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Perceptions of Science Communication’s Domain, Practices, and Identity: What Concerns Members on the Peripheral Edge of a Community of Practice

Rebecca Swenson
University of Minnesota

Corissa Marson

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Perceptions of Science Communication’s Domain, Practices, and Identity: What Concerns Members on the Peripheral Edge of a Community of Practice

Abstract

This research shares insights from qualitative interviews with scientists in agricultural and environmental science programs (n=26) to better understand how occasional, peripheral, or emerging members of the science communication community of practice perceive its domain, practices, and identity. Findings suggest concern about personal risks of communicating, especially control over messaging, interactions with disagreeable audiences, being incorrect, and reputation damage. However, many believe that communication is broadly important for their field and resources. Scientists did not have clear agreement on boundaries of science communication, and advocacy and uncertainty were points of contention. Suggestions for strengthening science communication training are proposed.

Keywords

science communication, training, interviews, curriculum, identity

Introduction

There is good news for scientists who are interested in public engagement and science communication efforts: the public has been paying more attention to science news over the last five years (Saks & Tyson, 2022). Universities, scientific societies, and other professional organizations are also increasingly interested in science communication and how to strengthen skills in this area (Dudo, Besley, & Yuan, 2021; McLeod-Morin, Rumble, & Telg, 2021). Science communication training helps students use appropriate skills, media, activities, and dialogue to shape awareness, interest, enjoyment, understanding, and opinions about scientific topics and issues (Burns, O'Connor, & Stocklmayer, 2003). However, audience identity, length and depth of program curriculum, learning outcomes, and application of skills is diverse, and science communication training encompasses broad contexts from single session workshops to full degree programs for a variety of science disciplines (Baram-Tsabari & Lewenstein, 2017). As interest in science communication grows and skill-building opportunities expand, it is important to understand the diverse group of scientists engaged in this work and training.

In an effort to better understand "what to teach - and to whom and why," Lewenstein and Baram-Tsabari (2022) used the concept community of practice (CoP) to make sense of the identity and participation level of those seeking out more information about science communication, separating individuals into three levels: occasional, active, and professional science communicators (p. 290). They suggested that all groups might be exposed to similar "threshold" concepts, but learning might progress through different pathways from essential to advanced competencies (Lewenstein & Baram-Tsabari, 2022, p.291).

To build upon that work, this research uses in-depth interviews to closely examine the perceptions of faculty and graduate students who are "occasional" science communicators, but with the potential to become "active" science communicators; specifically in this case, our focus is on graduate students and faculty working in agricultural and environmental science areas at U.S. land-grant institutions who report spending 50% or less time on science communication activities. We wanted to better understand their perceptions of the science communication community of practice, specifically, reflections around risks and rewards, best practices, and identity. These insights can help those designing science communication curriculum who want to structure learning progressions and develop specific learning experiences for emerging science communicators. It also provides some additional insights for those who want to sustain interest and engagement within a science communication community of practice. Next, we provide a review of the main literature that informed this study.

Literature Review

Science communication, according to Burns et al. (2003), is "the use of appropriate skills, media, activities, and dialogue" to encourage awareness, enjoyment, interest, forming of opinions, and understanding of science (p. 191). Ideal models have moved away from a deficit model, in which science communicators simply share facts that are accepted by unaware audiences, to an engagement model in which dialogue and two-way communication with audiences are stressed (Reincke, Bredenoord, & van Mil, 2020; Nisbet & Scheufele, 2009).

The distinction is important, as simply communicating scientific facts might not be effective in an environment where political agendas, heated public deliberations, and conflicting news accounts reign (Iyengar & Massey, 2019). Effective science communication requires knowledge of foundational communication techniques and a focus on audience engagement (Nisbet, 2009; Nisbet, Brossard, & Kroepsch, 2003). Further, current issues require science communicators to employ new approaches and new methods focused on engaged, relational communication techniques – and strategies that consider power and accountability (Kearns, 2021).

Yet, in practice, the deficit model of communication persists, as Simis et. al. (2016) argued, possibly due to conceptualizations of audiences, a focus on rational reasoning, a lack of formal training, negative views of the social sciences, and a desire for easy solutions for policy issues among scientists in science, technology, engineering, and math (STEM) fields. The challenge of consistently applying engagement models might also be due to the content within science communication workshops and short training programs (Dudo, Besley, & Yuan, 2021). Overall, science communication training programs have focused on practices like building technical communication skills and often ignore strategy, evaluation, and inclusivity (Dudo, Besley, & Yuan, 2021). However, for effective dialogue, science communicators must consider the attitudes, values, and behaviors of the audience (Besley & Dudo, 2022; Reincke, Bredenoord, & van Mil, 2020). Previous scholarship has identified important additions in science communication training and practice, including in outcomes related to identity formation (Baram-Tsabari & Lewenstein, 2017), positive attitudes towards public engagement (Koswatta et al., 2022), and responsibility for science communication work (Parrella et al., 2022).

Previous scholarship has also examined perceptions of value, rewards, motivations, deterrents, and risks for those engaged in science communication work. For example, in a survey of 465 science communication actors that span seven European countries, Wilkinson et al. (2023) found that individual enthusiasm, job obligations, educating others, and countering misinformation were main motivators for professional science communicators, while time, lack of resources, and difficulty getting others on board were deterrents. Similarly, Ho et al. (2020) also found time and lack of institutional resources were barriers for scientists to engage in public communication activities, while securing research funds and improving the public welfare were viewed as rewards. Not all scholarship findings have aligned. For example, Koswatta et al.'s (2022) examination of scientists at Texas A&M suggests that self-perceptions of skill level influences scientist's likelihood to contribute to and enjoy public science communication work, which is different than Besley et al.'s (2018a) insight that scientists' perceived skill level was not a strong predictor of willingness to communicate.

Work on competencies, motivations, and barriers should be ongoing, as science communication's practice, environment, perceptions of identity, values, training, skills needed, and the actors involved continues to rapidly change (Brüggemann, Lörcher, & Walter, 2020; Iyengar & Massey, 2019). In addition, there is inherent change and uncertainty within the scientific process, and addressing uncertainty and change while maintaining public trust is a growing challenge for science communicators (Gustafson & Rice, 2020). These shifts call for on-going scholarship on ever-changing competencies and challenges for science communicators (Fähnrich et al., 2021).

The role of activism in science, and its relationship to professional identity, values, norms, and boundaries, has been an especially hot topic of recent academic articles, especially connected to climate change communication (Nicolaisen, 2022; Brüggemann, Lörcher, &

Walter, 2020). For example, Brüggemann, Lörcher, and Walter (2020) argued that new scientific roles and norms have recently emerged for science communication, largely driven by polarizing discourse, the current media environment, political pressures, uncertainty, value questions, and an urgency to take action. They predict that "post-normal" patterns in science communication will emerge in which both journalists and scientists will increasingly move from roles of pure scientists, science arbiters, neutral observers, and watchdogs that embrace values like autonomy and objectivity to roles that advocate for common goods and broker consensus, dialogue, ideas, and knowledge (Brüggemann, Lörcher, & Walter, 2020). Conversely, Nicolaisen (2022) rejected some of these predictions, as their focus groups demonstrated that citizens, climate scientists, and journalists did not want science communicators to act as advocates, but they were open to scientists expressing emotions about findings.

Given these recent shifts in roles, changing boundaries, professional expectations, norms, and growing pressure, it is important to examine current perceptions of risks, rewards, and identity among learners on the periphery of the science communication community of practice. Recently, Lewenstein and Baram-Tsabari (2022) offered some essential and advanced general learning goals and objectives for science communicators, breaking these out for different participation levels (occasional, active, and professional communicators) and related training situations (short workshop, a course, full curriculum). This work is helpful and an important roadmap to build upon for development of competencies and learning progressions, and as Lewenstein and Baram-Tsabari (2022) wrote, to hopefully enable learners to become more engaged and move towards the core of the science communication community of practice.

Lave and Wenger (1991) proposed the concept community of practice to explore the learning process of communities of practitioners and interactions between new and established members. Wenger et al. (2002) described three elements of a CoP: the *domain* (common values, reasons for participating), the *practice* (shared knowledge, skills, and methods), and the *community* (purpose, identity, connection). The community of practice framework, and its three elements described by Wenger et al. (2002), guided the research questions described below.

The concept can be applied to better understand potential needs for personal growth, empowerment, support for members, interactions with one another, sharing of knowledge, and perceptions of belonging (Li et al., 2009). Carlone and Johnson (2007) examined science as a community of practice and argued that for inclusive retention and recruitment to science programs and careers, scholars must examine how aspiring members affiliate with, become alienated from, and/or negotiate the cultural norms within the science community. Using a science identity model based on competence (skills), performance (acting like a scientist), and recognition (viewed as a scientist), Carlone and Johnson (2007) described three science identity trajectories: research scientists, altruistic scientists, and disrupted scientists. These identities accounted for how scientists made meaning of their experiences and work, negotiated the culture of science, and gained recognition from others – and how these identities tied to gendered, ethnic, and racial factors (Carlone & Johnson, 2007). Applying Carlone and Johnson's (2007) framework to postdoctoral fellows in STEM fields, Hudson et al. (2018) found that science identity was highly salient, meaningful, and brought fulfillment for this group, and participants performed their science identities by conceiving of ideal notions of science, speaking the language of their scientific discipline, and wanting to be immersed in conducting science in the lab, while avoiding tasks like teaching, fundraising, and politics, which as authors point out, might not be realistic expectations for future careers.

It is vital to examine how professional identities are perceived and communities are experienced by those at the edge of a community of practice. Our work builds upon other scholarship by closely examining learners on the periphery of the science communication community of practice to better understand their current views of science communication, its practices, and related identities. This work helps science communication scholars and practitioners understand potential knowledge gaps, how to strengthen training and practice, which competencies to prioritize, and how to effectively structure learning progressions to better reach emerging or occasional science communicators.

Purpose and Research Questions

The purpose of this study was to better understand perceptions of science communication work. The specific research questions that guided this study align with Wenger et al. (2002) elements of a CoP and include:

1) How do occasional or emerging science communicators view the value and potential risks of conducting science communication work (*domain* element of the CoP)?
2) What science communication knowledge, best practices, and methods are important for success and mitigating risks, according to occasional or emerging science communicators (*practice* element of the CoP)?
3) How do occasional or emerging science communicators view the shared purpose of science communication work, its boundaries, and related professional identities (*community* element of the CoP)?

Methodology

The current study is a qualitative research inquiry designed to explore perceptions and experiences in relation to science communication work. This study is part of a larger research project to understand science communication skills desired and designed as a follow-up to survey insights. For this part of the project, researchers were interested in a deeper understanding of how faculty and graduate students in agricultural and environmental science-based programs viewed the values, risks, practices, identity, and boundaries of science communication work. Researchers were especially interested in following-up on the perceptions of scientists who indicated they had some interest in science communication but not deep expertise in this area. Insights from this work can inform science communication curriculum, workshops, classroom content, and communication about potential training opportunities.

Our focus on agricultural, food, and environmental science programs was intentional. Science communication is important for all science areas, but especially for those working in agricultural and environmental areas. All members of the public need food and are impacted by good stewardship of our natural resources, but there is intense disagreement about food, fuel, and fiber technologies and what constitutes good conservation, welfare, and minimal environmental impact (Lusk, Roosen, & Bieberstein, 2014). Critical stakeholders, public criticism, business demands, and partisan expectations are part of the communication environment in these scientific disciplines (Bayes, Bolsen, & Druckman, 2020; Landrum, Hallman, & Jamieson, 2019). Scientists in these disciplines are likely to experience some of the shifts in the current media, political, and scientific environments as described above, such as political pressure, contested debate, advocacy, and related changing norms and challenges (Doxzen & Henderson, 2020; Björnberg et al., 2017). Because researchers sought the specific perspectives of graduate students and faculty in agricultural and environmental science programs, who had some interest in science communication, researchers used a purposive sampling frame.

Participants

Researchers used in-depth Zoom interviews, focused on the research questions above, which were a follow-up to a larger survey. To identify participants, researchers reached out to 85 faculty, staff, and graduate students at University of California-Berkeley, University of Minnesota-Twin Cities, University of Wisconsin-Madison, and University of Florida, who had completed an online survey and indicated their willingness to participate in a follow-up phone or Zoom interview. These institutions were selected because they have colleges of agricultural and environmental sciences and are in different regions of the United States. They are also Land-Grant universities, established by the U.S. Morrill Acts, which have a long history of emphasizing service, public outreach, and engagement within institutional missions (Gavazzi & Gee, 2018). Faculty at land-grant institutions have expressed motivation for science communication participation connected to the land-grant mission (McLeod-Morin et al., 2020).

Scientists were included in this study if they fit the following criteria: a current faculty, masters or doctoral student at one of the four research institutions mentioned above, a biography on their program's website that mentioned a major area of scientific study connected to agricultural or environmental science (Animal Science, Plant Biology, Agronomy, etc.,) and publicly available contact information. They also must have participated in our previous survey on science communication skills, which confirmed that they were occasional or emerging science communicator (defined by a self-report of spending 50% or less of their time on science communication activities), and indicated their willingness to be contacted for a follow-up interview. After eliminating interviewees who were inactive, unreachable, had graduated, declined an interview, did not respond after multiple requests, or indicated that they spent more than 50 percent of their time on science communication activities, researchers were able to successfully complete 26 Zoom interviews to include in the current study. We obtained Institutional Review Board approval and followed best practices for recruitment, informed consent, and interviewing (Dillman, Smyth, & Christian, 2014).

Researchers conducted interviews with five scientists from University of California-Berkeley, one scientist from the University of Minnesota-Twin Cities, 12 scientists from the University of Wisconsin-Madison, and eight scientists from the University of Florida. Scientists were in departments that included Forest Resources and Conservation, Animal and Dairy Sciences, Entomology, Agronomy, Plant and Microbial Biology, Fisheries and Aquatic Sciences, Soil and Water Sciences, Food Science and Nutrition, Environmental Science and Policy Management, and Agricultural and Resource Economics. Regarding positions and roles, 17 scientists were graduate students or postdoctoral fellows[1], and nine were faculty, with a variety of teaching, research, and extension focused responsibilities[2]. Overall, scientists report spending an average of 21.9% of their time on science communication activities, based on their self-report of time spent on science communication activities, and all but one scientist expressed an interest in maintaining or increasing the amount of time they devote to science communication.

[1] Quotes are attributed to interviewees in this segment with the code GP and a participant number.
[2] Quotes are attributed to interviewees in this segment with the code FP and a participant number.

Interview guide

The interview guide developed for this research project included seven questions focused on the purpose, value, and risks of science communication work, risks of not engaging in science communication work, science communication best practices, boundaries, and professional identities. To mitigate researcher bias, enhance trustworthiness, and improve reliability of research, we had an outside panel of researchers with expertise in agricultural communication review the sampling plan, interview guide, and data analysis approach. This helped reduce leading questions, identify potential omissions of data, and added additional research perspectives. Researchers followed the interview guide but also had the freedom to digress from the script to probe additional emergent ideas and themes (Berg & Lune, 2011).

The interviews were completed throughout the 2021 calendar year. Scientists were initially contacted via email and invited to participate in a Zoom interview. All Zoom interviews lasted from 21-95 minutes for a total of 1,132 minutes or almost 19 hours of interviews. Zoom interviews were recorded with scientists' consent and transcribed.

Data analysis

Data analysis followed a constant comparative method of analysis, which is a cyclical and continuous method of analyzing data (Creswell & Creswell, 2018; Lindlof & Taylor, 2011). Multiple researchers reviewed the transcripts in multiple cycles to identify common themes and patterns across the data. After a first review to identify emerging themes, researchers compared notes, and then individually returned to the transcripts for a second round of analysis, following Esterberg (2002) and Strauss and Corbin's (1998) best practices for open coding. Once initial themes were identified and agreed upon, researchers uploaded the transcripts to NVivo, a software designed for qualitative research, specifically, the organization and systematic review of interview, survey, and web content. Researchers used NVivo for focused and iterative coding techniques, including a line-by-line analysis of interviews that matched "nodes" or major themes identified in the data set to evidence within the interviews. The major themes connected to each research question are discussed in detail below.

Findings

RQ1: Perceptions of the Science Communication CoP *Domain*

For a community of practice, the *domain* element includes the subject of interest that is valued and boundaries that help members decide to engage or not (Li et al., 2009; Wenger et al., 2002). Researchers asked scientists who participated in interviews about their perceptions of the science communication domain, specifically the value of being engaged in science communication work, as well as its dangers and pitfalls. Scientists described two main types of risks or worries: 1) being incorrect or inaccurately represented, and 2) personal risk to the scientist, including career loss, facing angry audiences, political backlash, and general burnout. Scientists also described the value of engaging in the science communication domain as a strengthening of connection, attention, and resources for their area of expertise, more information being shared with those who need it, science that is in touch, and a strengthening of reputation for the individual scientist. The main themes are described in more detail below.

Science Communication's Risks

Being Incorrect or Inaccurately Represented. Scientists described being wrong or misinterpreted as major risks or hesitations when considering science communication work, especially the potential of communicating information that could be harmful or have negative, unintended consequences. Scientists in our sample worried about the lack of control over how information might be used or understood. Scientists also said it was scary to give information on the fly, and when not prepared, it is easy to speak off the top of your head and be incorrect or unclear. One graduate student mentioned that they often found it difficult to "convey findings that are often very nuanced in a way that won't be misinterpreted in a way that could be potentially harmful" (GP26). The translation process isn't perfect, one faculty participant mentioned, and added:

> These days it is scary, how everything can be taken out of context. I could imagine that you say something, and it is taken by somebody in the audience to mean something else - or they put different words together - and they put it in a tweet. It is crazy that the interpretation and misrepresentation of what you say could come back to haunt you or the institution that you work with. It's a little scary, it truly is. (FP11).

Scientists were also concerned about communicating findings that might later change, which is especially a concern in trending or rapidly advancing disciplines. Graduate students were especially concerned about being misinterpreted by media organizations and individuals. One scientist said, "I know some folks that are cautious about engaging with communicators and journalists, because they are worried that their research will be taken or represented the wrong way or inaccurately and then they can't make corrections" (GP03).

Personal Risk. Both graduate students and faculty also described fear of major career fallouts associated with science communication efforts. They described both real and imagined angry audiences that might cause them to lose professional credibility, grants, and jobs. One scientist said, "If you're making an argument with evidence and stories that goes against somebody's ability to make money on the other side, they'll work pretty hard to discredit you" (FP05). One more faculty member shared a particular situation, in which an online argument was taken out of context and turned into bullying, "that's why people stay in the science silo. It's pretty safe over there. If I move into the public arena, it's like full contact sports" (FP25).

For some, the risk was more about being uncomfortable discussing topics with outspoken followers that were likely to disagree or argue with scientific findings. One scientist said:

> This is not so much a thing with workshops or webinars, but on social media, because anyone will say anything behind a keyboard, one of my Facebook friends might comment on a conversation where I've been taking the time to reply to this person in a nice, calm, constructive way, and someone comments to just 'go read a book' or something that's obviously attacking, and I think that can grow opposition and dislike (GP16).

Scientists also worried that it could be risky to publicly share viewpoints that aren't held by future employers, for example, as one graduate student said, "potentially there could be risks to yourself, if you are trying to advance your career or your standing within an organization, there could be risks just based on someone in power disagreeing with you" (GP02). One faculty member also mentioned risk in spending time on something that is not "valued in our jobs and in the perspective of people above us" (FP18).

Not being able to avoid political conflicts was also a concern. Some worried that their issue would attract the attention of politicians and be leveraged to further divide audiences along partisan lines. As one scientist said:

> It becomes really easy to politicize and polarize science. And then, research becomes contested and it becomes harder to do engagement. You have to overcome the fact that the public knows very little about most research, and…you are in the unfortunate situation where your research field gets tied to partisan identities. In the United States, those are very, very powerful drivers. It becomes even harder to achieve any objective because you aren't just overcoming communication and information barriers, you are also trying to overcome partisan tribal separation. (GP07)

Another scientist added that political and legal disputes are when "things get messy" and "young scientists don't know how to deal with that, as it's not part of our normal training," further, it can "discredit you and pretty much ruin your reputation here" (GP08).

Scientists also pointed to additional stress, heavy workloads, and burnout as risky outcomes of science communication. Scientists discussed how science communication added stress to their already intense academic and research careers, especially since communication channels require consistent content and efforts must be continual. One scientist also described risk to reputation when others see science communication as inefficient workload management:

> They're like, oh, you're spending so much time talking about what you're doing and you're not doing enough of what you are supposed to be doing. Why do you spend so much time making a presentation when you could have run a couple of extra rounds of experiments? (FP03).

Another scientist explained, "Most of the time the risks are personal and to your own mental health. If you put yourself out there, and you go on Twitter, you are arguing with people all day, every day about science topics, it's not good for your mental health and it's very stressful" (GP15). The scientist added:

> I think just talking about the same sort of things over and over again, hearing these points, thinking you've addressed them, then they keep getting brought up over and over again, that's a risk. Because you become desensitized to the original idea, which is probably to change people's minds, be an authority figure, set a good example by explaining things. The news cycle just kind of grinds you down. (GP15)

The scientist expanded personal risk beyond workload to include habituation or the negative mental implications of working with communication environments, goals, and channels that can feel constant and repetitive.

Value of Science Communication

The risks described above are barriers or worries about continuing to engage in the science communication domain. When asked about the value of science communication and risks of not engaging in science communication work, scientists described the following potential motivators for continuing to engage in the science communication domain: connection, emotion, relevance, and being able to correct narratives.

Strengthening Relationships with End Users of Data. Scientists discussed relationship building as a shared value for those who engage in science communication work. Specifically, they discussed how science communication is valuable because it helps build relationships with end users and groups ultimately impacted by research data. Scientists said that those motivated to do science communication work were scientists who valued getting off campus and out of research labs to meet new people. Science communication was appealing to scientists, according to interviewees, who wanted to connect with people impacted by science and who wanted to create relationships that could inform future scientific inquiries. This connection with the end user provides an important sense of purpose and meaning, for as one scientist said, “You can do all the science in the world, and if you don’t tell anyone, you basically haven’t done anything,” (GP29). Scientists also described both dissemination and knowing the user of your information to be closely associated with their professional roles and responsibilities.

Building Emotional Connections to Scientific Work. Related to the theme above, science communication is a way to help audience members learn and see the relevance of scientific information, but scientists also pointed out that they were motivated to engage in science communication work to strengthen their own sense of relevance and purpose. Specifically, scientists viewed science communication work as a way to build their own emotional connections with their discipline and feelings of fulfillment from their work. Science communication can help scientists feel that their work does make a difference in the world, according to interviewees, by building emotional connections with individual audience members, groups, classrooms, or at the broader public or policy-level. Scientists also discussed how “nerve wracking” it can be to see public policy not map to scientific results and really “gratifying and exciting” when it seems like policymakers and other audiences are getting it right (FP05).

More Relevance for the Field and Scientists. The risk of not engaging in science communication, according to scientists, is the fate of their field’s future, for science does not matter if you don’t share it. As one scientist said, if scientists avoid communication, they “risk losing interest in science from future generations” (GP19). A lack of science communication would widen the gap between “everyday people and the mad scientist perception” and “not engaging is going to further and further separate the two groups of people” (GP20). Similarly, another scientist added that the risk of no science communication is not learning what the current issues are, so scientists get “caught up in your own bubble and have a warped perspective of what matters to people” (GP23). These scientists felt that not engaging in science communication would further distance scientists from the public and current trends, making institutions and fields of inquiry grow stagnant.

Ability to Counter False Claims and Misinformation. Another risk of not engaging in science communication, according to scientists, would be giving up the opportunity to add context, explain findings, or correct any false claims. As one scientist said, “if somebody has these beliefs that are rooted in anecdotes rather than science, it is difficult to ever engage with them, and you may be the person that changes somebody's mind or teaches them something new" (GP30). Another scientist recognized that "people have so many things on their mind now," and unlike the scientist, who has time to do in-depth research on a topic, "most people don't have time to do that. So, if we're not answering questions and letting people know what we know as scientists, then they're going to carry around a lot of misconceptions and probably share them with friends and family" (FP09).

RQ2: Perceptions of Science Communication CoP *Practices*

Given perceptions of value and risks of engaging in science communication, we asked scientists in our sample how to best mitigate these risks and be successful when communicating about science. Themes identified in the interviews included foundational practices such as considering the audience, being culturally sensitive, building mutual trust, and building basic communication skills. Despite being able to say what should mitigate risk and increase chances of success, scientists also mentioned not being confident in knowing how to put these practices into action. Each theme is described in more detail below.

Consider the Audience

The most common way to avoid failure mentioned during interviews was to consider the audience carefully. Specifically, scientists recommended accounting for differences in power and reflecting on how that impacts the audience and speaker's communication dynamics. Scientists mentioned understanding how the audience wants to receive information, their frameworks, and how receptive they will be to different aspects of scientific news and data, as "it's easiest to meet people where they're at" (GP20). One scientist said, "Number one, I really try to understand who the audience is going to be, what's their mindset – are they dieticians or lawyers or teachers – and then come in from that perspective and really listen to what people are asking" (FP09). Another scientist said:

> It's important to understand your audience as much as possible. It's more than, what is your educational background, what is your socioeconomic background? It's even deeper, like, what are their moral frameworks, how do they go through life and make value decisions because of science? (GP07)

After mentioning the need to consider the audience at the start of the communication process, scientists were probed about the overall role of the public and public feedback throughout the entire communication process. Many scientists were unsure on what was the role of the public and how to use the public's feedback, beyond the initial planning of communication activities. Some mentioned that the role of the public was to act on the information shared, by voting, buying certain products, or sharing opinions with elected officials. Some saw public feedback as likely to focus on evaluating the communicator or question the overall value of research, which could be unhelpful or harmful – any lead to negative experiences. One scientist said, "I mean, I think public feedback is valuable, even if it might be kind-of dangerous…hopefully, it doesn't mean that they're going to limit your ability to communicate about something from a bunch of negative feedback" (GP22). Another one acknowledged, "I

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think there is a fear of public feedback...and like, in terms of two-way communication, that sounds a bit terrifying to me" (GP30). A few scientists described positive experiences with feedback, including hosting listening sessions to direct research agendas and using surveys to figure out where narratives might be incomplete or confusing.

Prioritize Culturally Sensitive Approaches

Science communication often fails, according to our interviews, because scientists are not tuned into differences and culture. Scientists described the importance of matching the speaker and the audience appropriately and recognizing cultural nuances and sensitivities within audience groups. One scientist said, "People just have such different life experiences that it's rather easy to create narrative interactions that create more problems than they are solving by the communication process" (FP14). Another scientist in our sample also acknowledged, "there is a vast gulf between academics and the community, particularly in BIPOC communities, and an inherent distrust of academics. Effective communication requires we leave our hubris behind and build a level of trust before you can have effective communication" (FP14).

Build Mutual Trust

According to scientists, building mutual trust was also a way to mitigate risk and avoid failure. Scientists said that science communicators need to know who the audience trusts and make sure there is a strong bond of trust between the receiver and source of the message. To do so, one scientist suggested:

> What you try to do is find a common ground. Maybe they'll start by being vehement about vaccines or something, and then you try to work around that to reach someplace where you agree. You can say, 'oh, actually, that's where I think you're right and let's talk about that for a minute.' Because otherwise, you'll go down this rabbit hole and nobody learns anything (FP09).

Scientists also discussed finding common experiences to relate to audiences and begin with those shared connections and emotions to build trust, including humor, failures, or human interest-type stories. Beyond common ground, other scientists discussed the need to communicate uncertainty in science fields, in order to build trust. Scientists suggested that science communication needs to include more discussion of what science is and how it is practiced, in order for audiences to trust changes in messages and accept new data. Other scientists mentioned letting audiences know "the risks, as well as the rewards, and give them the tools to make their own decisions" during interviews (GP22).

Hone Foundational Communication Skills

The general skill of the communicator was frequently mentioned as one reason that science communication efforts fail. Specifically, scientists mentioned that science communicators needed more skill development in the following areas: leveraging visuals correctly, making the audience comfortable, not patronizing the audience, developing credibility, reading audiences, being approachable, mixing data and stories, adding interest, being confident and not nervous, conveying the big picture, connecting with the audience, and building a strong base or relationship. Some scientists wanted to know how to go beyond just telling people facts and instead "communicate science in a way that resonates with the values and frameworks and schema that people have in their minds and what makes it stick" so they feel connected to your science and research (GP07). This leads into themes and findings in our next research question, which centers upon the purpose of science communication.

RQ3: Perceptions of the Science Communication CoP *Community*

Scientists had different views regarding the purpose of science communication. Some described science communication as education, in which scientists shared objective facts with audiences. Others felt that science communication was more focused on translation or application of objective facts to the needs of particular audiences. Others felt that science communication was a way to embrace dialogue, listening, and a back-and-forth relationship with audience members. The most varied discussions surrounding the purpose of science communication involved the role of advocacy within science communication efforts. More details about what scientists said about the role of advocacy is addressed below.

Science Communication as Advocacy

Some scientists fully embraced the purpose of science communication as advocacy. One scientist said, "The goal of science communication is to induce societal change, which is literally advocacy" (GP02). There was a strong connection between advocacy and education for these interviewees, and both were described as core responsibilities of scientists. Communication efforts could fully embrace advocacy, scientists said, as it was the way in which application of data happened. Facts must back up advocacy efforts, but some scientists felt it was their duty to share information in a goal-oriented manner and make sure interpretations of research were correct. As one scientist said, "I think if we've got the right information and we have the authority, we go to school for this for a reason. We should speak up when we think it's important" (FP21). Some mentioned strong guidelines at the university-level about when it was acceptable to publicly advocate a position. They wanted to respect those guidelines, but also speak as scientists and advocate particular positions. One scientist acknowledged that tenure and power would likely make them feel more comfortable being an advocate.

Some scientists warned that by not embracing advocacy on some level and only focusing on objective facts, scientists as a group risk coming across as too rigid, not enthusiastic, and not focused enough on having authentic conversations with audiences. By embracing advocacy, it allowed some scientists to embrace authentic conversations and enthusiastically engage in back-and-forth interactions with audiences, in which they could be vulnerable.

When thinking about the purpose of science communication, one scientist said translation and advocacy should be the purpose and said, "do we actually just try to be objective, which means we stay out of the political arguments, stay out of advocacy? That doesn't work, because the science never gets translated" (FP05). One scientist acknowledged that it is difficult to "separate the science expert identity from the fact that you are a citizen who has partisan, political interests" and opinions about policy outcomes (GP07). Another scientist added, by embracing science communication as dialogue and advocacy, "we can actually create new practices and cultures of science based on reciprocity and interconnection" (GP13).

Science Communication as Advocacy Only for the Common Good

Some scientists embraced the general idea of science communication as advocacy but put strong boundaries on this idea. If efforts were focused on betterment of society, advocacy was deemed a good idea. Some scientists felt strongly that scientists had to be advocates for science in general and for common community needs or the public good (like clean water or vaccinations), but scientists should not be advocates that share a particular position, suggest a solution, or support a certain viewpoint. For some scientists in our sample, the distinction was about benefits from the information being shared that separated good and bad advocacy efforts. For example, one scientist said, “If I’m advocating for clean water, is that really an advocacy position? I’m not making money off of it. That is a different thing from advocating for results from my research because I’m going to make money” (FP05). However, a boundary of advocating only for the public good might be difficult to judge for some topics or some scientists, as one scientist said, “I was going to say all advocacy on behalf of the public good should be welcome. But, of course, people who advocate for topics like GMOs think they’re in the best interest of the public, and really believe it” (FP05).

Some scientists felt that there was a need for scientists to be advocates and push for informed political discussions with their expertise, otherwise, the advocacy would be left up to public relations firms and non-experts. This is a fine line, as one scientist pointed out, “It’s a very fine line between advocating the right amount and ensuring that science has a seat at the table and informs policy making and gets research out there and ensures that people feel they can understand it” and acknowledging that a PhD in chemistry doesn’t give you “the power to make decisions about funding or health policy, you’ve got to run for office, as that’s someone else’s job” (GP07). Others felt science should be able to serve as a resource for policymakers and should inform and elevate public debate. If this is the case, they said, there should be space for advocating for policy outcomes. One scientist said, “We don’t look at lawyers or doctors who advocate for things and say, well, now medicine is partisan or the legal profession is against democrats. We look to those experts to offer their advice” (GP07).

When discussing science communication’s purpose, many scientists referred to a need to at least be an advocate for science, data, and scientific ways of thinking. This was akin to being an advocate for critical thinking and good decision making. One scientist said, especially now that “people don’t believe in science,” those doing science communication “have to convince people that science is always there and will always be there. Disbelieving it would actually harm it, harm individuals, and all of us as whole” (GP08). One scientist said, “I am an advocate. I’m an advocate of science. At the bottom of my email it says, ‘biased for science’” (FP09).

Science Communication as Sharing Objective Truth

In contrast, some interviews rejected ideas of advocacy in connection with their science communication efforts. These scientists described a need for scientists to stay objective and focus on data. This was one way to build trust with audiences and to stay in the neutral mind space that is required to find objective scientific results. For example, one scientist said that they have a hard time trusting even other scientists in their field, unless they share only raw data and evidence. Another added, “It is our job as scientists to not always be correct. To take in the latest information, weigh it, figure out what’s good quality data, what’s not, form a good hypothesis, and test it" (GP23). Unless you are completely neutral and scientific, for this scientist, you risk misinformation. Scientists in this group suggested that science communication focus on what we learned from the field or lab, and avoid discussions about what we can do with that information.

For these scientists, a focus on objective information and data allows them to avoid risks or pitfalls associated with advocating. As one scientist pointed out, advocacy is often very mission-oriented, and well-funded advocacy groups can be very vocal and popular, which in turn, can silence other voices on an issue. Scientists cautioned that if a scientist becomes an advocate, the public will devalue their messages, especially audiences with opposing viewpoints. As one scientist said, "I view science communication as a discussion. If you have loud voices, you are drowning out a discussion. I would say that's a real risk of advocacy" (GP15).

Some in our sample believed that scientists should avoid advocacy because most were not very skilled at doing this type of communication effectively. These scientists mentioned that advocacy efforts could backfire unless training is offered in this area. One scientist said, "we should do [advocacy work]; I think it is really important. But, who becomes an advocate? Are you trained for it? Do you have a degree in advocacy?" (FP11).

Discussion and Conclusion

The findings described above are specific to this group of interviewees, who are graduate students and faculty scientists at land-grant institutions within the United States that are committed to agricultural or environmental science disciplines and are new or occasional members of the science communication community of practice. The qualitative nature of this project and the focus on this specific group are limitations of this study. However, this specific focus also allowed for an in-depth examination of how emerging and peripheral members view the science communication CoP's domain, practices, and community identity, and allowed us to identify potential factors that might serve as motivations or constraints for ongoing engagement or further commitment to the CoP. Members participate in communities of practice at different levels and have different needs, values, and interest (Wenger et al., 2002). The information gathered in our research project can help with the development of specific learning interventions, activities, experiences, and discussions to support occasional science communicators and their potential move from the periphery to the core of the community of practice.

In our study, interviewees were especially concerned with personal risks of communicating (RQ1), especially the loss of control over messaging, interactions with disagreeable audiences, burnout, and reputation damage. At the same time, many scientists also believed that science communication is a valuable way to create personal relationships or emotional connections with their work. In some ways, our insights align with previous literature on general motivations and deterrents for science communicators (Wilkinson et al., 2023; Koswatta et al., 2022; Ho et al., 2020), yet, the in-depth nature of our inquiry also allows us to add some detailed insights. For example, personal motivators were important in our study, similar to the findings of Wilkinson et al. (2023), and further, we were able to build upon their insights by identifying personal motivators as specifically being focused on developing relationships with end users and strengthening emotional connections with their work. Additionally, scientists in our study were concerned with time, skill, and lack of resources, which echoes other scholarship (Wilkinson et al., 2023; Koswatta, 2022; Ho et al., 2020), but deterrents also included more highly personal risks connected to bullying, permanent reputation damage, and embarrassment. Additional research might continue to unpack some of the broad motivators and challenges identified in previous research to examine how catalysts, constraints, and views of the science communication CoP domain, practices, and identity change slightly among members - especially with shifts in participation level, years of experience, training resources, or scientific discipline. Our findings suggest that trepidation around unknown publics and fear of imagined angry audiences might be important constraints for new or occasional science communication CoP members. Trainings or workshops modeled after classroom crisis simulations that allow for trial, error, and reflection (Anderson et al., 2014) might be a valuable tool to allow scientists to practice communicating on social media in a fast-paced environment with multiple stakeholders.

Our findings connected to CoP practices indicate that scientists' perceptions on how to mitigate personal risks align well with best practices for strategic communication (Besley & Dudo, 2022). In our interviews, practices centered around the relationship with the audience, including considering power dynamics, using a shared language, understanding moral frames and receptiveness to information, considering communication preferences, building trust, and understanding social networks, (RQ2), yet there were some comments about not being confident in putting these principles into practice. Many communication theories and dialogical communication models align with these practices, which put audiences at the center of communication efforts (Taylor et al., 2019; Anderson et al., 2016). Our findings indicate that continuing to stress these audience-centered theories and approaches is important for new or occasional science communicators as well as early experience applying these principles.

Public relations theories and practices within the relationship-management area that examine how to build dialogue, communicate commitment, improve interactivity, and incorporate interpersonal communication (Capriotti et al., 2021; Anderson et al., 2016; Smith, 2012) might be useful to incorporate into training and early experiences. Further, although most scientists in our study were able to articulate a need to consider the audience at the start of the communication process, most were unsure of the role of the public, and useful ways to use public feedback, throughout the rest of the communication process. Other researchers have described the need for science communicators to invest in relationships, which includes gathering and learning from many voices during the communication process and fostering interpersonal trust, appreciation, and respect (Reincke et al., 2020; Besley et al., 2018). Competencies and learning progressions focused on early or occasional science communicators should include a specific focus on the role of the public, the role of experts, and valuable ways to gather and learn from public feedback throughout the communication process, in order for occasional science communicators to really invest in relationships. This is especially true for those working in fields like environmental or agricultural science, with politically charged or contested issues, who might fear public response. Agricultural communication experts, a subfield of science communication, are particularly well-positioned to provide training in these areas, but especially around communicating contentious issues in the public sphere (Parrella et al., 2023).

Scientists in our study did not have clear agreement about the purpose of science communication, and the role of advocacy within science communication was a point of contention for some scientists in our sample, as well as concerns about how to share uncertainty around scientific findings (RQ3). Future research should continue to explore potential concerns, barriers to, and differing conceptualizations about the purpose of science communication, especially for those who are just starting to explore science communication training and work. There was an alignment between scientists who embraced science and advocacy and relationship-based models of communication; scientists who described science communication as advocacy used descriptors such as authentic, dialogue-focused, interconnected, and reciprocity. There is also an opportunity for future research that examines these themes among different populations with different backgrounds, training levels, or other types of science communication experience (for example, more public sector experiences).

Regarding perceptions of professional identity, our research suggests that scientists, especially those new to science communication, have conflicting views on the role of advocacy in science and its relationship to professional norms or values. Some of the scientists in our study preferred to be advocates, interpreters, translators, or dialogue brokers, while others preferred to advocate only for the common good or science, and other scientists preferred to avoid advocacy altogether. This aligns with Brüggemann, Lörcher, and Walter (2020) prediction that some science communicators and science journalists will increasingly embrace advocacy in post-normal science communication environments. Further exploring how advocacy fits with science communicators' self-identity perceptions is important, as is continuing to explore the expectations that citizens, peers, and journalists might hold about scientists and their relationship to advocacy and objectivity (Nicolaisen, 2022). These differing perceptions about the roles of objectivity vs. advocacy might impact views of responsibility for science communication practices and explain insights from scholars like Parrella et al. (2022), who found a disconnect among some scientists who embrace disseminating science information in general, yet do not feel personally responsible for public engagement of their own work. These perceptions about advocacy can impact training too; for those new to science communication, some advanced audience-focused and persuasion-based communication practices and theories, like framing, might feel like a conflict for scientists when advocacy remains a contested norm (Brüggemann, Lörcher, & Walter, 2020; Wilke & Morton, 2015).

In order to attract a wide audience to training and workshops, science communication should align with a wide range of professional norms, roles, values, and practices, especially for those in contested disciplines such as agriculture, food, and natural resource sciences. Training might include opportunities for self-reflection about norms, values, and practices that align best with the professional identity, motivations, aspirations, and responsibilities of the individual scientist, and have that guide goal-setting and the selection of objectives, tactics, and competencies or skills needed. Self-reflection exercises might draw from social identity theory (Tajfel & Turner, 2004), as applications of this theory in research on journalists (Grubenmann & Meckel, 2017) and public relations professionals (Mellado & Hanusch, 2011; Gilpin, 2010) are useful in understanding how professional identity influences interpretations of change and acceptability of practices within a profession. Given previous scholarship on graduate students and postdoctoral fellows' science identity, and its strong ties to lab-based work and disciplinary talk (Hudson et al., 2018), self-reflection exercises that broaden science identity to include science communication and outreach as key components of a scientist's responsibility and professional identity would be especially beneficial for graduate students and postdoctoral fellows in science-based disciplines.

As the larger media environment changes and science's uncertainty is more directly addressed, it will be necessary for experts in many disciplines to build authentic relationships with publics. Scientists need to share their knowledge as they are comfortable; at the same time, facts without caveats, context, or emotion might not be enough to connect with public audiences that are navigating complex knowledge on contested issues and topics (Besley & Dudo, 2022). Science communicators must continue to strengthen their work by understanding the needs, concerns, and practices of members at the periphery of the community of practice and what motivations might help sustain their engagement in this work.

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