SCIENCE COMMUNICATION TRAINING, SKILLS, AND IMPORTANCE AMONG AGRICULTURAL, FOOD, AND ENVIRONMENTAL SCIENTISTS

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Abstract

Science communication practice aligns well with land-grant missions, can increase public understanding of science disciplines and institutional work, and has the potential to be a key part of agricultural, food, and environmental science programs. The purpose of this study is to explore perceptions of science communication's importance, skill needs, and training interests among faculty and graduate students in agricultural, food, and environmental science disciplines at land-grant institutions. Through open and closed-ended survey questions, participants describe time currently spent, time desired, perceived costs, and potential motivations for initiating or devoting ongoing time to science communication training and practice. Potential skills that are valuable to include in science communicating curriculum and training workshops are shared. The study identifies key similarities and differences between students and faculty participants and offers potential suggestions for how to approach science communication skill development within the agricultural, food, and environmental sciences.

Keywords: Science communication, agricultural communication, training, skills, survey

Science literacy, especially agricultural and environmental literacy, is vital to reducing public skepticism toward science and increasing evidence-based policymaking and behavior change (Besley & Tanner, 2011; Cologna et al., 2023). A key way to increase literacy and the quality of discourse on science-based topics with the public is to incorporate more formal science communication training into aspiring scientists' undergraduate and graduate curricula (Brownell, 2013). Burns et al. (2003) define science communication as the "use of appropriate skills, media, activities, and dialogue" (p. 191) that produces awareness, enjoyment, interest, understanding, and opinion change. Science communicators report offering training to engineers, bench scientists in many disciplines, health regulators, journalists, and medical personnel (Besley & Tanner, 2011).

Science communication training should be an especially important cornerstone within land-grant institutions and of interest to faculty and students across agricultural, food, and environmental science programs. The science communication research agenda adopted in 2017 by the National Academies of Sciences, Engineering, and Medicine (NASEM) aligns with agricultural goals and land-grant missions (NASEM, 2017). The agenda includes sharing scientific findings and excitement, increasing appreciation and use of science, influencing public opinion, behavior and policies based on scientific evidence, and addressing perspectives of diverse groups to create societal solutions (NASEM, 2017). There is also a logical home for science communication within these institutions: agricultural communications, a program within many colleges of agriculture that integrates agricultural science and communication skills (Miller et al., 2015), which can be viewed as a sub-discipline of science communication (Parrella et al., 2023). According to McLeod-Morin et al. (2020), agricultural research center directors perceive science communication as a service to public knowledge and obligation of scientists at public institutions, especially at land-grant universities and within Extension programs.

Despite this alignment with institutional mission, few programs require agricultural, food, and environmental scientists to complete science communication courses or workshops (McLeod-Morin, 2024). Science curriculum also does not address the wide breadth of scientists' potential roles in academia and industry, including roles and opportunities connected to public communication (Masambuka-Kanchewa, 2023). There is a need to expand science curriculum and to offer more science communication training programs for agricultural scientists, especially training that includes a focus on skill development (McLeod-Morin, 2024; Parrella et al., 2023; Washburn et al., 2022).

Science communication is evolving from a one-way communication model to a two-way communication model that prioritizes “interaction, interest, and participation among non-expert audiences and scientists” (White et al., 2023, p. 69). With this shift towards a more participatory model, scientists are expected to engage in more complex back-and-forth dialogue with audiences and have deep understanding of audience values, beliefs, needs, and motivations (Besley & Dudo, 2022). Science communication training is necessary for scientists to be successful communicators amid the growing complexity of science communication practices, platforms, and expectations (Lewenstein & Baram-Tsabari, 2022).

To increase the number of graduate students and faculty in agricultural, food, and environmental disciplines who engage in science communication training, we need ongoing investigations of desired skills related to science communication (Swenson & Marson, 2024; McLeod-Morin et al., 2024). We also need more focused exploration of what might motivate agricultural and environment scientists, especially those with early interest in science communication, to seek out science communication training and practice that can augment their major field of study. This manuscript seeks to help fill this gap examining perceptions of science communication practices, skills, motivations, value, benefits and costs among graduate students and faculty in agricultural and environmental programs at land-grant institutions.

Theoretical Framework

We used Expectancy-Value Theory, a motivational theory often applied within the education discipline, as a guide for our research. In general, motivation theories help describe, explain, and predict the initiation and persistence of different learning behaviors (Urhahne & Wijnia, 2023). According to Hattie et al. (2020), central dimensions cut across motivational theories of education that help explain why individuals select or continue a course of learning action. These dimensions include the self (efficacy and confidence and perceived capabilities), the social environment (comparisons or relatedness), the task (perceptions of importance), goals (sustained effort), perceived costs, and perceived benefits (effort, opportunity, and emotional cost compared to alternative or competing options) (Hattie et al., 2020). Expectancy-Value Theory, in particular, suggests that choice to engage in and sustain learning activities is often motivated by self-perceptions of skills and abilities, expectations for success, and subjective task value (Wigfield & Cambria, 2010).

For our study, we applied the tenets of Expectancy-Value Theory, as described by Wigfield & Eccles (2000), to our exploration of perceptions of science communication training. Expectancy-Value theory suggests that more time is spent on tasks where expectancy and value are high (Wigfield and Eccles, 2000). To apply Expectancy-Value theory to science communication, we explored questions about the *perceived importance of science communication*, which aligns with the value dimension of the theory, as motivation to engage in activities can be impacted by perceptions of importance to self and others. We also include questions about the *time spent on science communication and time desired*, and probe for related costs, benefits, opportunities, motivations, and risks. To examine self-efficacy and confidence, we also address comfort levels with a variety of *science communication skills*. Using common dimensions from Expectancy-Value theory helped us structure our inquiry and gave us a lens through which to interpret our data and its implications.

Purpose

The purpose of our study was to understand perceptions of science communication practice and training among faculty and graduate students in agricultural, food, and environmental science programs at land-grant institutions. We targeted faculty and graduate students who were not majoring in a communication or education field. There were four main research objectives:

- RO1: Examine perceptions of science communication’s importance among faculty and graduate students in agricultural, food, and environmental science programs at land-grant institutions.
- RO2: Examine time spent and time desired for science communication training and practice among faculty and graduate students in agricultural, food, and environmental science programs at land-grant institutions.
- RO3: Examine potential motivations and perceived costs or inhibitors for initiating and sustaining science communication training and practice among faculty and graduate students in agricultural, food, and environmental science programs at land-grant institutions.
- RO4: Evaluate potential skills that are valuable to include in science communication curriculum or workshops for agricultural, food, or environmental scientists.

Methods

Sample

To address our research objectives, we used a purposive sampling method to construct a list of potential survey respondents, which allows researchers to select participants based on specific criterion related to their particular knowledge and experience with a topic (Robinson, 2023). Our criterion included academics in agricultural and environmental disciplines at land grant institutions, with different levels of engagement in science communication. More specifically, we constructed our sample by collecting names and emails of graduate students, faculty, and staff from graduate programs at four land grant institutions within different regions of the U.S.: University of Minnesota, University of Wisconsin, University of Florida, and University of California-Berkley, from departments that include 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 Economics. After reviewing lists of departments at the four land grant institutions, these departments were selected because they represent a variety of agricultural and environmental science-based disciplines, and they were present across multiple land grant institutions. We coded potential respondents into three categories: low, medium, and high science communication experience levels based on the prevalence of information in their online profiles referring to their major, science communication experience, and membership in science communication groups. Specifically, we attempted to avoid anyone with high levels of science communication experience, defined for this research as someone who is majoring in a science communication-related discipline or who appears to do full-time science communication work. This was to limit selection bias. As students and faculty fully engaged in science communication work are more likely to respond to a survey on science communication, we focused on recruiting potential respondents from the low and medium experience categories. We defined the medium experience category as faculty and students who had a mention of some science communication-related projects, experience, interest, or group membership. We defined the low experience category as faculty and students who had no mention of science communication on their biographies.

After receiving IRB approval, we sent an initial request and two follow-up reminders. We had a total of 131 respondents who consented to the survey, and 87 respondents proceeded to answer some portion of the questions. Medium-interest targets were indeed more likely to respond and consent (10.8% response rate) compared to low-interest targets (3.6% response rate). The composition of respondents by institution was 18.3% from the University of California-Berkley, 2.3% from the University of Minnesota, 32.8% from the University of Wisconsin-Madison, and 46.6% from the University of Florida.

Survey Construction

The survey developed for this research project consisted of questions regarding the importance of science communication to self and others, time spent on science communication (current and desired), skills in science communication (overall rank of current skills, current and desired comfort level with 12 specific skills), and demographics. First, we assessed respondents' perceived importance of science communication (RO1) to themselves and others. Respondents were asked how important science communication is to themselves along with their perceived importance of science communication to their university, college dean, division, chair, state, colleagues, land grant institutions generally, and academic and public hiring committees. Respondents rated items on a 5-point scale with a "not sure" option, in which: one is *not at all important*, two is *somewhat important*, three is *important*, four is *very important*, five is *extremely important*, and six is *not sure*.

To assess current time spent and desired time spent on science communication activities (RO2), respondents were asked what percent of work time they currently devote to science communication and what percent of work time they would like to devote to science communication on a scale from 0-100%, in 10% increments.

Next, we asked questions related to current and desired skill level (RO4). Respondents rated their current overall science communication skills on a 5-point scale, in which: one is *terrible*, two is *poor*, three is *average*, four is *good*, and five is *excellent*. This was followed by a block of questions asking respondents to rate how comfortable they currently are, and how comfortable they would like to be, in twelve specific skill areas: presenting in academic, K-12, public, and informal settings, writing for the public, developing infographics and videos, developing outreach plans, speaking to the media, podcasting, use of social media, and blogging, which was again collected on a 5-point scale, in which: one is *extremely uncomfortable*, two is *somewhat uncomfortable*, three is *neither comfortable nor uncomfortable*, four is *somewhat comfortable*, and five is *extremely comfortable*.

In the following section of the survey, we asked thirteen open-ended questions on why science communication was perceived important to self and others, perceived costs and benefits, opportunities and risks of time spent on science communication, motivations for engaging in science communication work, and perceptions of ideal models and approaches for science communication training (RO3). We decided to include open-ended and closed-ended survey responses to give participants an opportunity to provide unstructured text feedback, along with the more defined responses. As Rouder et al. (2021) write, open-ended responses are "often a successful way to solicit authentic and unexpected feedback, highlight the diversity of responses or nuances in opinions, and capture the 'why' that complements quantitative survey data" (p. 1). To establish face validity, we had two experts in agricultural communications review the survey and provide feedback. The final survey section collected demographic information on respondents.

Analysis

Tables four to 11 report t-test results, and table 12 reports Pearson's correlation results using Stata software (StataCorp, 2017). Parametric tests of Likert scale variables can be justified with Likert scales of at least five options if they are approximately normal (Harpe, 2015). Although t-tests typically require normally distributed variables, in sample sizes greater than 30 CLT generally applies and the t-test is robust to non-normality, and quite often this is true even in cases with sample sizes less than 30 (Norman, 2010). For many of our variables, Shapiro-Wilk tests (Wilcox, 2017) reject the hypothesis that variables are normally distributed as reported in tables. Our sample sizes are somewhat small, and at times our sample size is lower than 30 so for all comparisons we performed non-parametric tests for robustness. Although parametric tests are discussed in the paper, applicable non-parametric tests were run and are reported next to parametric tests in all tables for robustness, confirming findings. The Kruskall-Wallis (Conover, 1999) test was performed for independent groups, and the Wilcoxon signed-rank test was performed for matched pairs. Pearson's correlations discussed in the findings are shown in table 12 with accompanying Spearman's rank nonparametric results.

Of the 87 respondents answering the survey, 30 dropped off at the introduction of open-ended questions resulting in a lack of demographic data for those respondents. Any comparisons using demographic data were done using this smaller subset of data. We tested for differences between those respondents that completed the survey and those that dropped off, using t-tests to compare stated importance of science communication to themselves and others, and found no significant differences. The number of respondents in all tables varies slightly depending on how many respondents answered a survey question and whether they chose "unsure."

Our open-ended responses were coded using qualitative open coding techniques (Strauss & Corbin, 1998). Key patterns were first identified to produce emergent themes and then a second round of focused, line-by-line coding confirmed themes, following Esterberg (2002) best practices for open coding. Once themes were refined and narrowed, researchers used a constant comparative method of analysis for qualitative data; more specifically, we reviewed content in multiple rounds to ensure themes accurately reflected respondents' intentions and then identified quoted content to illustrate patterns (Cresswell, 2013; Lindlof & Taylor, 2011).

This study is meant to shed light on perceptions and training desires regarding science communication of a specific population of professors and students in land grant universities. While endeavors have been taken to make this study statistically sound, this study is not presented as an infallible representation of this population and is not meant to be extrapolated to larger populations; instead, it is meant to generate discussion and further study of science communication programs in this arena.

Findings

General Demographics

Tables 1 and 2 show the demographics of survey respondents that answered the demographic questions. Of the respondents to the survey that answered, gender was nearly evenly split: 49% were female (*n* = 31), 46% were male (*n* = 29), and 5% identified as gender nonconforming (*n* = 3). Roughly half the respondents (*n* = 31) were less than 35, 80% (*n* = 50) were under 55. Regarding education, 14% of respondents (*n* = 9) had an undergraduate or master's degree and were not in the process of pursuing a doctorate, 31% (*n* = 20) were in the process of obtaining a doctorate degree, and 55% (*n* = 35) had already obtained a doctorate. Regarding respondents' current role, 44% (*n* = 28) identify as students, 9% (*n* = 6) identify as postdocs, 38% (*n* = 24) identify as professors, and 9% (n = 6) identify as "other." 63% (*n* = 41) of respondents report having professional experience outside of academia. The number of respondents answering each question ranged from 61 to 65.

Table 1

Summary statistics of survey participants: demographics

Variable	Description	Percent	*N*
Prof. exp.	*Professional experience outside of academia*		65
	Yes	63%	41
	No	37%	24
Education	*What is your highest level of education?*		64
	Undergraduate or masters degree	14%	28
	Working on doctorate degree	31%	20
	Doctorate degree completed	55%	35
Role	*What is your current role?*		64
	Student	44%	28
	Post-doc	9%	6
	Professor	38%	24
	Other	9%	6
Age	*How old are you?*		61
	Less than 25	3%	2
	25-35	48%	29
	36-45	13%	8
	46-55	16%	10
	56-65	8%	5
	66-75	12%	7
Gender	*How do you identify?*		63
	Male	46%	29
	Female	49%	31
	Other	5%	3

N varies due to number of respondents answering each question.

Table 2

Summary of statistics of survey participants: social media use, politics, and trust in media.

Variable	Description	Percent	Mean	*SD*	*N*
Social Media Use	*5-point Likert*		2.1	1.33	62
	1 = Multiple times a day				
	5 = Less than once a week				
Liberal or Conservative?	*5-point Likert*		1.95	0.96	63
	1 = Very Liberal				
	5 = Very Conservative				
Trust in Media	*5-point Likert*		3.05	0.89	64
	1 = A great deal				
	5 = None at all				

N varies due to number of respondents answering each question.

1. Importance of Science Communication (RO1)

To analyze the perceived importance of science communication, we asked respondents to rank the importance of science communication to themselves on a 5-point Likert scale from *"not at all important"* to *"extremely important."* The mean response was 4.44, with 63% of respondents (n = 55) reporting science communication as extremely important, 22% felt it was very important, and no respondents reported science communication as *"not at all important."*

We added context to the importance of science communication to survey respondents by also asking about the perceived importance to respondents' university, dean, division, chair, state, colleagues, land grant institutions, and public and academic hiring committees, as shown in Table 3. Respondents reported perceived importance of science communication to themselves (M = 4.44, SD = 0.86) and land grant institutions (M = 4.51, SD = 0.67) highest. Perceived importance of science communication to respondents' state (M = 3.09, SD = 1.08) was ranked lowest.

The importance of science communication to individuals was strongly correlated with the perceived importance of science communication to individuals' university, $r(87) = .56$, $p<.00$, and department chairs, $r(86) = .48$, $p<.00$. Importance of science communication to individuals was still positively correlated, but at lower levels, with perceived importance of science communication to colleagues, $r(87) = .33$, $p<.00$, dean, $r(87) = .30$, division, $r(87) = .26$, $p<.00$, and academic hiring committees, $r(86) = .25$, $p<.02$. See table 12 for more correlation statistics and supporting nonparametric evidence.

Table 3

Summary of reported importance of science communication to various groups.

Variable	Mean	*SD*	*N*
Importance to you:	4.44	0.86	87
Importance to your university:	4.14	0.95	86
Importance to your dean:	4.11	1.00	72
Importance to your division:	4.15	0.92	80
Importance to your chair:	3.95	1.06	82
Importance to your state:	3.09	1.08	77
Importance to your colleagues:	3.69	0.98	84
Importance to land grant institutions:	4.51	0.67	71
Importance to public hiring committees:	3.52	1.14	71
Importance to academic hiring committees:	3.47	1.16	72

All questions asked on a 5-point scale from not at all important (1) to extremely important (5) inclusing an option for "unsure."

Science communication's importance: Open-ended responses

When asked if science communication is important in open ended questions, 97% of respondents specifically say yes. In other words, their response includes the word yes, with no caveats. In open ended questions, a sense of responsibility was the most often stated reason for science communication's importance, and it was mentioned in 35% of responses for both students and professors. Professors (13%) were a little less likely to say there is a negative view of science communication than students (21%) and were less likely to say science communication is not prioritized.

In open ended questions, improving rapport and trust with communities was the most listed reason for importance of science communication for students, listed in 41% of responses, and helping people be more aware was the most often listed benefit of science communication, listed in 51% of professor responses and 62% of student responses.

Science communication's importance to you

Fulfill responsibility and obligation as a scientist. Respondents described the importance of science communication as tied to their responsibility and obligation as scientists. Some saw science communication as the final part of the scientific process. Respondents also described science communication as part of their obligation or calling as scientists and a way to fulfill debt to society.

Serve community. Respondents also saw science communication as important because it increased community access to information, strengthened public education, and improved general literacy. They saw science communication as a bridge between science and society. For example, science communication was a way to gather feedback from the community and give community members a voice within the scientific process.

Inform decisions and decision-makers. Science communication is important, according to respondents, because it can improve the decision-making process and support decision-makers like policymakers. Science communication could help inspire independent thought among members of the public and slow down the misuse of information. Respondents also believed science communication improves policy creation, as well as the choices made by the public. It can motivate behavior change, change laws, and direct funding.

Translate for university. Science communication is important for universities, as it can help translate institutional work to multiple groups and support land-grant missions. It can improve the social relevance of a university and increase respect for institutional work.

Develop mutual appreciation. Science communication can inspire curiosity, wonder, trust, and understanding among members of the public, according to respondents. It can also give scientists purpose, agency, satisfaction, and improve how they feel about the meaning or impact of their work. Respondents said science communication is important to them because it can help them connect with others and improve their usefulness as a researcher.

Perception of science communication among others in discipline

When asked in the open-ended questions about how others within their discipline felt about the importance of science communication, many respondents said that their discipline supported science communication in general and viewed it as a growing and important element of the educational experience. However, some respondents admitted that many would say science communication is important but would not devote resources to its work nor would they prioritize it. Further, the bottom-line investment in science communication was unclear. Similarly, respondents admitted that others in their discipline might see a need for science communication but wouldn't be bothered to do it themselves, as it was work for other people to complete, and it could interfere with "real" work. Others admitted that science communication was viewed negatively among others in their discipline, as a waste of time, an activity that

Table 4

Comparisons of importance of science communication to various groups.

Group	*N*	Mean	*SD*	*T*-test	*df*	*p*	Wilcox
Self	86	4.44	2.1	1.33	62	.00	.00
University	86	4.14	0.95				
Self	72	4.46	0.87	3.00	71	.00	.00
Dean	72	4.11	1.00				
Self	80	4.48	0.86	3.01	79	.00	.00
Division	80	4.15	0.92				
Self	83	4.44	0.86	4.74	81	.00	.00
Chair	83	3.95	1.06				
Self	77	4.43	0.86	8.74	76	.00	.00
State	77	3.09	1.08				
Self	84	4.48	0.81	7.95	83	.00	.00
Colleagues	84	3.69	0.98				
Self	71	4.42	0.86	-0.68	70	.50	.66
Land grant institutions	71	4.51	0.67				
Self	56	4.46	0.89	5.13	55	.00	.00
Public hiring committees	56	3.52	1.14				
Self	72	4.42	0.85	6.67	71	.00	.00
Academic hiring committees	72	3.47	1.16				
Public hiring committees	56	3.52	1.14	0.00	55	.00	.93
Academic hiring committees	56	3.52	1.21				

Wilcoxon signed-rank nonparametric test reported for robustness could lead to ideas being stolen, something that exposed scientists to dangerous interactions with the public or to pressure from opinion outliers, like donors or the public with extreme views. Science communication could also force scientific consensus rather than elucidate differences in ideas.

2. Time Spent on Science Communication: Current and Desired (RO2)

Respondents were asked for the percentage of work time they currently spend on science communication, and the percentage of time they desire to spend on science communication, as shown in table 6. T-tests are reported here, supporting nonparametric results are reported in tables. The percentage of work time respondents report currently spending on science communication (*M* = 29.9%, *SD* = 24.8) is lower than the percentage of time respondents would like to spend on science communication (*M* = 40.2%, *SD* = 26.8), $t(84) = -5.50$, $p < .00$. Assuming a 40-hour work week, this difference of 10% equates to a desire to spend four more hours per week doing science communication. Regarding how much time is currently spent on science communication, 60% of respondents (*n* = 50) reported currently spending 20% of their time or less on science communication. A significant portion of respondents (*n* = 12) report currently spending exactly 50% of their time devoted to science communication. The rest of the respondents (n = 22) are fairly evenly distributed up to 100% of time spent on science communication.

Figure 1 shows the current and desired amount of time spent on science communication by perceived value of science communication. Those who believe science communication is extremely important have the highest values of both current and desired time spent, and desire to do more science communication than they currently do. As depicted in table 5, the difference in time currently spent and time desired is only significant in the groups reporting science communication is very or extremely important to themselves.

Figure 1

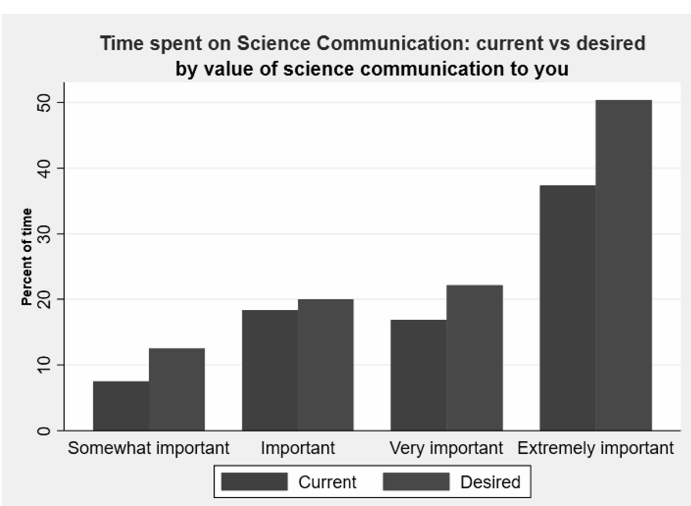


Figure 2 depicts how much more time respondents would like to spend doing science communication work. Currently, 42% (*n* = 35) of respondents report working less than 20% of their hours in science communication while 21% (*n* = 18) of respondents desire such a low portion of their work to be in science communication. 36% of respondents (*n* = 30) would like to keep their current science communication workload, and 55% of respondents (*n* = 46) would like to increase the amount of science communication they do as part of their work. Ten percent of respondents (*n* = 8) report desiring between 10% and 20% less time spent on science communication. Not all of these respondents answered demographic questions. Of those that did respond to demographic questions (*n* = 5), one was male, two were professors, two were somewhat conservative, and two were distrusting of the media. Three list controversy and public backlash as a risk of science communication in open ended questions.

Figure 2

Importance by role

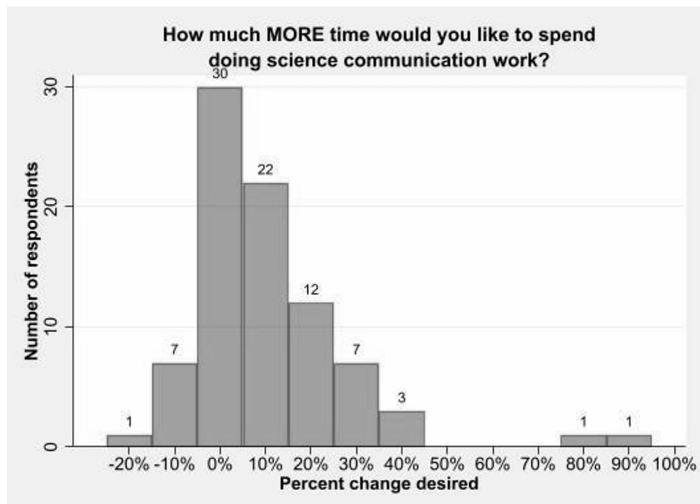


Table 6 compares current and desired time spent on science communication for subgroups. Although there is no significant difference in desired time spent in science communication between respondents with and without professional experience, those with professional experience report higher levels of current science communication work (*M* = 35%, *SD* = 25.33) than those without professional experience (*M* = 20%, *SD* = 21.47), $t(60) = -2.36$, $p<.00$. This is possibly due to a higher level of perceived importance of science communication by those respondents with professional experience, with the difference between perceived importance of science communication between those with professional experience (*M* = 4.60, *SD* = 0.74) and those without professional experience (*M* = 4.21, *SD* = 0.98) mildly significant, $t(62) = -1.81$, $p<.08$ as reported in table 5.

Table 5

Comparisons of importance of science communication to self for subgroups.

Group	*N*	Mean	*SD*	*T*-test	*df*	*p*	K-Wallis
Students	34	4.5	0.86	0.00	56	1.00	.96
Professors	24	4.5	0.83				
Professional Exp	40	4.6	0.74	-1.81	62	.08	.07
No Professional Exp	24	4.21	0.98				

Kruskal-Wallis nonparametric test reported for robustness.

Table 6

Comparisons of current and desired time spend on science communication by various groups.

Group	Variable	*N*	Mean	*SD*	*T*-test	*df*	*p*	Wilcox	K-Wallis
All	% time currently	84	29.88	24.76	-5.50	83	.00	.00	
All	% time desired	84	40.24	26.75					
Professional Exp	% time currently	38	34.74	25.33	-2.36	60	.02		.01
No Professional Exp	% time currently	24	20	21.47					
Professional Exp	% time desired	39	43.59	26.7	-1.50	61	.14		.11
No Professional Exp	% time desired	24	33.33	25.99					
Students	% time currently	33	25.15	23.2	-1.29	54	.20		.24
Professors	% time currently	23	33.91	27.26					
Students	% time desired	34	42.06	27.39	0.51	55	.61		.57
Professors	% time desired	23	38.26	28.39					
SC: Somewhat imp	% time currently	4	7.5	5	-1.73	3	.18	.16	
SC: Somewhat imp	% time desired	4	12.5	5					
SC: Important	% time currently	6	18.33	21.37	-0.35	5	.74	.51	
SC: Important	% time desired	6	20	14.14					
SC: Very Important	% time currently	19	16.84	12.5	-1.88	18	.08	.09	
SC: Very Important	% time desired	19	22.11	13.98					
SC: Extremely Imp	% time currently	55	37.27	26.07	-5.23	54	.00	.00	
SC: Extremely Imp	% time desired	55	50.73	26.17					

Wilcoxon signed-rank (paired samples) Kruskal-Wallis (groups) nonparametric tests reported for robustness.

Those identifying as students or postdocs want a larger increase in percent of time devoted to science communication (*M* = 16.8%, *SD* = 17.5) than professors (M = 4%, SD = 9.45), $t(55) = -3.10$, $p<.00$. This is not explained by the perceived importance of science communication to oneself, as there is no significant difference (Table 5). Professors report a higher amount of time spent currently on science communication (*M* = 33.91%, *SD* = 27.26) than students (*M* = 25.15%, *SD* = 23.2) but the difference is not significant, $t(54) = -1.29$, $p<.2$. There are no significant differences in current vs. desired science communication workload by gender, politics, trust in media, or social media use.

3. Perceived costs and benefits of science Communication (RO3)

In open-ended questions, students were more likely to list specific benefits (generating awareness: 62%, skill building / creating opportunities: 24%, impacting policy: 38%) than professors (30%, 13%, and 17% respectively). Regarding risks, students were more likely to state being wrong (62% of students listed, 22% of professors) and professors were more likely to state controversy/public backlash (43% of professors listed, 31% of students).

Motivators, incentives, and benefits

Institutional recognition and prioritization. Respondents mentioned extrinsic motivators connected to their institution or discipline, including more recognition from advisors, mentors, hiring committees, and promotion committees for science communication work. Respondents mentioned a desire to list science communication work as items on a vitae or connect it to awards, stipends, certificates, scholarships, grant funding, or publications. One respondent wrote that institutions need to place "less value on the only quantity of science completed and more value on communicating results, findings of impactful research."

Science communication impacts. Some respondents mentioned that the impact of science communication work itself is a motivating benefit. Intrinsic motivations like fulfilling obligations as a scientist, knowing your own science better, a sense of fulfillment and joy, giving back to others, raising awareness on important topics, making a difference, sharing new and valuable information, supporting science literacy and equity, public adoption of useful ideas or practices, and improving public decision-making were mentioned.

Improve science communication practice and support. Respondents also mentioned that changing science communication's practice and support would be motivating. They wanted science communication to pay more, for science communicators to be more skilled and diverse, and for the public to be more supportive of science and scientists.

Risks and inhibitors

Confidence. Respondents mentioned a lack of confidence in their communication skills, not understanding where to begin, and lack of coaching as inhibiting factors for practicing science communication and seeking out training. Respondents also mentioned challenges related to having your authority, legitimacy, or objectivity questioned and perceived costs of "wasting" time on science communication because it was ineffective or taking away time that could be spent in the lab doing additional research.

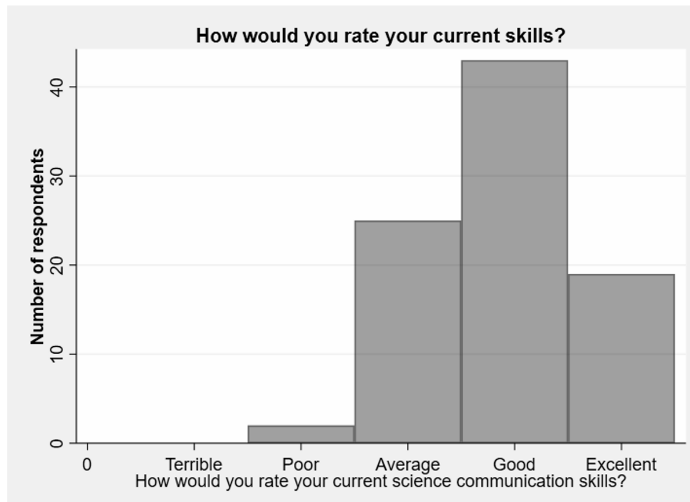
Negative atmosphere. Respondents mentioned risks related to being challenged, creating controversy, making science political, facing public backlash, or offending people as inhibitors to science communication practice. One respondent wrote, "The risks are being personally targeted by individuals or groups who disagree with your point of view or work. In extreme cases, this can get quite dangerous. You can also get too focused on science communication to the point of having it take over your entire program." Others mentioned failing at science communication, giving the public unrealistic expectations of their involvement or say in how science is conducted, turning people against funding science, and negative disciplinary norms or reactions.

4. Comfort Level in Skill Domains

Figure 3 shows the vast majority of respondents ranked their current overall science communication skills at or above average. While 2% of respondents (*n* = 2) rated their current science communication skills as poor, 28% (*n* =25) rated current skills as average, with the rest of respondents self-reporting skills as good to excellent. The two respondents that reported current skills as poor were very different: one was a doctoral student; one was post doctorate; one was aged 25-35 and the other 46-55; one was male and one female; both were moderate in trust of the media; both very liberal. As before, t-tests are reported here, supporting nonparametric test results are in the appendix.

Figure 3

Importance by experience



Those with professional experience report a higher level of current science communication skills (*M* = 4.03, *SD* = 0.82) than those without professional experience (M = 3.67, *SD* = 0.73), *t*(62) = 1.82, *p*<.07 as shown in table 7. The difference between self-reported overall skill level is not significantly different for students/postdocs and professors. Figure 4 shows current (blue) and desired (purple) skill level in science communication broken down by domain of skill. Respondents show a desire for training in every domain. For several domains of science communication, there are differences between students/postdocs and professors current and desired skill levels, reported in tables 8-11.

For example, we separated oral communication within an academic setting from oral communication with the public. Regarding academic oral communication skills, students report lower current skill level (*M* = 3.79, *SD* = 0.88) than professors (*M* = 4.79, *SD* = 0.51), and the difference in desired skill level is not significant. The variance is significantly smaller for professors, indicating a wider spread of skill level among students. Interestingly, both students and professors indicate a desire for better academic presentation skills. For both groups, the variance for current skills is higher than the variance for desired skills, indicating a shared desired skill level for members of both groups.

Table 7

T-tests: Self-reported current skills level

Group	*N*	Mean	*SD*	*T*-test	*df*	*p*	K-Wallis
Professional Exp	40	4.03	0.82	1.82	62	.07	.11
No Professional Exp	24	3.67	0.73				
Students	34	3.71	0.72	-1.44	56	.16	.13
Professors	24	4	0.83				

Kruskal-Wallis nonparametric test reported for robustness.

Table 8

Comparisons of importance of science communication to various groups.

Group	Variable	*N*	Mean	*SD*	*T*-test	*df*	*p*	K-Wallis
Students	Oral -peers	34	3.79	0.88*	-5.44	56(54)	.00	.00
Professors	Oral -peers	24	4.79	0.51*				
Students	Oral – overall public	33	3.76	0.89	-1.94	55	.06	.06
Professors	Oral – overall public	24	4.19	0.76				
Students	Strategy and Media	33	2.71	1.15	-2.04	55	.05	.05
Professors	Strategy and Media	24	3.33	1.12				
Students	Writing for public	34	3.65	1.04	0.07	56	.94	.87
Professors	Writing for public	24	3.63	1.28				
Students	Design / digital	34	2.57	0.81	-0.68	56	.50	.55
Professors	Design / digital	24	2.74	1.06				
Students	Social media / Web	34	3.12	0.97	2.03	56	.05	.07
Professors	Social media / Web	24	2.56	1.1				

Satherwaite degrees of freedom reported in parentheses where applicable.
Kruskal-Wallis nonparametric test reported for robustness.
* SD's are significantly different.

Figure 4

Oral communication for the public consists of three subcategories: informal education, K12, and public presentation. There is a slightly significant difference in reported current skill level for students (*M* = 3.76, *SD* = 0.89) and professors (*M* = 4.19, *SD* = 0.76) overall, *t*(56) = -5.44, *p*<.00. This significance is driven by differences in reported skill level in informal educational and public presentations, with no significant difference in reported current skill level in K12 presentations. There is no significant difference in desired skill level between students and professors in any of these categories, with both students and professors indicating a desire for increased skills in all three subcategories. Desired skill level increases for both groups to *M*= 4.78, *SD* = .033, *t*(32) = -7.42, *p*<.00 for students and *M* = 4.67, *SD* = 0.41, *t*(23) = -3.98, *p*<.00 for professors. Variance in responses decreases for both groups from current skill level to desired.

Regarding writing for public audiences, there is no significant difference between current and desired skill levels between professors and students. Both students and professors desire more skills in this area. Students desired skill level increases from *M* = 3.64, *SD* = 3.64 to *M* = 4.76, *SD* = 0.50, *t*(33) = -6.94, *p*<.00, professors desired skill level increases from *M* = 3.63, *SD* = 0.83 to *M* = 4.46, *SD* = 0.83, *t*(23) = -3.89, *p*<.00, and variance is smaller for desired skill level than current in both groups. Interestingly, there is more variance in professors' desired skill level in writing for public audiences than for students, indicating a wider range of desired skill levels among professors. Also, there is more variance in professors' desired skill level for public writing (*SD* = 0.83) than for professors' desired skill level for oral communication (*SD* = 0.51).

Skills in strategy and media have two subgroups: outreach and media skills. Regarding outreach skills, there is no significant difference in reported current skill level between students and professors but students desire a higher level (*M* = 4.45, *SD* = 0.87) than professors (*M* = 3.79, *SD* = 1.10), *t*(55) = 2.54, *p*<.01. Regarding media skills, professors report higher current skills (*M* = 3.54, *SD* = 1.32) than students (*M* = 2.45, *SD* = 1.23), *t*(55) = -3.20, *p*<.00, and there is no significant difference in desired skill level. Both students and professors desire more skills in both subcategories, with professors showing a wider variance of desired skill level.

Design and digital communication skills are broken down into skills in graphics, video creation, and creating podcasts. There is no significant difference in overall current skill level, and students show a higher desired skill level (*M* = 4.23, *SD* = 0.49) than professors (*M* = 3.72, *SD* = 1.05) in this domain, *t*(55) = 2.14, *p*<.04. Again, professors show a wider variance of desired skills. While there is no difference in reported skill level between professors and students in any of the three subcategories, the difference in desired skill level is driven by desired skills in graphics and creating podcasts. Both professors and students indicate a desire for more skills in these areas, with both professors and students showing a wider range of desired skill levels.

Regarding overall web-based communication, students report higher current and desired skill levels. There is no difference in variation between students and professors reported current and desired skill levels in sub-categories, and variation is high. There is higher variation in desired skills for professors in this domain. Both students and professors indicate a significantly higher desired skill level. Students desired skill level (*M* = 4.18, *SD* = 0.75) is higher than their current skill level (*M* = 3.17, *SD* = 4.18), *t*(32) = -7.24, *p*<.00 and professors *desired* skill level (*M* = 3.35, *SD* = 2.56), *t*(23) = -4.33, *p*<.00. Interestingly, students reported that their current skill level is not significantly different from professors' desired skill level.

Table 9

Desired skill level by type, students compared to professors.

Group	Skill Type	*N*	Mean	*SD*	*T*-test	*df*	*p*	K-Wallis
Students	Oral -peers	34	4.88	0.33*	-1.09	56(55)	.28	.31
Professors	Oral -peers	24	4.96	0.20*				
Students	Oral – overall public	33	4.78	0.33	1.14	55	.26	.26
Professors	Oral – overall public	24	4.67	0.41				
Students	Strategy and Media	33	4.42	0.71	1.54	55	.13	.11
Professors	Strategy and Media	24	4.1	0.86				
Students	Writing for public	33	4.76	0.50*	1.57	55(35)	.13	.32
Professors	Writing for public	24	4.46	0.83*				
Students	Design / digital	33	4.23	0.59*	2.14	55(34)	.04	.07
Professors	Design / digital	24	3.72	1.05*				
Students	Social media / Web	33	4.18	0.75*	3.01	55(36)	.00	.01
Professors	Social media / Web	24	3.35	1.18*				

Satherwaite degrees of freedom reported in parentheses where applicable.
Kruskal-Wallis nonparametric test reported for robustness.
* SD's are significantly different.

Table 10

Reported Skill level for students.

Group	Skill Type	*N*	Mean	*SD*	*T*-test	*df*	*p*	Wilcox
Current	Oral -peers	34	3.79	0.89*	-8.01	33	.00	.00
Desired	Oral -peers	34	4.88	0.33*				
Current	Oral – overall public	33	3.76	0.89*	-7.42	32	.00	.00
Desired	Oral – overall public	33	4.78	0.33*				
Current	Strategy and Media	33	2.71	1.15*	-10.42	32	.00	.00
Desired	Strategy and Media	33	4.42	0.71*				
Current	Writing – Overall	33	3.64	1.06*	-6.94	32	.00	.00
Desired	Writing – Overall	33	4.76	0.50*				
Current	Design / digital	33	2.6	0.81	-16.94	32	.00	.00
Desired	Design / digital	33	4.23	0.59				
Current	Social media / Web	33	3.17	0.94	-7.24	32	.00	.00
Desired	Social media / Web	33	4.18	0.75				

Wilxocon signed-rank nonparametric test reported for robustness.
* SD's are significantly different.

Table 11

Reported Skill level for professors.

Group	Skill Type	*N*	Mean	*SD*	*T*-test	*df*	*p*	Wilcox
Current	Oral -peers	24	4.79	0.51*	-1.70	23	.10	.08
Desired	Oral -peers	24	4.96	0.20*				
Current	Oral – overall public	24	4.19	0.76*	-3.98	23	.00	.00
Desired	Oral – overall public	24	4.67	0.41*				
Current	Strategy and Media	24	3.33	1.12	-4.84	23	.00	.00
Desired	Strategy and Media	24	4.1	0.86				
Current	Writing for public	24	3.63	1.28*	-3.89	23	.00	.00
Desired	Writing for public	24	4.46	0.83*				
Current	Design / digital	24	2.74	1.06	-5.29	23	.00	.00
Desired	Design / digital	24	3.72	1.05				
Current	Social media / Web	24	2.56	1.1	-4.33	23	.00	.00
Desired	Social media / Web	24	3.35	1.18				

Wilxocon signed-rank nonparametric test reported for robustness.
* SD's are significantly different.

Science communication skills and training goals: Open-ended responses

In the open-ended questions, respondents discussed their perceptions of ideal science communication training, potential opportunities created by science communication training programs, and desired core skills to include in science communication programs.

Ideal Science Communication Training

Flexible structure and real-world practice. Respondents mentioned opportunities to engage in real practice with a variety of audiences and formats as key to successful training. There was not one view of an ideal structure for training, as some respondents preferred short skills-based workshops, while others wanted embedded curriculum, a minor, or required courses. There were many mentions of a need to prioritize flexibility and include opportunities to apply concepts to specific research interest areas. Respondents mentioned these training opportunities might increase specialization, strengthen science communication networks, and allow scientists to more intentionally pursue science communication work.

Table 12

Correlations of importance of science communication to self with various groups.

Group	*N*	Pearson	*p*	Spearman	*p*
Self and university	*86*	0.59	.00	0.56	.00
Self and dean	72	0.46	.00	0.42	.00
Self and division	80	0.41	.00	0.44	.00
Self and chair	*82*	0.55	.00	0.56	.00
Self and state	77	0.06	.63	0.08	.48
Self and colleagues	84	0.50	.00	0.50	.00
Self and land grant institutions	*71*	0.07	.57	0.14	.25
Self and public hiring committees	56	0.10	.47	0.11	.43
Self and academic hiring committees	72	0.34	0.00	0.33	.01

Spearman nonparametric test reported for robustness.

Content production and relationship-building skills. Respondents listed a wide variety of skills to include in science communication development programs, including those related to content production like leveraging social media, writing for different genres, storytelling and framing, visual communication, podcasting, blogging, oral communication, and audio and video production. Respondents also listed relationship-building skills like listening, code-switching, partnering with other scientists, interviewing, translating complex ideas, handling conflict, making information accessible, and connecting with diverse audiences. Some respondents mentioned theory, ethics, data management and visualization, improvisation, and being succinct.

Discussion

Respondents to our survey skew heavily towards believing science communication is important. While this is likely due to bias when answering a survey on science communication, it is not known what this number would be with a representative sample. Although respondents nearly all report that science communication is important, answers varied widely on reasons why, the amount of time respondents spend and would like to spend in science communication, perceived risks and benefits, and desire for training in skills areas.

Findings from this study demonstrate several important points. First, the goals of science communication often listed were helping people be more aware of science and improving rapport and trust with communities, which indicate a desire to connect with the public. The biggest reason listed for why science communication is important was a sense of responsibility, and science is not complete without communication. At the same time, respondents ranked the importance of science communication to their state the lowest. This might be linked to concerns of public backlash, as concerns that science communication can be controversial were common in responses. Students and professors appear to focus on slightly different aspects of this risk, with students focusing on being wrong and professors on public backlash. In the context of political communication, Weeks et. al (2024) found that larger, more ideologically diverse networks can create perceptions of unwelcoming or threatening environments, which decrease a communicator's willingness to engage, discuss opinions, and share information. Further research might explore how scientists imagine large, ideologically diverse networks - like their state or generic visions of publics - and if this influences their willingness to engage in science communication efforts and impacts perceptions of receptiveness or importance.

Second, our findings echo insights shared by McLeod-Morin et al. (2021) and Washburn et al. (2022) on benefits and risks of science communication. In addition, our research found that on average, respondents would like to spend 10% more time doing science communication. In open-ended questions, students were more likely to list specific benefits of science communication, perhaps indicating that specific benefits are less salient to professors. Faculty were less likely than students to say there is a negative view of science communication, and faculty were less likely to say that science communication is not prioritized. This suggests that more discussions between students and professors might be valuable to share positive and negative experiences with science communication and to align understanding of how science communication fits within shared professional priorities.

Third, despite self-ranking their overall skills as high, both students and professors report higher levels of desired skills compared to current skills. As we move from more traditional academic skills (i.e. academic oral presentations and writing) towards broader science communication and web-based skills (i.e. outreach, design, web based communication), students report higher current skills, and desired skill levels become more varied for all respondents. Professors report higher current skill levels in academic and public oral skills and dealing with media. There is no difference in the current reported skill level between students and professors in writing for public audiences, outreach, design and digital communication. Students report higher current skill levels than professors in overall web communication, and there is no significant difference between current student skill level and professor desired skill level in this domain.

The variance of current skills is higher than desired skills for academic oral, K12 and public outreach, and writing for public audiences, suggesting a target skill level that is shared by respondents in these domains. For all other domains, skills that may be considered outside "traditional" academic communication skills, professors show a higher variance of desired skills. Both students and professors have higher variance in desired skills (compared to current) for design and digital communication, and variance was markedly high for both students and professors for web communication, suggesting heterogeneity in desired skills in these domains. Further research might explore these differences and consider opportunities for joint trainings, customizable or flexible sessions, peer workshops, or even sessions that students lead for peers and faculty, to cultivate and practice skills. The results of this research echo broader examinations of science communication perceptions and offer insights for land-grant institutions and applications for agricultural, food, and environmental sciences.

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