al. 2013; Deuze 2005; Zelizer 2004). To define these roles, Fahy and Nisbet (2011) provide a useful perspective on the crisis of professionalization in a science journalism context in "The science journalist online: shifting roles and emerging practices" which can be mobilized to understand the various factors at play dividing scientists and journalists. Through the use of semi-structured interviews in the United Kingdom and the United States, Fahy and Nisbet map a typology of science journalists, consisting of nine different types of roles of science journalists that exist today, with suggestions on how these roles might evolve. This typology is then used as a starting point for understanding how roles might need to evolve for science journalists to uphold their critical function in society.

Some of the science journalist "types" mapped by Fahy and Nisbet mirror common definitions and professional characteristics of a journalist, especially in the United States, such as "watchdog" (a journalist who holds institutions and individuals accountable) and "agenda setter" (a journalist who calls attention to specific topics to push a specific movement forward) (p. 780).

However, two types of science journalists they identified are of particular interest to science journalism today: the "conduit" and the "convener." While the conduit translates scientific information to non-scientific publics, the convener takes on a more robust challenge: connecting and bringing together scientists and "various non-specialist publics to discuss science-related issues in public, either online or physically" (p. 780). Critical to the typology mapped by Fahy and Nisbet is the fact that these roles are not fulfilled solely by science journalists, but instead, a "diverse group of actors" who are disseminating scientific information to the public, especially individual scientists who are using their own platforms to distribute information, and science writers who use personal blogs and social media to report on science-related stories, rather than solely filing stories to the media (p. 782). Fahy and Nisbet call this a "shift in journalism space" that allows amateurs and citizen journalists to participate in the creation of science journalism (p. 782). In their view, this rise has led to the decline of science writers employed by legacy media in the USA, which has contributed to challenging the science journalists authority and role. Fahy and Nisbet ultimately propose specific solutions for science journalists confronting this crisis, writing: "In the new media ecosystem credibility for reporters is rooted in the reporters' ability to criticize and speak to the process of how science was created, perhaps looking at the study and critiquing it, rather than simply reporting on it (p. 789)." Further, they also suggest that since scientific "certainty" is no longer relevant in today's science-media ecosystem, journalists must collect information from various sources and present them accordingly (p. 784).

The concepts presented by Fahy and Nisbet are useful in their ability to allow journalists and scientists to think about how the "shift in journalism" space requires a reinvention of the way we look at the role of journalists. But writing from Brossard and Scheufele adds a layer of complexity to the neatly packaged definitions set forth by Fahy and Nisbet. In "The chronic

growing pains of communicating science online" (2022), Brossard and Scheufele emphasize the urgency behind the evolving journalism space, urging that scientists need to act more swiftly to rapidly changing communication landscapes, namely on social media channels. In particular, Brossard and Sheufele focus on the power of social media channels as conduits, arguing that "social media platforms are the central gatekeepers of information about science" and that the scientific community has been "slow to react" (p. 613). In their view, the battle for scientists to ensure that they get the right information to the right public is no longer just about accuracy and distribution, but has evolved into a more complex exercise wherein scientists must understand social media channels, algorithms, and user behaviors that influence these. They write:

> When scientists do engage [on social media], the fast-moving and almost real-time back-and-forth on social media can change the way they use and represent evidence. Rules of scientific discourse and the systematic, objective, and transparent evaluation of evidence are fundamentally at odds with the realities of debates in most online spaces (p. 614).

While the nature of social media presents a challenge to communicating the fundamental principles of science, Brossard and Sheufele also highlight the fact that both scientists and individuals who are more-science literate typically follow and engage with important conversations about science. In other words, the audiences that scientists need to reach the most to increase education and even battle misinformation, are harder to reach, given the algorithms that dictate who receives what content: "Most perniciously, this has allowed scientists to live in their own science-centric bubbles on social media platforms, sheltered from often sizable cross-sections of citizens that feel disconnected from the scientific community" (p. 613). In

short, in the lens of Brossard and Scheufele, scientists must become social media literate in order to harness its full potential as a medialised space.

Molyneux and Holton (2015) paint a contrasting picture of journalists versus scientists' use and mastery of social media, investigating how journalists in health reporting leverage social networks in their profession. Molyneux and Holton conducted interviews with journalists to uncover why journalists were developing "personal brands" online, especially as the principles of a personal brand may contradict the professional norm of objectivity (p. 228). The authors suggest that the movement toward using social media as a channel to develop journalists' individual brands is a normative process that has been developing as technological advancements have forced these journalists to adapt to new realities wherein traditional newsrooms have become obsolete (p. 229). Interestingly, the authors found that health journalists often leverage their audiences for interactions and engagement on key topics, wherein their audiences are "co-creators" of science journalism rather than a "static group of listeners" (p. 229), which is an argument that is well-aligned with Fahy and Nisbet's "convener" characterization of the science journalist. Indeed, this rests in sharp contrast to the picture painted by Brossard and Schefuele, where scientists are more concerned with relaying messages around scientific accuracy among communities already interested in science, rather than creating meaningful dialogue with audiences on social media.

In examining the work of Molyneux and Holton, one of the clearest tensions that divide the science and media today is illuminated: whereas modern media organizations see value in working with journalists who have their own social media following for multiple reasons—the same is not necessarily true for scientists. Although scientists and the institutions that employ them consider communication a professional duty, and understand the value of public

communication for generating awareness, impacting policy and funding (see Albaek 2011; Brownell, Price & Steinman 2013; Dijkstra 2015; Larsson et. al 2019; Jensen & Gerber 2020), the core difference is perhaps the degree of how important social media is to the profession. Further, whereas media institutions and have been forced to adopt their revenue models and the subsequent professional expectations of journalists to be economically viable in the social-media driven world, science has not seen the same cataclysmic shift to force the institution, and the professionals within it, to adapt to the social-media first world. Indeed, the spread of misinformation in the post-coronavirus context may change this.

While Brossard and Shefuele call for more awareness of the intricacies of social media channels from scientists, and Molyneux and Holton provide a contrasting viewpoint on how health journalists are adopting social media, Besley et al. (2021) showcase a meaningful perspective on scientists openness for public communication practices in the wake of the coronavirus pandemic. The authors suggest that the scientific community is open to testing various science communication tactics for a wide range of communication objectives (p. 16). In the survey of scientists at American research universities, Besley et. al. concluded that there are two key predictors to scientists' willingness to communicate science are first, the scientists' belief that the tactic would be effective, and second, that the scientist believed they have the skills to communicate adequately (p. 5). Besley et. al. note that those who are encouraging scientists to increase public communication activities should be aware of the normative beliefs pervasive within the science community about the practice. They write:

> ...People who want to get scientists to consider adopting an informal communication style—a communication choice that often takes preparation and other types of effort—might focus their pitch to potential

> communicators by emphasizing the likely benefits of using an informal communication, as well as finding ways to ensure informal communication seem feasible to the potential communicator (p. 5).

Like several science journalism scholars, Besley et. al. see value in having communication and journalism training for scientists, a key topic of science journalism and science communication research that will be assessed in the next section of this literature review. However, they extend the idea of training beyond improving practical communication skills, and suggest that more research needs to be done "to better understand evaluative, normative and self-efficacy beliefs about communication choices" confronting scientists (p. 17). In all, Besley et al. illustrate that scientists are, by and large, happy and willing to communicate, but understanding the choices they make about their communication tactics requires deeper research and understanding in order to be effectively actioned.

Part Four: Who's Learning What? Journalistic Training for Scientists and Science Training for Journalists

While many scholars discuss the overarching impacts of the disjointedness of the science and journalism communities, others look for practical solutions for ensuring strong science journalism practices. Specifically, many examine the usefulness and practicality of formal training in the sciences for journalists, or call for greater communication and media training for scientists. Dunwoody (2004) examined this topic in-depth in her article, "How valuable is formal science training to Science Journalists?" Dunwoody's position is clear: formal training in the sciences is not critical for science writers' work; the number of years in a newsroom and newsroom "socialization" are the key factors in determining the quality and efficacy of good science journalism (p. 75).

Furthermore, Dunwoody casts a critical lens on the current state of training for science journalists today, noting that many of the top science communication and journalism programs in the United States require degrees in science before admitting individuals to graduate programs. In her view, this hierarchy is a way for science culture to maintain control over popular representations of science (p. 76). Furthermore, as Dunwoody notes, scientists are increasingly interested in becoming apt public communicators as it can influence the trajectory of their careers in a positive way, as public clout can influence funding opportunities for research and projects (p. 83). Dunwoody's view, rooted in the realities of the media today, are contrary to the assertion that scientists have fears when "stooping" to media popularization. In her view, scientists understand the value of public visibility, and outlines three core tenets shared by many scientists when considering the power of the public communication of science: 1) visibility equals more resources; 2) the public is "a market ripe for exploitation", which is particularly relevant for any scientist developing consumer-focused products or tech; 3) "Media coverage confers social legitimacy", meaning that media coverage could place more importance on certain science research over others. (p. 79).

The disadvantages of having scientists as public communicators rather than having journalists communicate on science stories suggested by Dunwoody are rooted in the professional norms of journalism and its differentiating characteristics, like the power of storytelling and need for objectivity. She suggests that "scientists as communicators undervalue the core tenets of good science communication: understanding of topic, understanding of audience, and understanding of storytelling" (p. 82). And, alluding to journalistic objectivity, Dunwoody asserts that scientists may be better "advocates than critics of scientists" (p. 82). Whereas scientists are closely attached to the material at hand, journalists can remain

"ideologically independent" from the material, maintaining their roles as a watchdog for the public (p. 82).

On the other side of the spectrum, some research looks to assess the value of science communication training for scientists in post-secondary education. An Australian study titled "Integrating Communication Skills into Undergraduate Science Degrees: A Practical and Evidence-Based Approach (Mercer-Mapstone & Kurchel 2016), suggests that, although innovations in how to teach science and integrating science with communications exist, they are rarely published, which invariably impacts the development within the fields (p. 2). For this experiment, the researchers identified a number of core communication skills to be integrated into three undergraduate science programs at research-intensive Australian universities in biology, chemistry and physics. The skills included understanding audiences, understanding context, and how to leverage writing style to get the right communication across to audiences, among others. In this study, 94.9% of students reported improvements in their communication skills when communicating about their subjects (p. 6). The researchers also reported that increased communication education led to a decrease in the use of "scientific jargon" and an increase in the use of analogies to foster broader understanding of complex topics. The study ultimately concluded that teaching science communication skills improves confidence in communicating on science, and the students' self-perception in their ability to communicate on scientific topics (p. 7).

In *Escape from the Ivory Tower* (2010), Nancy Baron teaches scientists practical advice for rethinking their interactions with journalists, and empowers scientists with techniques and tools for contextualizing their work and research in a way that has meaning to public audiences. Whereas Mercer-Mapstop and Kurchel look for adding specific science communication

curriculum in science programs, from Baron's point of view, it's critical for professional scientists to develop a deep understanding of the media and how journalists work. Furthermore, much like Dunwoody, Baron does not argue in favor of science-trained individuals becoming journalists, instead, she compares and contrasts the working conditions of scientists and journalists to showcase the fundamental differences that divide the communities, effectively illustrating where scientists should have more awareness in the fundamentals of journalism. In Baron's view, it's critical to understand that, whereas journalists fact-find for their audiences and look for truths, scientists are uncomfortable with communicating uncertainties. Baron also notes that journalists and scientists are at odds when it comes to communicating findings for public audiences: journalists put primary emphasis on results in journalism, whereas scientists prioritize background and methods of a study (p. 50). Baron's goal is for scientists to enrich their awareness of these differences, while dispelling myths surrounding science journalism and the media, to effectively allow scientists to reframe their understanding of science journalists and leverage their relationships in a more productive, meaningful way.

Ultimately, Baron puts the onus on scientists for deepening their understanding of the working realities of science journalists, while also empowering them with information and tools to increase their efficacy in their interactions with the media as a whole. She writes:

> The tensions between the worlds of scientists and journalists will likely always exist. But by understanding each other's culture, and trying to accommodate each other's needs, you can find common ground. By being more accessible -- in language, attitude, and availability—scientists can go a long way toward more frequent, higher quality science coverage in the news (p. 60).

Baron's assertion that scientists can educate themselves on the field of journalism as a way to improve collaboration is complemented by research by Koswatta et. al. (2022) who looked at university faculty at Texas A&M University, examining the factors that contribute to the likelihood of a science faculty member participating in public communication activities. Although Baron believes that positive science communication and science journalism activity may be predicated on a scientists' ability to understand the inner-workings of journalism—Koswatta et. al. suggest that nurturing the "intrinsic" motivation of university faculty to communicate on science could increase science communication activities (p. 186). The study argues that examining true barriers versus perceived barriers to help create actionable solutions, writing: "Scientists across several studies, including ours, have identified time as critical for them to engage effectively but one must ask if this an actual barrier to participation or is it a perceived barrier?" (p. 186). They propose building out robust communication teams to mitigate this barrier for scientists, while also decreasing the amount of time spent on other organizational commitments to allow for more time to think about participating in science communication activities (p. 187). One of the key findings was also that early-career scientists saw engaging in public science communication activities as a necessity, in comparison to scientists who are 20 years into their careers. The authors suggest this could be due to stronger perceived importance on the topic, in addition to increased efforts on communications training for early-stage scientists; however, they state that more research to examine normative beliefs, institutional culture or training is required (p. 188).

Looking at the suggestions from these scholars on training more holistically, it is evident that the literature around training and teaching presents multiple viable options, yet a few singular, agreed-upon approaches are yet to be determined, and there are pros, cons, and layers of

institutional complexities implicated in all approaches. Mercer-Mapstone & Kurchel suggest that increased communication learning in science programs could lead to more productive, impactful science communicators, yet this direction is reliant on shifting syllabuses across the world. On the other side of the spectrum, Dunwoody's argument that "on the job" training is the most important success factor for strong science reporting does not necessitate shifting science education programs, yet the notion of "on the job" for journalists is one that is constantly in flux. But Dunwoody's assertion that focusing on science journalism training for scientists risks maintaining a healthy, critical distance between science and the media is an important one: through this lens, Dunwoody is not suggesting an upheaval of professional norms and practices, but instead, a recognition that these norms may be best kept separate, albeit understood and recognized. Baron's proposed solution could be considered a complement to Dunwoody's perspective, wherein scientists might learn a few journalism essentials to increase communication efficacy, yet this is reliant on both practical barriers of time and resources being nonexistent. Finally, Koswatta et. al. provide a critical additional perspective, showcasing how science communication research should examine perceived versus real barriers in a scientists' likelihood to participate in public communication activities, looking at the normative, institutional, and training influences that coalesce to form a scientists' opinion on communication and subsequent activities. With this in mind, the viewpoints of graduate-level science students on the importance of training for science journalists and their own interest in learning about science journalism becomes all the more critical.

Part Five: Current Perspectives and Epistemic Communities: Understanding the Evolved Challenges of the Science-Media Relationship

Critical to note is the fact that a bulk of the literature aforementioned was completed prior to the coronavirus pandemic.With that said, many researchers have suggested that the pandemic

crystallized the longstanding questions asked by science journalism and science communication scholars (see, e.g., Angler 2021). However, it also brought to light some fresh challenges, tensions and perspectives, especially pertaining to the roles and responsibilities of science journalists and science communicators in the context of a global health crisis.

Sharon Dunwoody's article "Science Journalism and Pandemic Uncertainty" (2020) looks at how journalists should manage reporting in a time of uncertainty, and suggests that audiences' levels of uncertainty during the early days of the pandemic created a unique challenge for both journalists and scientists. She cites that social media is the most common place to get news for Americans, and yet only 50% view Facebook as a reliable news channel (Ballew et. al 2020; p. 472). Furthermore, conflicting messages about coronavirus on social platforms only serve to increase uncertainty more, which can then lead to fear and helplessness, possibly leading publics to ignore the news altogether (p. 472).

In the face of these unique challenges, Dunwoody asks how journalists can eliminate uncertainty. Her suggestions are not a departure from her earlier work, suggesting that journalists need to continue to rely on scientists as sources as they remain "high in the credibility line-up", stating "most of us are more likely to believe what scientists tell us about scientific issues than what we glean from other types of sources" (p. 473). She also calls for a continued focus on pandemic-related stories that focus on context and understanding, a science journalism practice that has increased in the past years (p. 473), which can help alleviate uncertainties through knowledge-based journalism. She also highlights the fact that audiences can compare sources today in real-time, therefore placing an emphasis on fact-checking is key, although misaligned facts can decrease trust in media sources overall.

Additionally, in an interview entitled "Science is a matter of facts, not opinions" (2021), Mike Shäfer provides an interesting perspective on the speed of scientific advancements related to the pandemic, and how this impacts the quality of reporting. He argues that the time-pressure for journalists to deliver up-to-the minute stories on science is complexified by the speed at which science research and discovery is happening at an unprecedented rate, and there is an inherent risk in contributing to the sense of uncertainty that Dunwoody highlights. He states:

> Robust knowledge is continually and gradually emerging. Researchers have produced tens of thousands of research papers in the past months. Many of their findings come with a certain degree of uncertainty. Some of these papers have not yet been peer-reviewed but published as preprints. They have not received the scientific community's stamp of approval yet. That poses a specific challenge for science journalists: how can they deal with an increasing societal appetite for science when the science they have to deal with is only just emerging (Angler 2021).

Crucially, Shäfer highlights the professional, lived realities of journalists that are impacting science journalism: science journalists are tired, historically have fewer resources than other types of journalists, and the requirement to be constantly active on social media as a part of their everyday roles continues to be draining. As a result, he calls for "sustainable business models" for science journalism that maintain editorial independence of journalists while also increasing the range of sources available to them from the science community (Angler 2021).

While Dunwoody and Shäfer showcase cracks in the science-media landscape that lead to greater public uncertainty, looking at how science news is created through the framework of epistemic communities is a valuable exercise in possible solutioning. In "Re-ordering epistemic

living spaces: on the tacit governance of the public communication of science" (2010), Felt & Folcher define epistemic living spaces as the "individual or collective perceptions and narrative re-constructions on the contexts, rationales, actors and values which mould, guide and delimit the potential actions, both in what they aim to know and how they act in social contexts and beyond" (p. 4). Critical to the research questions asked in this thesis, Felt & Folcher argue that "the multiplication of interactions with the media" invariably impact what science is focused on and for whom, which is, in part, anchored by the fact that medialised representations of scientists impact them and how they conceive their career (p. 6). Therefore, if young scientists do not see their type of research represented in medialised contexts, they may think that it is irrelevant or not fitting for public consumption.

Carrie Figdor (2017) mobilizes this concept of epistemic communities to look deeper at the practical concerns of creation of science news, arguing that science news should be an "interdisciplinary" product that sits between both scientists and journalists within a shared epistemic community (p. 2). Further, she argues that the over-reliance on scientists to uphold the "epistemic integrity" of science journalism is unjustified, and journalists need to be more aware of the intricacies of science research and its institutions (p. 2). Furthermore, Figdor calls on journalists and scientists to be more aware of questionable research practices, and highlights the prominence of questionable research practices in peer-review journals, despite the fact that journalists "objectively" report on the study's findings. In this vein, Figdor questions if journalistic objectivity might be considered a type of "questionable practice" in and of itself. (p. 4). Most critically, Figdor points to the fact that the institutional norms of journalism and science invariably impact how this interdisciplinary epistemic community functions, stating:

> Each group is highly motivated by practical pressures: the scientific equivalent of "What does this mean for the everyday person?" is "What does this mean for a follow-up study and another grant?" Each group individually can undermine the reliability of science news by engaging in profession-specific QRPs. They need to work together to ensure an epistemically virtuous product (p. 4).

Figdor proposes that scientists and journalists should engage in consensus conferences, a practice that brings experts together on a specific topic to assess evidence, look at current research gaps, and create recommendations for public policy. In Figdor's vision, adding science journalists and science communication experts from various media could contribute to these conferences, reviewing stories related to topics being explored, and creating best practices guides for reporting on these topics (p. 5). Indeed, this would require a cultural shift that includes journalists dissolving the boundaries between scientists' research and the stories they write, and scientists increasing their overall trust of journalists (p. 5). And, while much of science journalism and science communication research focuses on improving the communication skills of scientists, Figdor argues that improving the numeracy of a journalists' skills is key to improving collaboration and outcomes, stating that "journalists [need] to be functionally bilingual between 'Sciencese' and 'Publicese'" (p. 6), allowing them to share responsibilities of scientific validity in a deeper way, wherein journalists are capable at investigating the validity of methods and results inasmuch as they can write a compelling headline.

Thinking about scientists and journalists as actors within a shared epistemic community is both meaningful conceptually and highly practical in a post-coronavirus context. While Dunwoody illuminates how uncertainty can put all forms of science news at risk, Shäfer looks at

how the lived realities of both scientists and journalists converge to create unique challenges: a science journalist inundated by the pressures of time, objectivity, accuracy and readability, and scientists are challenged by the need to complete meaningful research discoveries quickly and accurately. In the scenarios presented by Dunwoody and Schäfer, the impact of poor science journalism and an inability to communicate uncertainty effectively is proven by the outcome of the coronavirus pandemic: the urgency to learn how to create an "epistemically virtuous" science news product is evidenced by the rapid proliferation of scientific misinformation, leading to poor health outcomes for communities globally. With this in mind, while the suggestions put forth by Figdor may be the most theoretically complex and require the highest degree of both institutional and cultural shifts, perhaps the pandemic proved that shared responsibility for scientists and journalists via the formation of epistemic communities is the best path forward. In this vein, both professions can rely on the shared normative behaviors that were underscored during the pandemic: rapid adaptability to change and challenges and deep collaboration (Quant & Wahl-Jorgensen, 2021; Gao et al., 2021). Crucially, this research builds on these arguments by showcasing how the scientists of tomorrow consider the science journalism space, suggesting how these viewpoints make these solutions either viable or unlikely.

Chapter 3: Methods

This chapter will outline the study approach and describe in detail how the constructivist worldview was used to inspire the design of the research. Further, I will highlight how qualitative analysis was the optimal approach considering the subject, and how semi-structured interviews were used to underscore key themes and important perspectives on science journalism from the graduate-level science students. Semi-structured interviews have noteworthy drawbacks which will also be discussed, alongside how thematic analysis was used to examine the data.

Constructivism & Qualitative Analysis: Complementary Frameworks for Research

As suggested by Creswell (2014), determining a worldview of a study is an important initial step as it lays the foundation of the research design and helps the researcher create more informed decisions. In this context, worldviews are considered a "basic set of beliefs that guide action" (p. 6). In his book, Creswell outlines four distinctive worldviews: postpositivism, constructivism, transformative, and pragmatism. The constructivist worldview is the most well-suited to lay the foundation of this study. Drawing on the work of The Social Construction of Reality (1967) and Naturalistic Inquiry (1985), among others, Creswell suggests that social constructivists "believe that individuals seek understanding of the world in which they live and work. Individuals develop subjective meanings of their experiences—meanings directed towards certain objects of things" (p. 8). He goes on to say that meanings are "varied and multiple", urging researchers to uncover the multiplicity and complexities of meanings within qualitative research. This concept is well aligned with the purpose of this study. Creswell notes that this worldview is primarily concerned with the processes of interaction among individuals, and through "social and historical norms that operate in individuals' lives." Most importantly, this worldview positions the researcher as an interpreter of meanings that others have about the world

(p. 8). Further, it should be noted that elements of the pragmatist worldview have useful applications for this study, namely the focus on practicality, wherein there is "concern with applications—what works—and solutions to problems" (p. 10). As this study aims to elicit new perspectives on how to understand how viewpoints are formed, a desired outcome of the research is to recommend practical approaches to improving relationships, pedagogy, and ways of framing the science-journalist relationship.

The elements of constructivism as a worldview in research is also discussed by Crotty (1998), who highlights the connection between constructivism and qualitative research. Citing Crotty, Creswell highlights three pillars that connect with constructivism and the process of making meaning: 1) Humans construct meaning as they interact with the world around them, and researchers "tend to use open-ended questions so participants can share their views" (p. 9); 2) "Humans engage with their world and make sense of it based on their historical context and social perspectives" (p. 9), which guides the researcher toward understanding the context of the research participants, through interpretation influenced by the researchers' "own experiences and backgrounds; 3) Generating meaning is a social process fueled by the interaction within human communities. In short, Crotty illustrates that, within the framework of constructivism, qualitative research allows for the symbiotic process of creating meaning through human interactions.

While constructivism is a useful foundation for understanding one's world, this way of thinking is enriched by the key elements of qualitative research analysis. In *Doing Media Research* (1996), Susanna Hornig Priest maps prominent methods for undertaking analysis in media and journalism studies. Complementing the work of Creswell, Hornig notes that qualitative analysis "encourages a more holistic approach, recognizing the interconnectedness of many aspects of social and cultural life" (163). More specifically, she emphasizes how

qualitative research in media studies is closely aligned with a researcher's interest on broad social influences rather than specific individual experiences (p. 163). As this project is concerned with investigating the complex factors contributing to levels of trust that influence opinions on science journalism, undertaking a qualitative analysis that allows for uncovering common themes from groups of individuals is a useful approach to employ.

Semi-structured interviews were chosen as the methodology for this research. In *InterViews* (2009) Steinvar and Kvale provide an in-depth overview of interviewing as a methodology for qualitative research. Steinvar and Kvale provide useful definitions and guidance for undertaking a successful interview study. They define interviewing as "an active process where interviewer and interviewee through their relationship produce knowledge", while "interview knowledge is produced in a conversational relation; it is contextual, linguistic, narrative, and pragmatic" (p. 15). Furthermore, the authors suggest that interviewing is a process of "knowing through conversations", wherein the "interviewer and interviewee are co-constructors of knowledge." This framework for thinking about interviews as an approach for qualitative research significantly influenced the decision-making process in the design of this research. Steinvar and Kvale's principles of interviewing are in harmony with the benefits of qualitative research and the constructivist worldview, as each concept focuses on knowledge sharing between humans to interpret meaning and elucidate new ideas through interactions.

Semi-Structured Interviews: Approach and Key Challenges

The selection of semi-structured interviews versus close-ended interviews was key to ensuring themes and ideas could easily flow from the interviewee and the interviewer. During my time as a research assistant for the iSCOPE project, I had the opportunity to pilot a few of the questions from this study to graduate science students while at UnB in 2017. Although informal

in its nature, piloting questions allowed for a degree of experimentation with semi-structured interviewing as a technique, and led to a more in-depth understanding of the type of dialogue that can emerge from open-ended questions. The experiment illustrated the importance of allowing thoughts and ideas to meander, a key benefit of the semi-structured interview (Adams 2015).

Upon submission of a thesis proposal, key research questions and topics for the study were refined. All interview subjects received access to the interview questions prior to the discussion to minimize fear and uncertainty around the key topics we would address, although interviewees were briefed that they did not have to prepare, and the discussion would be open and fluid. This was a strategic decision that was made in order to ease hesitation on the topic which will be explained in more detail on pages 43-44.

In recruiting interviewees, I relied on a network of individuals at both UnB and Concordia University. My thesis poster (Appendix A) was distributed on a number of email faculty lists at both universities. This group was selected at each corresponding university due to involvement in the iSCOPE project, as aforementioned: Concordia was selected for its convenience in Montreal and my connection as a student at the university, while UnB was selected due to the ability to access graduate-level science students as a result of my research activities there. Use of the snowball technique to recruit interviewees was also intended at the outset of the study, which was successful in recruiting two participants total (Priest 1996). Notably, the most successful recruiting technique at both universities was enlisting the help of professors to spread the word with specific classes. I provided text to be distributed via email that briefly described the topic, emphasizing that no experience in science journalism was required to participate. In keeping with the practical advice on semi-structured interviews recommended by Adams (2015), time requested for interviewing was critical: proposing a long

period of time could seem too daunting for participants, while an unrealistically short interview time could risk the quality and depth of the conversations. As such, a 30 minute time proposal was laid out to ensure potential interviewees felt this could easily fit into their schedules.

My original goal was to have seven students from each university, for a total of 14 interviewees. However, six interviews from each institution were ultimately completed as patterns began to emerge in the data. Interviews took place from January 2020 to May 2021. All interviews were done virtually via Zoom, Skype or Google Meet. As noted by Sah, Sah & Singh (2020) virtual interviewing for qualitative research increased dramatically during the pandemic, and is a good alternative for in-person interviews as interviewees tend to feel safe using these forums, and the convenience of scheduling interviews at any time is considered a benefit (p. 1104). Virtual interviewing was previously planned for all UnB students due geographical distance, while interviewing for Concordia University students was originally intended to be in-person on Concordia campus, but plans shifted to virtual due to social distancing required by the pandemic. In total, there were seven students enrolled in PhD programs and five in masters programs. The majority of all students were studying in biology-related programs, with two pursuing graduate studies in psychology. **Figure 1** provides an overview of the interview subjects.

Table 1: Interview Subjects by School, Program Specialization and Grade Level

UnB Students		
Student Alias*	**Specialization**	**Grade Level**
Con1	Biology	Masters
Con2	Biology	Masters
Con3	Biology	Masters

Con4	Psychology	Masters
Con5	Psychology	PhD
Con6	Biology	Masters

Concordia Students		
UnB1	Biology	PhD
UnB2	Biology	PhD
UnB3	Biology & Ecology	MA
UnB4	Biology	PhD
UnB5	Biology, Fisheries, Management	MA
UnB6	Biology	PhD

**All identifying characteristics for the students were removed to ensure students felt comfortable sharing stories and experiences with instructors, colleagues, and peers.*

Prior to interview sessions, an interview guide was created (see Appendix B) and followed for each interview. For most interviews, the order in which questions were asked was influenced by a confluence of factors, including: 1) the students' familiarization with science journalism; 2) their level of eagerness to explore a specific topic (some students began the conversation with a topic of interest in science journalism they wanted to speak to); 3) their previous experience speaking about their research and how it relates to broader contexts and subjects; for example, many of the PhD students were more likely to dive deeper into the influences and impacts of their research, and speak to professional or scholastic experiences dealing with various challenges in science communication.

As noted by Kvale and Brinkman, ensuring interview subjects feel comfortable is a key component that leads to a meaningful semi-structured interview (p 15). As such, interview

questions were provided 24 hours in advance to the interview. While this could impact the natural flow of the conversation, the intended benefit of this decision was two-fold: first, to ensure that interview subjects had a general sense of the topics we would cover to feel more at ease with the familiarity of the material. And secondly, related to ensuring maximum comfort, was to ensure students who speak English as a second or third language some time to prepare. All participants received a consent form (see Appendix C), and consented to an interview, as per Concordia Ethics Certificate SPF#: 30010180.

Constructivist Grounded Theory and Thematic Analysis

Upon completion of the interviews, interview data was transcribed, coded and analyzed. As noted by Hornig-Priest in *Doing Media Research*, qualitative research encourages a holistic approach by "recognizing the interconnectedness of many aspects of social and cultural life." Hornig Priest explains the creation of theory in this tradition of research as "bottom up" (inductive), wherein patterns emerging from the data allow researchers to showcase the complex interplay of the media, society, and social institutions (p. 163). Further, Hornig Priest discusses the notion of "sensitizing concepts", which are certain topics that can "lead the researcher to particular dimensions, even if they are not full-blown theories" (p. 163). In this research, some of the sensitizing concepts were: a) confidence in one's ability to produce science journalism; b) negative viewpoints on the media and one's perception of science journalism; c) pedagogical influences and the foundation of one's opinion on the media.

Complementary to Hornig's inductive approach to media research is Strauss and Corbin's Grounded Theory (1967). Strauss and Corbin developed grounded theory as a new approach to social sciences research that allowed qualitative research methods to contribute more meaningfully to the production of "truths" about the world (Tie, Birks & Francis, 2019).

Grounded theory involves the assigning of data to "a few tentative categories and then continually adding new data, asking at each stage whether the new data reasonably seems to fit in" or if a new category needs to be either revised or constructed (Horing Priest, p. 170). Per Tie, Birks and Francis (2019), there are three different forms of grounded theory that can be employed by a researcher: traditional, evolved and constructivist. The constructivist form was the most useful for this study. As signified by the naming, constructivist grounded theory has underpinnings in the constructivism worldview and examines how participants in a study create meaning in which the researcher co-creates with them (Tie, Birks & Francis, p. 2).

Charmaz (2006) describes coding in grounded theory as the "bones" of the analysis (p. 48). The initial interview codes were as follows: 1) barriers of science education when it comes to the media; 2) trust in the news; 3) perspectives and opinions on the news; 4) opinions on training. These codes were used to evaluate the interview transcripts and annotate the text based on initial themes. Following this step, the interview research questions were added to an analysis spreadsheet, and the sentiment of each answer was identified on a spectrum of "always, sometimes, never, and often", or other relevant scales such as "yes, no, uncertain, maybe" beside each interviewees name to elucidate the common trends associated with each question, further solidifying common themes in the original data analysis or helping to elicit new ones. Following this step, key quotes from each participant for each of the six guiding questions were added to the analysis spreadsheet alongside the questions and associated sentiments or answers from each interviewee. From there, data was analyzed again by leveraging thematic analysis, through the process of combining and contrasting codes, generating what Chapman, Hadfield and Chapman (2015) call a "network of associations" (p. 203). The process to develop themes presented in the next chapter followed the steps recommended by Guest et. al (2014), including the organization

of transcripts, followed by identification of possible themes, review and analysis of the themes, and the construction of a theoretical representation to understand the data. Upon initial drafting of themes, data was reevaluated to ensure accuracy and relevancy. From there, all themes were reviewed, discussed and challenged with my thesis supervisor to arrive at the reported results in Chapter 4.

Chapter 4: Research Findings
The Four T's of Science Journalism

Each of the students who were interviewed as part of this thesis were generous with their time, sharing their experiences and unique anecdotes that represent their realities as graduate students in the sciences. Notably, the majority of students at University of Bergen in Norway were interviewed prior to the outset of the COVID-19 pandemic, whereas the majority of the students interviewed from Concordia were interviewed at least one or two months into pandemic realities. Indeed, some of the data captured through the interviews references news coverage about vaccines and vaccine safety in relation to COVID-19, as well as pandemic coverage in general, but the majority of data captured more broadly references viewpoints on science journalism at large and the students' individual areas of research and interest.

This chapter illuminates the perspectives of science students that range from hopeful, motivated and inspired to distrusting, uncertain and apathetic. The wide range of experiences shared illustrate how an individual's context, including program specialization, cultural background, language, and overarching experiences as a student coalesce, invariably influencing their views on science journalism. Added layers of complexity emerge when it is evident that an individual students' view can oscillate from eager to contribute to science journalism to demotivated from lack of time and resources. At the same time, the patterns that emerged from the interviews illustrate that, regardless of the deeply varying contextual factors that impact each individuals' perspective, there are salient themes that can provide a meaningful contribution to science journalism research. Four key themes will be explored in this chapter, presented as The Four T's of Science Journalism: training, trust, tensions and teaching. Figures 2 to 6 give an overview of results from key questions asked in each interview.

Figure 1: Overview of interviewee sentiment, question 1:

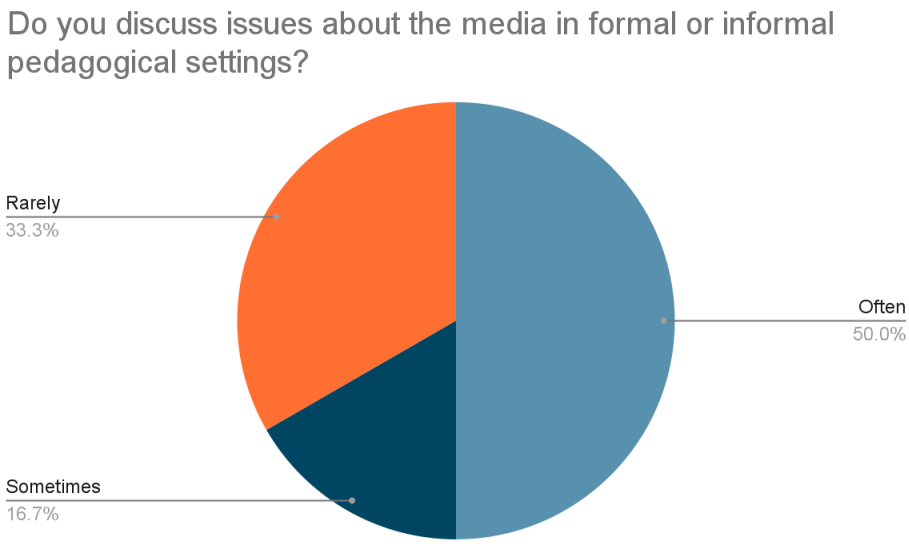


Figure 2: Overview of interviewee sentiment, question 2:

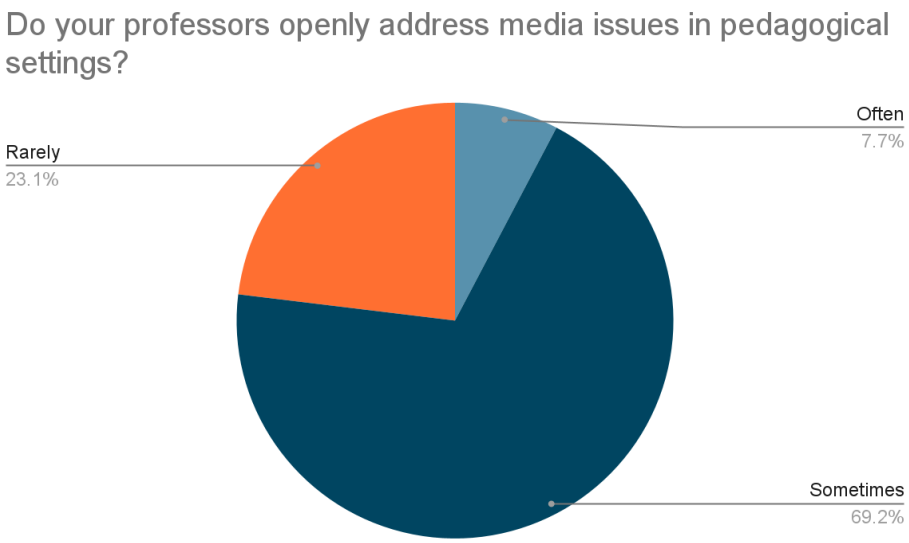


Figure 3: Overview of interviewee responses, question 3:

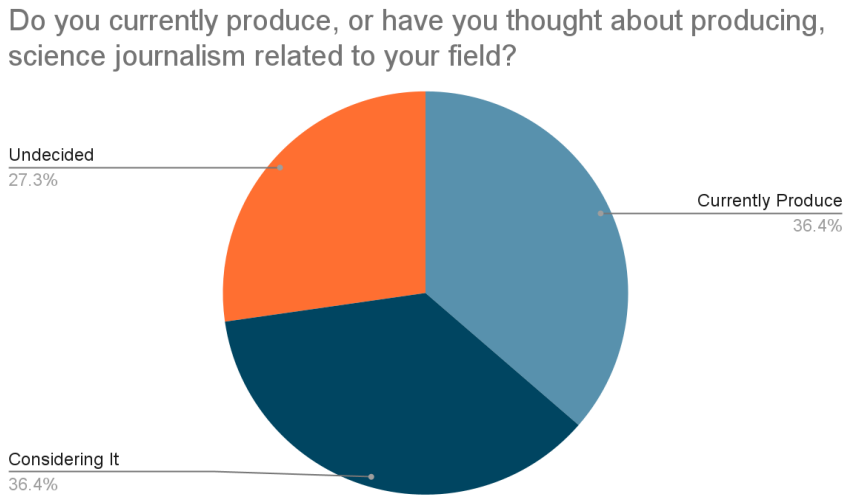


Figure 4: Overview of interviewee responses, question 4:

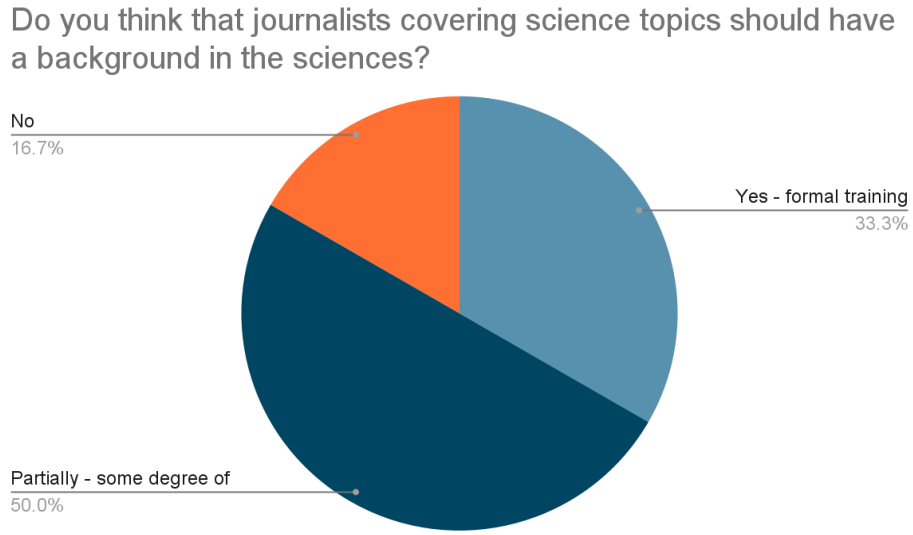
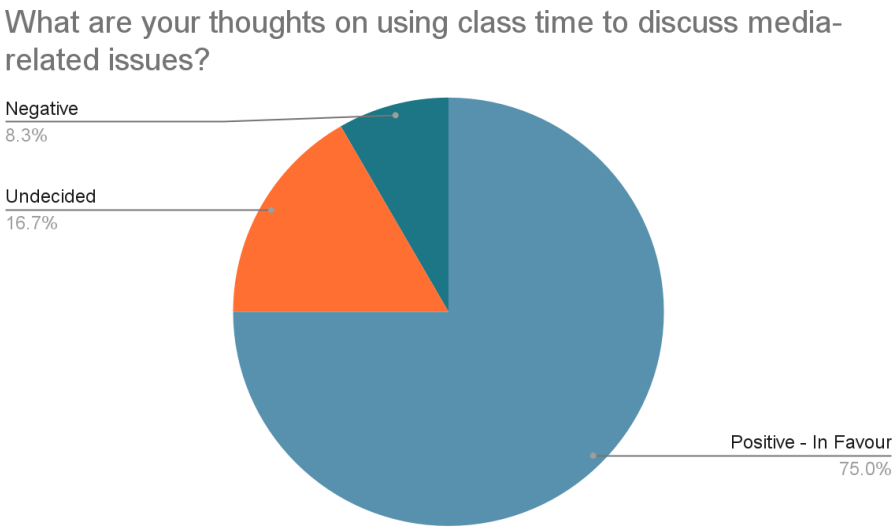


Figure 5: Overview of interviewee responses, question 5:



Theme 1—Training: The Why and How Behind Scientific Training for Journalists Reporting on Science

Each one of the students was asked, "do you think journalists who cover science should have a background in the sciences?" to elicit thoughts and ideas around the level of experience and understanding science journalists should have when reporting on scientific topics (see figure 5, page 49). This question in particular unearthed a myriad of responses, especially as many interviewees interpreted the word "background" differently, which was an intentional phrasing of the question to ensure students could speak to their own perspectives on training, whether formal or informal. Generally, however, 10 of the 12 interviewees believed there should be at least some level of scientific training for journalists.

A handful of the responses could be categorized as a straightforward "yes", wherein students expressed that journalists should be equipped with degrees in the sciences, but the majority of students spoke more generally to the importance of honing skills and characteristics fostered in science programs rather than formalized training on scientific topics. UnB4 expressed

that knowledge of scientific principles was key, speaking to the critical need and skill to effectively report on research in the news:

> Yes, they should have a scientific background…but it doesn't necessarily need to be in the discipline they are reporting on. A lot of newspapers I read for [fun] are stories like 'chocolate causes cancer'...I find a link to the paper based on the authors, and find out: it was a chemical compound tested on mice.

UnB4 concludes by suggesting that journalists adopt a more measured understanding of science's nuances, stating: "They should know that science does not deal in absolutes… it's ifs, ands, buts, whens… some journalists just breeze right over that, and don't give the authors a chance to describe their message." On the flip side, UnB5 described how journalists and scientists' skills can be complementary, referring to journalists and scientists' unique strengths:

> I think that journalists with a good understanding and a good ability to listen… can be just as good as a scientist - because the scientist alone is not good at explaining outside of his box… that's something that a lot of professors even fall into with their pedagogy.

This sentiment was shared by Con5, who suggested that formalized science education is "unnecessary", while also emphasizing journalists' professional duties:

> It's up to the journalist to keep everyone accountable. If they are going to interview people in the fitness industry to distribute more information, [they should] make sure that the information has merit, and it doesn't contribute to the diluted and watered-down information that could be hurting people.

Here, Con5 speaks more explicitly to the risks inherent in sharing scientific information via the media about topics and studies that may not be credible or showcase critical facts about health, similar to UnB4's suggestion that journalists should be aware that science does not deal in absolutes.

Interestingly, Con4 mentioned the importance of journalists understanding the scientific process to be able to adequately investigate scientific papers as part of the reporting process. They said:

> I do think that journalists need to have some kind of streamlined training that could help them read scientific articles to know what to look for. For me, with a scientific background, it took certain courses, certain mentors, and certain supervisors and professors coaching you on how to pick apart a study to see if it holds.

This sentiment is complemented by Con1, who did not believe specialized training in science was necessary, but instead emphasized the importance of critical thinking abilities and awareness of bias as a means to effectively analyze scientific information. They note:

> I don't think that journalists have to be a scientist, but they have to be a critical thinker… in a scientific way… people need to be aware of their bias. If you can analyze both sides, that in and of itself is an advantage. If you can say, 'this could also be a possibility', that is a scientific skill, but you don't need a science background to do that. You don't need the grueling school of biology for that.

While both Con1 and Con4 spoke of needing critical thinking and analysis-focused skills, another student at UnB thought that it was imperative for journalists to understand the institution

of academia at large, which is closely connected to Con4's call for journalists to have an ability to "pick apart" a study: "They should know how academia works...how they acquire this knowledge could be through any means" (UnB 3).

The above data highlights an interesting perspective on "background" that might not necessitate specific science degrees, professional experience or formal science journalism training, but instead, a toolbox to help journalists understand the sciences at large through effectively reading papers and having a broad understanding of the workings of academia, while also having "critical thinking" aptitude. "Critical thinking" as a core characteristic for anyone producing or reading science journalism is one of the consistent themes throughout each of the following sections, linking issues of trust and the legacy of science-media tensions, whether real or perceived, that influence students' eagerness to participate in the production and consumption of science journalism. Moreover, a number of students showed an awareness and a sense of empathy for the lived realities of journalism and their own professional expectations, while others used examples of what they considered to be bad journalism to add weight to their responses. Overall, analyzing the students' perspectives on formal training for journalists is a valuable springboard for imagining new ideas for further research on this topic, which is explored in more detail on pages 84-86.

Theme 2—Trust: Factors Contributing to Science Students' Trust in the Media Influenced by Science Pedagogy

Critical to this study was also understanding the media consumption habits of the science students interviewed in order to elicit meaningful discussions about their personal viewpoints of the media, with the intent of revealing general insights around trust and credibility. Understanding these consumption habits was paired with an investigation of how these viewpoints might be nurtured or challenged in formal classroom settings. The interview data

elicited from the research questions “where do you go for news?” and “do you discuss issues of the media in formal and informal pedagogical settings?” builds further on the key findings explored in the previous section, namely because many students seem to bind the skills and characteristics learned and highly valued in the sciences—such as strong analysis of research practices and the ability to think critically—with their perspectives on science journalism and the news at large.

While the interviewees were almost equally divided for either “often” or “never” discussing science journalism in their classrooms, some who responded “often” talked about examining a hyper-critical lens of the news, suggesting that reading or watching news requires sophisticated critical thinking skills. Two students at Concordia spoke to validating news sources: “As a researcher, I am constantly trying to dig deeper, asking ‘how do I know this [information] is OK? And I also ask, ‘what do I have [access to] to validate this information?” (Con5). Con3 took a similar approach, noting, “Many different outlets have different funding sources, so they are very biased. Since they are all biased, I try to take raw data and analyze it myself.” The notion that news outlets have an indoctrinated point of view was also shared by UnB5, who referred to outlets as “parallel universes”: “I read the newspapers of several different countries. I have several nationalities, and [Norway] is the fifth country I’ve lived in, so it’s like a parallel world.” Differentiating international and local sources was also mentioned by Con6:

> If the news is about Pakistan, I try to take a look at the sources... some are biased towards one particular party. But I try to go through it on the international channel versus BBC or CNN. And I fact check from multiple sources to make sure that what I'm looking at is more than one side of the story.

Students were not only concerned with critically assessing global news from mass media sources, several also spoke to how they assess science journalism. UnB4 had specific viewpoints on *The Guardian's* science reporting, for example:

> The Guardian is very heavy on climate change, it's very evidence-led journalism there…it's trustworthy. If it comes to conservation, I think it's biased, the conserving of animals is a bit too fundamental... but [for] general climate change, and environmental [journalism], it is good.

Another student from UnB spoke to how they weighed trust for science journalism sources:

> I weigh trust differently [for news sources] based on what they are reporting…if it was science, I would probably read it, see who wrote it, and then I would weigh it. It depends on how it's written. It's difficult to write popular science in a way that's scientifically interesting and easy to read (UnB3).

While UnB3 and UnB4 emphasize perceived shortcomings in science journalism, Con4 referenced agenda setting in science journalism: "The line between [articles] that are very agenda strong and news sources that straddle the line between opinion pieces and reporting is very small." And, interestingly, while students may not always have dedicated class time to discuss science journalism within their courses or curriculum, some say topics around the media emerge regardless. As UnB5 puts it: "Yes, [we] often [discuss the media]. [Professors] usually say: 'the media is not properly informing folks' and they basically tell us that they have to sell a story and that's their job… it doesn't matter what the truth can be, as long as they can sell the story."

Students also spoke to the fact that professors bring various media formats to classrooms to critically analyze stories:

> We discussed issues of the media in our classroom, such as body shaming and body issues. My professor would show us some article clippings… and we would read articles that would say things like, 'you can lose weight like this in 10 days'…it was stuff that was clearly not true, but it was trying to bend the facts (Con6).

Criticizing the misuse of scientific facts in the media may sometimes manifest as formal learning exercises, mentioned by both Con5 and Con4. Con4 remembers one specific assignment: "In a course, research methods and design, we had an assignment where we had to pick out an article, and then go to the source study, and we had to critique an article about what the journalist reported properly, what they didn't report properly, how it could have been better."

Indeed, the individuals who are more likely to participate in a study of this nature may also be more likely to have strong viewpoints when it comes to trusting the media. However, it should be noted that several interviewees did not have hard stances on mistrust in the media or absolute trust in the media, and some even shared an apathetic stance towards news consumption in general: "if the news is directly related to me personally, I'll read it. If not, I don't really pay attention to it" (UnB6). In light of the pandemic, Con5 also spoke to limiting news time: "I have taken a huge step back [from the news]... When [the pandemic] first started, I thought, 'Oh, I need to watch Trump's briefing! But I could only stand two minutes of it."

Trust and the media is a complex topic, and students shared a multitude of perspectives on how they consume news and their experiences in the classroom discussing news. A compelling feature of this data was students' diligent and proactive investigation of news stories to determine trustworthiness of news pieces. This process of weighing facts to glean the best possible answer could be characterized as a "scientific" way of consuming news, wherein

exercising critical thinking skills influences consumption habits, a topic that is increasingly complex as scientific misinformation continues to have a foothold on publics across the globe thanks to social media. And yet, not all students shared an appetite for critically engaging with news stories or sources on their own time, with some citing pandemic news fatigue (Con6), or a simple lack of interest in topics outside of their specialization (UnB6). And one student spoke to a more passive observation of news on a social timeline: "Like a typical millennial, I read what other people are sharing on social media" (Con1). Examined more holistically, the data suggests there are two layers of science pedagogy at play, which could influence a students' trust in the media: first, how the media is characterized by their professors either through assignments or during classroom discussions, and second, how the normalized practices of analyzing data and ensuring validity, deeply ingrained into science training, are applied either consciously or unconsciously to examining news sources.

Theme 3—Tensions: Appetites and Barriers for Producing Science Journalism

As demonstrated in the trust section, many of the students interviewed hold a specific lens to the media, applying learnings from science programs to their consumption and perspectives on the news. These perspectives did not negatively impact the majority of students' appetite to produce science journalism. In fact, 8/12 students interviewed said they currently produce, or would consider producing, science journalism related to their field. An awareness of journalism as a powerful tool to garner visibility for certain topics and issues in science, influence policy, educate public audiences, and dispel widely held scientific myths were all motivations expressed by the students in the interviews. Here's how UnB1 described their desire to participate in science journalism:

> I feel strongly that we should write about how the fish stocks are doing, because I always get met by people who say, 'oh those fishermen, they are always fishing too much!' and I think that is a really old school thought. I really feel that I should write about that, so that people can learn that it's actually quite different.

UnB1 noted that they have created a few blogs on the topic thus far, although they are not focused on writing at the moment. While UnB1 showed passion for their field of study, Con1 was more interested in creating science journalism around important popular science topics, such as vaccines:

> [I wouldn't produce] about my topic, but I have definitely had moments thinking: there should be more easily accessible information for people who aren't trained in analyzing information…such as: vaccines. Like, what's in a vaccine?...I could totally understand a mom saying, 'I don't know what this is… I'm not just going to go with the norm.' But at the same time, what's the next step? How do we get them to understand? So, I've thought about it. But have I gone further than that? No.

Interestingly, Con1 referred to non-science trained publics as "people who aren't trained in analyzing information", which connects to the data shared in the *trust* section, again highlighting the connection science students make with media consumption and critical thinking skills normalized in science communities. Con3 builds on this concept further:

> I [have] never produced any kind of journalism. But I've been thinking about it. I've noticed there is a disparity between what's in the [news story] versus what's in the published article and the data. There is

> misjudgement of a lot of the experimental methods and procedures. I was thinking about writing articles about filtering this difference… I could act as a scientist judging the knowledge.

Two fellow students at Concordia spoke about their current science journalism projects. Con6, a PhD in exercise science, uses social media to share insights about her specialization: "I have an online business that shares information on [exercise science]. I have created a couple videos so far and I have a series about injury prevention." Con2 also uses social media platforms such as Instagram and Facebook to share news about her specialization with her community, while Con4 sees a professional career in science journalism:

> Yes, [science journalism] is one of my potential career directions. In my undergrad, I was really frustrated with this lack of accessible information… it's almost as if [because] scientists are trained on an objective way of producing information, and writing for publishing scientific articles, that we lose touch with our more creative side. And it becomes more difficult for us to explain things simply and in Layman terms.

One of the most interesting aspects of Con4's view is their emphasis on available training for scientists to be able to explain their work in "simple" terms. Confidence in the ability to produce effective science journalism was a barrier expressed by UnB3 as well. When asked why they don't produce science journalism, even if they'd like to try it, UnB3 they responded: "I don't know what to publish, and I don't know where to publish it... and I don't know how to write it in a way that makes it interesting to the public. How to write is the biggest issue." UnB4 also

showed hesitation when it came to publishing: “It's extremely important for me to publish something [on my topic] in the mainstream media, but it has to be done right.”

Another common barrier to science journalism production was more practical: the constraints of being a graduate student. UnB1 stated: “It’s a time constraint. It is hard doing both a PhD and doing other writing on the side. The PhD is already so heavily computer and writing based...when you finish the day, sitting down and writing other things is really hard.” Diverting focus away from primary studies was also expressed by UnB6: “I've thought about it...sort of as a side job...but it's not really where my interest lies. Seeking out opportunities takes more effort than I'm willing to put in.”

The above data suggest there are two distinct levels of tension at play that impact a science students’ willingness to produce science journalism: at the individual level, students are constrained by time and limited training in writing and communication skills for public audiences. In a broader sense, some students also conveyed a lack of confidence in what to publish and where to publish it. While tensions at the individual level might be solved through practical pedagogical approaches such as dedicated science journalism or science media courses, and courses to produce science journalism embedded within graduate programs, the tensions surrounding confidence are more complex. As addressed in the “trust” section, many students cast a critical lens of the media, whether encouraged explicitly in classroom settings or less directly by applying scientific approaches to consuming news. This degree of rigor could add pressure for students, who might fear being critiqued or judged by their peers who consume news stories in a similar way they do, which may be an additional barrier for students’ who have an appetite to produce science journalism, but choose not to.

Theme 4—Teaching: How Science Pedagogy Structures Create Opportunities and Challenges for Journalism and Media Training

A compelling feature arising from this data is the fact that there is a desire among many students to produce science journalism, but the journey from the research lab to the newsroom is paved with complexities. Most graduate-level science programs do not offer journalism training or courses as part of their programs, and yet it is partially woven into classroom learning in various ways, as discussed in the *Trust* section. Adding to this, many students spoke to the informal interactions they have with their peers about science in the media and the news at large, while 10/12 strongly believed in the benefits of using class time to speak about the media and its issues.

The way that some students use time to address the media informally with their peers varied. Con4 reported frequent conversations, noting:

> In lab meetings, every time we meet, we are talking about the latest things that are being reported… Especially with my peers who are studying [the effects of cannabis]... we go back into articles and track the source of the story. We want to know: 'did the journalist report what the study found?'... even in major news outlets, there is a lot of sensationalizing the results.'

This sentiment is mirrored by UnB2, who stated that "during off hours or lunch breaks, we would talk about…things that we saw published that we knew to be wrong." UnB3 also speaks to a less formalized but frequent integration of media topics into everyday life as a student:

> We discuss, on a daily basis, the kind of news that is going on. We get the national industry newspaper [on fisheries], that always has something to discuss and go deeper on. Someone has always done research attached to it. And then, when something big in the [mass] media comes up, it's

> discussed really casually. For example...'I don't think that's the case, they didn't cover it very well, things like that.'

Interestingly, these anecdotes connect to the fact that students are reinforcing their critiques of news and how science is presented in the media in informal pedagogical settings, such as the lab. This suggests a shared interest in how the media covers the news beyond the classroom and their specific topic, which is further supported by the fact that almost all interviewees agreed discussions around media should be integrated into formal educational settings. Students delivered strong stances on its benefits. As Con3 stated: "I think it's extremely important. No matter how much we criticize it… the only way we get scientific events to the public is through journalism. New scientists and the people in the classroom really need to understand this process." Similarly, Con4 noted:

> It's absolutely necessary. It goes beyond science, relevant to a lot of different fields…it's useful because it can help put things into perspective: 'how should you communicate your findings? How should you collaborate with journalists to communicate your findings?' It also provides you with the tools to use critical thinking.

Some students offered practical solutions for implementing learning about journalism in their programs. Con1 noted, "Keeping time open to say 'if you saw anything [in the media] you want to discuss', would be cool. It could be more of a conversation." However, some students were also mindful of limitations of doing so in a specific setting, stating: "Teachers have their own inherent biases, as does the media, so you're always getting the information on a slant." UnB2 discussed the possibility of integrating science journalism learning into coursework, while also recognizing the limitations of time: "It would be beneficial to at least instruct various levels of

students on the importance of science communication and give them examples of science communication…this could be an entire 5 credit course, but then the question is: what are we then choosing not to do instead?" Another UnB student spoke to practical skill development for bringing their work to the public:

> It would be extremely helpful to learn how to frame your work to public audiences. I never knew that scientists did press releases until I worked [in the field]. And there's a skill in writing press releases, because you're not writing a scientific abstract. And learning how to deal with the press in interviews, too (UnB 4).

While UnB4 and UnB2 offered suggestions from a science training and science profession point of view, UnB6 spoke about the realistic limitations that professors in the sciences confront:

> On one hand, I think it's important that you [teach] that, but on the other hand, since professors are trained on a specific path…it would be difficult for them to feel confident in critically assessing these other sources. In my mind, it would be more beneficial if the professor would invite journalists from other departments who have more experience in these specializations.

Furthermore, when UnB6 reflected on the challenges of science communication working in more professional settings as a PhD student, observing challenges that could be mitigated with more proactive teaching:

> You see the struggle of working with people who are trying to emphasize your work that is filled with uncertainty, and [lack of] clarity, but then people are sort of forcing you to give an answer... it's really hard to

> communicate [uncertainty] in a way that doesn't invalidate your own work and your own science.

The above data highlights shared passions and interests for learning about science journalism and science communication in the media. Interestingly, many students conflated more practical "communication" skills with learning about the media. Interesting to note, in particular, is how students leverage lab environments and informal social settings to engage in various levels of discourse about news and the media. This is tightly interwoven with findings in the "trust" section, which illustrates the deep connection with scientific principles and the consumption of news, a behavior that might be normalized and reinforced in informal settings with other scientists. Furthermore, while students shared actionable ways to integrate science journalism in educational settings, the practical limitations in doing so were recognized by some: the time allotted in a classroom and the limited knowledge or biases of instructors among them. Indeed, these limitations mirror the two key barriers to producing science journalism at the individual level, as outlined in the "tensions" section.

The Four T's of Science Journalism: Summary of Key Findings

When the core themes emerged from the data above, the connections between trust, training and tensions became clear. While students shared complex feelings about trusting the media through describing their own news consumption habits, they also shared an awareness that the media and science journalism at large are a fixture in the life of a scientist: whether viewed as a tool to generate publicity for an individual's work, or a point of concern for its portrayal of certain studies. At the same time, many interviewees were conscious of the fact that extensive training for journalists in the multiple scientific domains they may report on is an unrealistic expectation. The tensions that serve to either demotivate or motivate science students from

participating in media related-activities today or in the future, are storied: at an individual level, students may not feel adequately equipped in their own communication skills to participate in public communication activities. At the institutional level, the ways in which science and the media are woven into pedagogical settings, either formally or informally, should be investigated at a deeper level to understand how and if normalized behaviors in the sciences are impacting the the ways in which scientists are creating, or participating in the creation of, science journalism in any form. Indeed, a critical look at ideas around training, trust and tensions requires a thoughtful approach to teaching about science journalism for graduate students: one topic that almost every interviewee saw as a valuable addition to their programs.

Discussion

At the outset of this thesis project, my research goal was to answer two questions: Does a science student's trust in science journalism impact their willingness to participate in the media? And have students been encouraged or discouraged to interact with, or produce, media by their mentors or peers? A review of the literature required approaching previous versions of this question from multiple angles to capture a broad view on the historical tensions and unifications amongst scientists and journalism to garner a grasp on how these play out at individual and institutional levels. This process was complexified by the onset of the coronavirus pandemic, which brought to light both new ways of thinking about, and addressing, widely known challenges in the science journalism space, while also reaffirming the urgency by which the relationship between science and journalism should be addressed.

This discussion chapter will reflect on how the research questions intersect with the disparate, yet complementary bodies of literature on this topic, and highlight how some of the findings support or contradict previous research. I will also briefly cover the limitations and strengths of this study (see pages 82-84), and then revisit the four themes outlined in the previous chapter: trust, tensions, training and teaching to explain how these can serve as a springboard for future research (see pages 86-86).

Part 1: Introspections on RQ1: Does a Student's Trust in Science Journalism Impact Their Willingness to Participate in the Media?

Trust is a complex concept that is difficult to measure and assess with a single research question, requiring a combination of open-ended interview questions that encourage dialogue for interviewees to share personal perspectives on the media through previous experiences with science journalism production, nature of conversations they have with peers and professors around the media, and how they personally consume journalism. The multidimensional nature of

this research question sparked a cascading theme: the pervasive *tensions* that exist at the individual and institutional level between scientists and journalists which invariably influence feelings of trust and an appetite for science journalism production (see pages 53-57). Looking at issues of trust in combination with the complementary theme of tensions allows for a more holistic picture of students' potential barriers or motivations to participate in the media.

Are Legacy Trust Issues Seeping Through Student Coursework?

In terms of trust, the literature review presented perspectives that explore the credibility of the media—and science journalists more specifically—through the lens of scientists (Dunwoody 2014; Larsson 2019; Dijkstra 2014; Soldovsky et al. 2017). Scientists' complaints of how the media sensationalizes scientific results to generate readership and visibility, and a pervasive sentiment that journalists may lack the ability to understand complex topics, was covered by Nelkin (1997). Nelkin's argument that journalists and the media at large has a legacy of placing science on a pedestal is one of the most interesting ironies when examining legacy trust issues: while scientists feel journalists misrepresented facts in the quest for an interesting story, journalists were simply intending to perform their professional duty by reporting on scientific information and discoveries.

But looking closer, Nelkin's views on science as an institution that benefits from blind celebration from the media would be reliant on fully embracing Lewenstein's "traditional" model of science communication, wherein scientists merely transmit facts and information to the public to be digested. Fast forward almost four decades later, the medialisation model of science communication, wherein a complex web of information is exchanged to produce and present and share information is much more fitting for a present-day context wherein people spend hours a day consuming content from countless sources (Weingart 2022). And yet, some of the anecdotes

shared by the students, when asked about the nature of the discussions in their classrooms, point to the potential lingering effects of a Nelkin-esque viewpoint: a framework where journalists aren't critically investigating the facts, and scientists are simply trying to get information across to audiences, but are failed by the process. For example, when students talked about using class time to discuss issues of science journalism, a number referenced formal exercises that were challenging how science stories were represented in the media, and where journalists seemingly missed the mark on their presentation of the facts. This is evidenced by experiences shared by UnB5 and Con6 who both spoke about how professors used examples of journalism to showcase how the media "sells stories." In a similar vein, Con5 and Con4 referenced assignments wherein the goal was to critique the journalists' ability to report accurate facts. Indeed, a close companion to the idea of selling stories is "hype" in the media, a science communication challenge that has been explored by Intemann (2022), who critically examines the pros and cons of leveraging specific communication tactics for the public communication of science—some of which may be wrongly accused of overly relying on "hype"–to effectively reach layman audiences, thereby garnering much-needed attention. From this perspective, Intemann is proposing a more nuanced approach to defining "hype", wherein scientific accuracy is not sacrificed, yet a story still contains elements of excitement.

The limitations of this type of thinking about how science is portrayed in the media have also been noted by Allchin (2022), who argues that the approach to focus on critical thinking to bolster science trust through the media is not the right focus for classrooms in the age of misinformation. In his view, people do in fact trust science in general, but parallel worlds of truth and fact have emerged in today's media landscape, wherein people trust specific sources and individuals, sometimes leading to "trust[ing] the wrong voice for science" (p. 1476). From this

perspective, science classrooms must focus less on the content itself in the mainstream media, and instead, understand the complex web of information facing public audiences consisting of advertisements, politics, influences from family and friends, social media, to name a few, and understand better why people trust certain "science."

In the interviews, students did not explicitly speak about having conversations in pedagogical settings of how social media, journalism, and science coalesce in the complex process of medialisation, yet many showed an awareness that journalism is in and of itself a specialized skill, just like science. This level of awareness and knowledge for journalists having a complex job (see Amend & Secko 2012) was something I found surprising, and one that might possibly be explained by the fact that some of the students have either tried creating science journalism before, or are considering it at some point in the future. More specifically, this brought to light the fact that, while the nature of most of the conversations about media that took place in formal classroom settings were critiqued-based exercises intended to highlight the failures of journalism, students largely still see its value as a profession and understand the role it plays in society. The positive value that science journalism has in society in the lens of scientists, regardless of how opinions toward it are normalized in science communities globally, has been supported by A. Dijkstra (2015) and Larsson et al. (2019).

In light of this, perhaps there is an opportunity for media-related discussions and exercises in pedagogical settings to go beyond analyzing and dissecting misrepresentations of science in the media to more productive dialogue that creates an opportunity to learn about the complex histories of science journalism, the crisis of professionalization within the science journalism space, and the challenges and opportunities that come with the medialisation of science at large, the crisis and challenges of trust in the media, to name a few (Allchin 2022).

Framed as a question, I am curious to know: how can instructors of graduate-level science courses capitalize on students' interest and awareness of the power of the media with more meaningful, evolved learning experiences? A version of this question has already been asked about science faculty members by Koswatta et. al (2022), who suggested that nurturing the "intrinsic" motivation to share information about one's work is a reliable predictor for increased science communication activities. Examining this at the graduate level more closely could be an interesting future direction for research which will be discussed in more detail on page 86.

Where Does Distrust Lie: Science Journalists or Media Institutions at Large?

A lack of trust toward science journalists specifically, or journalists reporting on science, did not emerge as firmly in the data as I expected. On the other hand, words that connect more closely with trust or a lack thereof came to light when students talked about their own media consumption habits: "agenda strong" and "biased" were used to describe the media in general (Con5, UnB4). UnB5 even described different media outlets as "parallel universes." This question was perhaps one of the most revealing, as it led to students describing their news habits, wherein some described their critical analysis of news stories and sources which included, but were not limited to, weighing sources differently and undergoing personal fact-checking exercises to examine the source material that is being reported on (UnB3, Con5). In spite of these viewpoints, the overall willingness to produce science journalism either today or in the future did not seem to suffer. Furthermore, students spoke about certain publications they referenced for science news stories, such as UnB4's preference for *The Guardian.* As such, although students may not view media or news sources in a generally positive light, they still see the role of science journalism as an integral one.

A degree of discontent with the media paired with a strong willingness to participate regardless is a dichotomy supported by Larsson et. al.'s 2019 study on medical professionals engagement with journalists. Furthermore, Dunwoody (2004) and Baron (2010) both suggested that scientists' interactions with the media is a core skill that should be nurtured and developed, as it can advance their body of research through driving awareness, influence funding, and more, which may be key to the graduate students' motivations as well. However, Larsson's study also revealed one of the opinions shared by scientists on the media's weaknesses was a feeling that there was an over-emphasis on specific topics such as discoveries in health. The latter point is at odds with some of the comments shared by some of the students, who spoke about a desire to participate in demystifying important, common topics that are more widely relevant to the public as they relate to public health, such as vaccine efficacy (Con1) or diet culture (Con6).

The conflicting nature of the interviewees opinions on the media, wherein a level of distrust is expressed and yet a real, measured understanding for its value is also communicated, is perhaps the most challenging tension point in the literature and this research to unpack. However, closely analyzing the data to glean additional insight into why students may distrust the media at large yet want to participate in public communication of science in spite of this viewpoint, the following possibilities arise:

1) Students may believe that institutions, generally, are rife with challenges*:* throughout the interviews, many students referenced challenges that exist within the sciences: such as professors having their own inherent biases (Con1), and graduate studies having time constraints that do not allow for communications training (UnB1, UnB2)
2) Students may understand that journalists, just like scientists, have specialized skills: when speaking about training, students referenced journalists as "specialized" in their skills

(Con1) and communicated the need for individual training for scientists to understand communications skills (UnB4)

3) Students may want to maximize the benefits of the media to increase the public understanding of science: Students referenced the need to use journalists as a vessel to get key information to public audiences, and journalists' storytelling skills need to be relied on for this (Con5, Con3)

Looking at the three possibilities above, the interplay of trust in the media and desire to participate in the public communication of science is a complex topic to investigate that requires multiple avenues of investigation. How this might be unpacked in future research is outlined on page 85.

Evaluative, Normative or Self-Efficacy Beliefs? Looking at Motivations and Hesitations More Closely

One of the strongest and most complex issues impacting the science-media relationship and its legacy of distrust is the fact that the working conditions and professional norms of scientists and journalists are not only different, but inherently at odds. This fracture was investigated by Carrie Figdor (2017), who suggests that professional demands from scientists and journalists prohibit the potential for meaningful collaboration: whereas scientists confront pressure of exactness and thoroughness, journalists must remain objective and work quickly. Figdor's suggestion is especially meaningful when viewed in combination with Besley et. al. (2021) who urge that science journalism and science communication scholars need to better understand the evaluative, normative, and self-efficacy beliefs influencing communication choices from scientists. Besley et. al. ask: even if scientists understand the importance of science

journalism, what might be holding them back from publicly communicating science, and why? In other words, how are limitations felt and understood by these groups?

Looking at the data presented in the previous chapter, these types of beliefs were woven throughout the data, most frequently elicited from two research questions: “have you thought about producing science journalism related to your field?” and “do you currently produce science journalism?” The former question, in particular, revealed hesitations related to training and communication aptitude, while the latter unearthed motivations for participating in science journalism today. See **Table 2:** for a breakdown:

Table 2: Belief Type Categorization of Interviewees

Belief type	**Expressed by:**	**Example quote**
Evaluative	UnB1, Con1, Con3, Con2, Con6, Con4	“I [have] never produced any kind of journalism. But I’ve been thinking about it. I’ve noticed there is a disparity between what’s in the [news story] versus what’s in the published article and the data. There is misjudgement of a lot of the experimental methods and procedures. I was thinking about writing articles about filtering this difference… I could act as a scientist judging the knowledge.”
Normative	UnB1, UnB6	“I’ve thought about it, but it’s not really where my interest lies. Seeking out opportunities takes more effort than I am willing to put in.”
Self-Efficacy	UnB3, UnB4	“I don't know what to publish, and I don't know where to publish it... and I don't know how to write it in a way that makes it interesting to the public. How to write is the biggest issue.”

Indeed, evaluative beliefs were most commonly expressed by students when describing their stance on producing science journalism, wherein students saw a specific and clear value of doing so for public audiences; while Con1 talked about improving vaccine information, UnB1 is interested in demystifying outdated thoughts around overfishing. As the researcher, I was expecting the data to be more evenly distributed amongst normative, self-efficacy, and evaluative beliefs. In particular, I expected students to express more normative perspectives that had been possibly formed and influenced by conversations with professors in pedagogical settings. As noted on page 9 of the introduction, one of the key inspirations of this research spawned from observing professors share negative views on the media, and specifically, journalists' ability to report on science effectively. I hypothesized that this view might be shared by the students, who may adopt the views of their professors. The data proved otherwise, wherein many science students see communication activities as a necessary feature of their roles as scientists in society. Notably, this finding is aligned with the work of Koswatta et al. (2022) who found that early-career scientists were comparatively more motivated than scientists 20+ years into their career to engage in public communication activities.

Introspections on RQ2: Have Students Been Encouraged or Discouraged to Interact With, or Produce, Media by Their Mentors or Peers?

This research question was designed to understand how the interviewees experienced incitement to create science journalism of their own, or interact with the media in any capacity at all, whether this would be about their research or any science topics more broadly. "Mentors" in this scenario were loosely defined as any course professors or teachers they have come across in their educational endeavors, while peers would be any one in their programs. Open-ended questions elicited revealing responses for this research question, ranging from explicit opinions on the integration of science journalism topics into science programs, to more generic topics

around how and if topics of the media are discussed in the classroom or beyond. Knowing that learning in graduate-level programs takes many forms and exists in many different settings, I wanted to encourage dialogue with the interviewees that allowed me to understand how discussions take place with fellow students, at what frequency, and the general nature of these interactions.

What emerged was the findings outlined in the *teaching* section (pages 61-64) as well as enlightening examples of the nature of the discussions around science journalism happening in peer communities. As the researcher, I was expecting students to share that they speak about the possible downsides of participating in the media, paired with anecdotes of stories shared by professors in instances of being misquoted, or research being misrepresented. By and large, however, when speaking about conversations with their peers, most students reflected on the failings of the media to accurately represent a study they were reporting on. Furthermore, the dominant majority of students interviewed are looking for a way to unpack these issues in a formal pedagogical setting. Below, I consider how these findings coalesce with current research on science journalism training for science students and science professionals.

Sentiments on Science Journalism: Where is Social Media?

Most interviews opened with a broad question, "Do you discuss issues of the media with your classmates in pedagogical or casual settings?" A few of the students referenced discussions they had with their peers (see pages 61-63). Overall, in the anecdotes shared, the sentiment was negative toward either journalists or media outlets at large. Con4 made note of discussing how journalists were "sensationalizing results" and asking if "the journalists report[ed] what the study found", which is closely connected to UnB2's discussions centered around "things we saw published that we knew to be wrong", and UnB3's description of conversations where fellow

students share their thoughts on why science stories weren't covered well. These comments might be expected as some students will approach an interview setting under the expectation that a critique on the topic is expected, but I was surprised that social media wasn't a prominent feature in the anecdotes shared by many of the students, and little to no reference into how this is impacting how information is distributed online, although Con1 did state they go to social media for news "like a typical millennial" (see page 57). This supports Brossard and Scheufele (2022) argument that science communities are lagging in their understanding of the complexities and power of social media as it relates to science communication.

The focal point of discussions described above, and the sentiments that convey media inadequacy, show that while the conversations around science journalism and scientists' opinions on the media have continued to be ingrained in the fabric of science culture, perhaps the nature of the discussions, and topics worthy of investigation, have not evolved as rapidly as communication channels themselves. This is interesting when viewed in combination with the research of Mercer-Mapstone & Kurchel (2016), who concluded that integrating science communication into undergraduate-level science degrees led to an increase in confidence and improved self-perception on one's ability to communicate about science (see page 32). Crucially, while 94.9% of students reported improved science communication skills, this program included understanding audiences, understanding context, and how to leverage writing styles to get the right communication across to audiences. A notable gap in these learning outcomes is understanding social media distribution, and more specifically, how social media algorithms influence who actually sees the content that one is producing. Beyond distribution and content visibility, a critical learning for any science communicator is the role of social media and

trustworthiness of scientific information, which was reinforced as an urgent matter for scientists and journalists to consider in Dunwoody's (2020) work on pandemic uncertainty (see page 33).

With this in mind, the discrepancy between the power of social media and its influence on science and its lack of presence in discussions about science journalism, is a notable one. Perhaps this is due to the fact that social media is not a central focus in the lives of the students interviewed, but, as urged by Brossard and Schefuele (2022), understanding the power and presence of social media is critical, although scientists continue to lag in their social media aptitude (see pages 24-26). In another vein, perhaps this disconnect is a byproduct of the "disparate literatures" of science communication and journalism studies that Lewenstein (2011) highlighted (see pages 15-16). In this context, journalism and communication education deeply considers the impact of social media on key topics such as professionalization, facts, objectivity, and public misinformation, and literature in science communication focuses on different topics for science-focused audiences. Ironically, the pitfalls and dangers of informational echo chambers on social media and beyond, and the subsequent impact on public science discourse this has is a critical topic being examined in the post-coronavirus era (Inteman 2022; Shafer 2021), and yet, these echo chambers are sometimes parallel to the divisions within the literature itself: borrowing UnB5's description of different news sources as "parallel universes" (see page 54) is also a fitting description here.

Science Journalism and Communication Training: What Do the Scientists of Tomorrow Really Want?

Understanding how students perceive learning about science journalism in their coursework as a graduate-level science student was a critical component to this research. In 2004, Dunwoody suggested that scientists were seeing public communication activities as useful

for their career as scientists. And yet, as I examined the literature on both science journalism and science communication, the perspectives of graduate-level science students and their opinions on science journalism was largely missing, further inspiring the direction for this research, and illuminating a key gap: while I witnessed topics in the media and journalism being discussed amongst science students in the iSCOPE and research project (see pages 7-9), a consideration on the root purpose of these discussions and the potential impact of content shared in such discussions was largely unexplored.

I was eager to glean insights from the question, "do you think you should use class time to talk about the media?", and the responses I received were spirited, ranging from highly pragmatic to theoretical: some considered the value of adding science journalism training formally to class syllabuses (Con3, UnB4), while others pointed to the value of learning how to communicate uncertainty (UnB6). As outlined above, most students considered producing science journalism based on an evaluative belief, knowing that it would either provide measurable impact to the public or within their careers (see Figure 8, page 73), a critical learning as this points to the fact that capitalizing on this belief for early-career scientists could multiply science communication activities significantly. This adds further urgency and emphasis on the need to integrate more meaningful exercises into coursework for graduate-level science students to empower the scientists of tomorrow with practical skills and the confidence to participate in the medialisation of science.

A Call for Pragmatic Training on Media, Communication and Journalism Fundamentals

The highly practical recommendations suggested by the students when it comes to integrating learning about science journalism into their coursework revealed a desire to acquire an understanding of the media landscape as well as writing skills. There are two quotes that are

particularly interesting here, the first is from Con3 "I think it's extremely important. No matter how much we criticize it…the only way we get scientific events to the public is through journalism. New scientists and the people in the classroom need to understand this process." Beyond processes, UnB4 stated that it would be "extremely helpful to learn how to frame your work to public audiences…and learning how to deal with the press in interviews, too."

A look back at the literature explored on science journalism training for scientists supports the argument that this type of training and learning could have. Dijkstra (2015) argued that scientists face a number of barriers to entry when it comes to participating in science journalism, which range from their relationship and viewpoints on the media, as well as confidence in their own skills. Dijkstra's finding that scientists face public and peer criticism by participating in science journalism and also their own perceived abilities including lack of basic communication skills indicate a clear opportunity to mitigate future barriers through learning and education in graduate-level programs.

Creating the Foundations for Thriving Epistemic Communities in Graduate Science Programs

In the literature review, I highlight the work of Shäfer (2021) and Dunwoody (2020), who both outline the significant challenges scientists and journalists encountered communicating in the context of the coronavirus pandemic (see pages 32-37). Both Dunwoody and Shäfer agree that communicating uncertainty within a media context that requires rapid speed is a complex endeavor, made further complicated by the fact that those who may need to understand scientific nuance exist outside of the communities where this information exists. One of the student's reflections on why journalism training should be implemented into graduate science programs

was particularly compelling, as it situates Dunwoody & Shäfer's argument in the mind of an early-career scientists who is grappling with how one might untangle this complexity:

> You see the struggle of working with people who are trying to emphasize your work that is filled with uncertainty, and [lack of] clarity, but then people are sort of forcing you to give an answer... it's really hard to communicate [uncertainty] in a way that doesn't invalidate your own work and your own science (UnB5).

Well before the coronavirus pandemic, scholars such as Figdor (2017) argued that science news should be seen as an "interdisciplinary product" that is not negatively impacted by the practical pressures on each profession: whereas scientists might be motivated by ensuring their work is publicized, journalists are motivated by ensuring there is meaning in their news for the "everyday" person. Figdor argued then that scientists and journalists need to ensure an "epistemically virtuous product" (see pages 34-37), and makes suggestions for current career scientists and journalists. For the purpose of this research and its focus on graduate-level science students, I am curious to know: how might the foundations of an "epistemically virtuous" science news product start to form in pedagogical settings? Based on feedback from students throughout the interviews, here are some initial starting points:

1. **Creating credit-based courses for learning about science media and science journalism in both graduate-level science and journalism programs:** Creating the foundations for a knowledge community that is "interdisciplinary" in its nature can start with more interdisciplinary educational opportunities. Indeed, the inspiration for this study was seeded in an interdisciplinary research on science communication, and specialized programs exist for science journalism in various forms (see pages 7-9) But,

beyond the practical elements of "how" to communicate science effectively to the public, are students in both journalism and science programs connecting on a joint "why"? Furthermore, in the post-coronavirus era, can the joint "whys" behind creating an ideal interdisciplinary product propel these various programs into more widespread adoption, thereby building the foundations for epistemic communities?

2. **Regularly inviting journalism and communications professors to speak on specific topics and issues:** UnB6 suggested that science science professors today are "trained on a specific path", it would be useful to have journalism professors from other departments teach specific classes to these students. With this approach, perhaps there is also an opportunity for journalism and science professors to model how they would interact as career scientists and career journalists together, thereby giving students a vision for what these interactions might look like in their own careers.
3. **Highlighting examples of scientists-as-professional-communicators in classes:** One of the most compelling features of the data was the fact that students shared stories about criticizing journalists reporting on science in the mass media, but very few talked about the proliferation of scientists who have created highly engaged communities. Author and professor Emily Oster, for example, has built an online community of over 65,000 subscribers with her newsletter "Parent Data", which anyone can subscribe to for $60/year (North 2021). Oster is a prime example of embracing the medialisation model of science communication, actively engaging in weekly Q&As with her audiences via social media, answering questions, and inspiring fellow parents to give their tips and advice on key issues. Her chief mission is to root questions in parenting discourse (such as vaccines, illnesses, allergies) in data, improving data literacy for parents and dispelling

myths that might be caused by misinterpretation of scientific studies. If these examples of science journalism were used in classrooms to showcase how experts are increasing critical thinking skills through their work, would the scientists of tomorrow have a clearer path of how they might participate in science journalism? While Oster's purpose is not squarely rooted in her background and training as an economist, she has parlayed her scientific ability to analyze data and thinking critically into a form of science journalism targeted at improving how parents interpret and understand scientific studies. With that, given that the data found that graduate-level science students are not purely motivated to engage in telling stories about their own research, perhaps exposure to this type of medialisation would be both useful and inspiring.

Limitations and Strengths

There are three limitations to this study worth noting. The first is the reliance on using English for all interviews, despite the fact that English may have been a second or third language for over half of the interviewees. Van Nes et al. (2010) highlight the challenges of language limitations in a qualitative research:

> Qualitative research seeks to study meanings in subjective experiences. The relation between subjective experience and language is a two-way process; language is used to express meaning, but the other way around, language influences how meaning is constructed. Giving words to experiences is a complicated process as the meaning of experiences is often not completely accessible for subjects and difficult to express in language (p. 314).

With this in mind, meaning may have been impacted and influenced by my own comprehension of how interviewees expressed their thoughts, and interviewees may have also felt constrained in

their ability to describe their experiences with more expressive techniques such as metaphors and symbols. However, as stated on pages 43-44 of the method section, delivering a list of questions at least 24 hours before the interviews was intended to relieve uncertainties and help participants prepare for the discussion in English.

The second limitation of this study is the sample size. Given the focus of the research, twelve participants was an adequate number of participants to to glean themes across graduate-level science students, however these students do not span multiple geographies and institutions, as recruiting was focused on students at Concordia University and the University of Bergen. Students were also predominantly studying the field of biology, which may possibly impact the prevalence of shared views and perspectives from the program-level. Enriching the results within each theme with a higher volume of data would be beneficial, however, the results in this study are still a viable starting point for understanding this topic and a useful springboard for future directions of research.

The third limitation worth noting is more complex: the timing of this research and the coronavirus pandemic. As outlined in the methods section, interviews began January 2020, and the research design and questions were articulated before the pandemic. Indeed, if all interviews took place squarely before or after the pandemic, the anecdotes shared would have been impacted. This timing also required reevaluating the literature review to ensure that current perspectives on science journalism and the science-media interaction were adequately captured.

However, looked at from another perspective, the timing with the coronavirus pandemic could be also be considered the pillar strength of this study: while the research questions and therefore data do not explicitly focus on the coronavirus pandemic and its implications on how graduate-level science students view the media and science journalism, the importance of this

topic and the collective need to battle scientific misinformation through a unified epistemic community has never been more apparent. The relevance of this topic from both a scholastic and public discourse perspective is unarguable. The perspective of graduate-level science students, albeit limited to 12 perspectives in this research and focused on students from two institutions, is a largely ignored one. And this research is a viable bridge between two disparate sets of literature that divides the science communication and science journalism worlds, setting the foundation for further directions of research that can emerge from either science communication or science journalism fields, or perhaps a new facet of literature entirely that focuses on bridging both concepts together.

Directions for Future Research: Building on The Four Ts

Given the wide proliferation of research in science journalism and science communication that has followed the coronavirus pandemic, the directions for future research on this topic are expansive. In keeping a focus on the core themes outlined in the findings section, I have proposed a number of emerging questions that can be asked to unpack critical questions relating to these themes in more depth.

Training

This research found that most students did not necessarily believe that science journalists should have a formal degree in the topic they are reporting on, or in the sciences more generally. Students referenced the ability to understand how science worked, wherein the concept of "critical thinking" and its importance for adequate science reporting emerged.

Directions for future research: How can "critical thinking" competency be measured and assessed on a universal scale for those responsible for the medialisation of science? Furthermore, how might the advent of epistemic communities help foster a shared definition for "critical

thinking" to align both professions with unified goals? And how might this exercise be extended to increase critical thinking skills for public audiences who are consuming information around scientific studies and research on their own terms?

Trust

This research revealed that many students apply elements of their training in the sciences, such as comparing and contrasting sources (data) to configure truths, in their own media consumption habits. It also highlighted that the nature of science journalism "exercises" in classrooms was primarily focused on indicating the failings of how information was presented via the mass media.

Directions for future research: How do specific courses in science and science journalism at the graduate level speak to the foundational issues of trust in the media? How can we create better programs to promote media literacy in science programs? How are science leaders learning to build trust with public audiences today, and how might these case studies be integrated into science education in a meaningful way? Throughout the coronavirus pandemic and beyond, how have scientists and journalists effectively collaborated to communicate critical health information accurately and quickly, and what can we learn from these case studies?

Tensions

This research suggests that there are two levels of tension at play influencing a students' appetites or barriers for participating in science journalism. At the institutional level, practical constraints of time and focus inhibit students' science journalism production. At the individual level, students may not feel like they have the skills needed to adequately communicate topics around their own work or otherwise.

Directions for future research: What are the most effective core skills to teach graduate-level science students to prepare them for communicating their work in the post-coronavirus world? How has the proliferation of scientific misinformation either accelerated or reduced the existence of barriers or appetites for participating in science journalism? Have the scientists of tomorrow been galvanized in the pursuit of communicating facts and fostering more critical thinking from audiences, or do they feel more hopeless?

Teaching

The research found that almost all students believed integrating science journalism learning into graduate-level science programs would be meaningful, but how formal this should be, via syllabuses or through class discussions, varied. Students also notably conflated core communications skills (writing press releases, for example) with learning about science journalism.

Directions for future research: What are the success metrics for integrating science journalism education into graduate-level science programs? How might teaching science students about journalism studies, and journalism students about science create the foundations and learning frameworks for a science-journalism epistemic community? How are early-career or established scientists using social platforms to share information about their specializations, or more general topics? How are scientists today learning about the influences of social media as it relates to their areas of specialization? And furthermore, are teachers in science journalism or science communication questioning the impacts of using time to create media content for more niche, science-informed publics versus disseminating information via traditional mass media networks and channels to broader audiences?

Conclusion

The original title for this thesis was "Systems of Silence: A Qualitative Analysis on Graduate-Level Science Students' Views on Science Journalism." As the name suggests, I was bullish on my assumption that I would hear stories of students being encouraged—either explicitly or implicitly—to proceed with caution when it comes to the media, to limit interactions with dangerous science journalists as much as possible, and to stay focused on their research. As elements of my hypothesis started to take form, I thought I would ultimately prove that the ways in which professors addressed issues of science in the media in the classroom led to feelings of distrust. And, most critically, this feeling of distrust would underpin scientists' potential fear about creating science journalism in the future, and they'd tell me they would have no intention in participating in any journalism-related activities in their future.

Indeed, my neatly packaged assumptions that could have created a simplistic yet solid argument were not what emerged from the data. Instead, the Four T's of Science Journalism—Training, Trust, Tensions and Teaching—paint a layered picture of how individual viewpoints on the media, media consumption habits, and normalized behaviors encouraged in science programs coalesce to form each of the student's relationship with the media and their opinions on science journalism. Most notably, the overwhelming support in favor of formally integrating science journalism learning into graduate-level science programs, combined with their desire to produce science journalism, illustrates an alarming gap in the type of learning and discussions taking place in science classrooms and the practical and theoretical knowledge the scientists of tomorrow are seeking. In this vein, while my hypothesis about the framing of science journalism in graduate-level science classrooms being predominantly negative was true—I uncovered that the critical thinking skills that influence how science students consume

news also influences how they perceive the ways in which science journalism is presented in pedagogical settings. In short, their critical thinking aptitude does not exist in a vacuum and therefore does not deeply influence their willingness to participate in science journalism. This dichotomy became apparent when Con1 poignantly stated: "Teachers have their own inherent biases, as does the media, so you're always getting the information on a slant" (see page 62).

While the future directions for research propose several answers to the question "now, where do we go from here?", one of the questions to urgently answer next is: who is responsible for bridging the disparate literatures of science journalism and science communication together, and who will continue to monitor, improve, and critically examine the ways in which the media is conveyed in science classrooms? Indeed, the formation of epistemic communities consisting of leaders in science, science journalism, and science communication who are bound by a joint mission to improve outcomes of the public communication of science through improved media literacy *and* science literacy, and who are also uninterrupted by the professional norms and pressures that have derailed progress in the past, is seemingly the most viable next step. One might dismiss this as an idealist approach, yet the ever-growing dominance of scientific misinformation proves it's one worth tackling, lofty or not, with a unified front. And why wouldn't we try? As we learned, the scientists of tomorrow do not, in fact, want to be silent.

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Appendix A

Thesis poster for research study, used to recruit participants:

Share your thoughts on Science Journalism.

I am currently seeking interviewees for a research study, titled:
"Systems of silence – a qualitative exploration of graduate-level science students' views on science journalism."

To participate, you must be:

- Currently enrolled in a graduate science program (MSc or PhD)
- Available for a 30 minute video chat in the month of May

Participation is confidential and voluntary. No previous science journalism or science writing experience is required.

If interested, please contact me, Colleen McNamara, at **colleenrebeccamcnamara@gmail.com**

Appendix B

Semi-structured interview guide used for each interview:

Interviewer Role

- My role is to guide the discussion, keep the discussion on topic, and probe for key questions should they not arise.
- Purpose of recording the interview is to have an accurate script of the interview; Please note that information will not be attributed.

About Interviews

- Via the exchange where interviewer hopes to learn from the interviewee's expertise.
- Purpose of the project is to investigate how graduate level science students form their opinions on the media, which in turn may impact their willingness to cooperate with journalists in the future.
- The interview should take between ½ and 1 hours, interviewer will ask an introductory question and allow the interviewee to talk.
- Interviewer will prompt for additional information when needed.
- Emphasize confidentiality of responses.

Overview of Project

- The study is being carried out by me, a Master of Arts student in Journalism Studies collecting data for her thesis; this involves exploring the view of participants.

2. Introductory Question: Characterization of Background

Interviewer says:

- You've read and signed the informed consent, but do you have any questions or concerns at this time? Feel free to indicate if there are questions or topics you do not wish to discuss.
- I wanted to start with learning about your background and the classes you take.
- Q1: Do you discuss issues of the media with your classmates in pedagogical or casual settings?
- Note to the interviewer: Do not spend too much time on this section because it is not the most important one

3. Main questions: Science journalism

Interviewer says:

- We have discussed a bit about your background and I would now like to discuss your personal experiences with science journalism.
- **Q2: Do you currently produce, or have you thought of producing science journalism related to your field**?
- *Interviewer listens for:* expressions of hesitation, fear or excitement around the idea of publicly communicating scientific facts to public audiences.
- Interviewer Prompts Additional Information (as appropriate), on: the foundation of the interviewees' opinion on the importance or irrelevance of producing science journalism.

Interviewer looks for influences that may have impacted the aforementioned feelings of the interviewee.

{Once complete, the interviewer repeats the process to ask the following questions}

- **Q3. Where do you go for news?**
- Interviewer listens for: sentiments of trust or distrust in certain media outlets or loyalty to particular outlets, and words that connote "quality" or "best" or "trusted"
- Interviewer Prompts for Additional Information (as appropriate), on: interviewees' classification of what makes news "good", the science community's 'go-to' news sources, and if their choice of news outlets has evolved or changed within the last 2-4 years.
- **Q4. Do you think journalists who cover science should have an educational background in the sciences?**
- Interviewer listens for: opinions and views on the importance of journalists "understanding" science, and anecdotes or references to science journalism controversies, as they relate to public health or science facts in general
- Interviewer Prompts for Additional Information (as appropriate) on: the meaning of "understanding" science, views on the impact of misinterpretation of facts, and recommendations for an improved scientist-to-journalist cohesion.
- **Q5. Do any of your professors openly address issues of the media in educational settings?**
- Interviewer listens for: particular experiences or stories related to media issues, and sentiments that allude to strong feelings of either positive or negative experiences.
  Interviewer Prompts for Additional Information (as appropriate), on: their teachings or curiosities in the public understanding of science, and feelings on how worthwhile their pedagogical work in science and the media is in the framework of their larger educational framework and personal objectives.
- **Q6**. **What are your thoughts on using class time to have a discussion around science in the news?**
- Interviewer listens for: opinions on previous experience with this or openness to doing this in the future.
  Interviewer Prompts for Additional Information (as appropriate), on: what the interviewee would like these discussions to be centered around, and whether or not journalism experts should be involved in pedagogical discussions, and, if so, what that impact might be.

4. Final Question: Further sources of information

Interviewer says:
Thank-you for taking the time to talk with me, it was very helpful. I will only ask two final questions.

Interviewer asks:

- Are there other people that you would suggest I talk with?
- Is there any literature you think I should read?

{Allow interviewee to speak freely until finished, no additional prompts}

Appendix C

Consent form distributed to all interview participants:

INFORMATION AND CONSENT TO PARTICIPATE IN A RESEARCH STUDY

Study Title: Systems of silence: a qualitative exploration of graduate-level Science students' views on science journalism

Researcher: Colleen McNamara, MA Student

Researcher's Contact Information: Department of Journalism, Concordia University, Montreal, Canada, 514-467-7352], colleenrebeccamcnamara@gmail.com

Supervisor: Dr. David Secko, Department of Journalism, Concordia University, david.secko@concordia.ca

Source of funding for the study: N/A

You are being invited to participate in the research study mentioned above. This form provides information about what participating would mean. Please read it carefully before deciding if you want to participate or not. If there is anything you do not understand, or if you want more information, please ask the researcher.

A. PURPOSE

The purpose of the research is to explore student views on science journalism, in the context of a Masters thesis on how pedagogical practices are being implemented and perceived in university classrooms.

B. PROCEDURES

If you participate, you will be asked to complete an audio-recorded interview. The interview will involve questions on your view on science journalism and its role in science education. In total, the interview will last up to 60 minutes.

C. RISKS AND BENEFITS

This research is not intended to benefit you personally. Potential academic benefits include an increased understanding of science journalism and its role in society, which may improve university teaching and learning practices.

D. CONFIDENTIALITY

By participating, you agree to let the researchers record your interview.

We will not allow anyone to access the information, except people directly involved in conducting the research, and except as described in this form. We will only use the information for the purposes of the research described in this form.

The information gathered will be coded. This means that the information you provide will be identified by a code. Only the researcher will have a list that links the code to your name.

We will protect the information by storing the recording in a locked cabinet in a locked office, and password protecting any files that identify participants' names.

We intend to publish the results of the research. However, it will not be possible to identify you in the published results.

We will destroy the information five years after the end of the study.

E. CONDITIONS OF PARTICIPATION

You do not have to participate in this research. It is purely your decision. If you do participate, you can stop at any time. You can also ask that the information you provided not be used, and your choice will be respected. If you decide that you don't want us to use your information, you must tell the researcher 2 weeks prior to the submission of the thesis submission. There are no negative consequences for not participating, stopping in the middle, or asking us not to use your information.

F. PARTICIPANT'S DECLARATION

I have read and understood this form. I have had the chance to ask questions and any questions have been answered. I agree to participate in this research under the conditions described.

NAME (please print) _____
EMAIL (please print) _____
SIGNATURE _____
DATE _____

If you have questions about the scientific or scholarly aspects of this research, please contact the researcher. If you have concerns about ethical issues in this research, please contact the Manager, Research Ethics, Concordia University, 514.848.2424 ex. 7481 or oor.ethics@concordia.ca.