

## Introduction

Advancements in science and technology can be hindered by public backlash due to misunderstandings, lack of transparency, and declining trust in science and scientists (Muralidhar, 2017; National Academies of Sciences, Engineering, and Medicine [NASEM], 2017; Kennedy et al., 2022). Effective public-facing science communication is crucial to mitigate such issues and promote quality public opinion towards scientific topics (Price & Niejens, 1997). In line with this, land-grant universities are expected to engage in teaching, research, and Extension activities, with Extension activities emphasizing the importance of communicating research-based information to stakeholders (Association of Public and Land-Grant Universities [APLU], 2012; National Institute of Food and Agriculture [NIFA], n.d).

However, some studies have raised concerns about the effectiveness of science communication by land-grant faculty (Opat et al., 2021; Ruth et al., 2021). These studies also highlight a lack of multimedia communication skills, low utilization of multimedia communication techniques, and a perception that science communication is not valued by peers and higher education institutions. Scientists usually focus on individual communication skills such as public speaking, writing, or two-way dialogue (Besley & Dudo, 2017), while strategic communication skills such as goal setting and utilizing appropriate communication practices are often neglected (Besley, 2020). A study at a land-grant university found that while faculty engage in about one science communication activity per month, these activities are mostly one-on-one conversations, social media posts, and formal talks/presentations (Ruth, 2018), which mostly reach other scientists rather than the intended public-facing audiences (Ruth et al., 2019).

The limited engagement in effective science communication by faculty has been linked to limited training opportunities (Bankston & McDowell, 2018; Dudo, 2012; Ruth et al., 2020), low recognition and perceived value of science communication in higher education (Besley, 2020), and varying motivations across personal and professional demographic groups (Ruth et al., 2020; Wade & Demb, 2009). In addition, faculty members with high research appointments were found to be less likely to engage in science communication compared to those with low research appointments (Ruth et al., 2020). To overcome these challenges, training opportunities for scientists and prioritizing science communication in higher education during hiring, promotion, and annual reviews have been recommended (Bankston & McDowell, 2018; Besley, 2020). This study aims to further investigate the factors that influence agricultural research faculty members' engagement in science communication to understand the resources and trainings needed to help them effectively engage with the public.

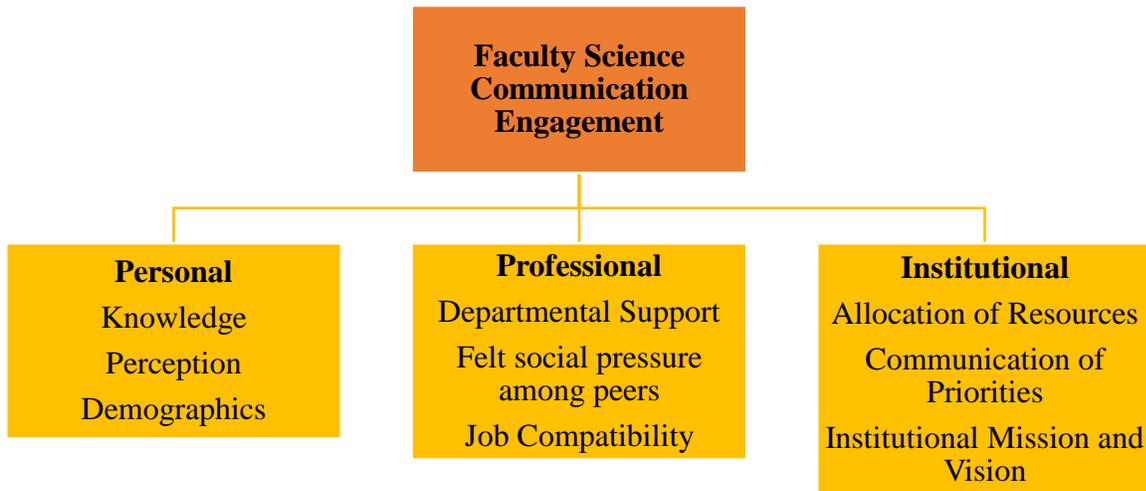
## Conceptual Framework

The Faculty Engagement Model, first introduced by Wade and Demb (2009) to assess community engagement of faculty members and later adapted by Rampold et al. (2018) to focus on university-based activities, served as the organizational framework for this study. The term "faculty engagement" is defined as faculty participation in science communication activities. The model considers the impact of three dimensions on faculty engagement: institutional, professional, and personal. This study modified the previous model by conducting a comprehensive review of the literature and proposing a modified framework that includes the aforementioned dimensions and their hypothesized relationship with science communication

engagement (see Figure 1).

## Figure 1

### *Faculty Science Communication Engagement Framework*



### **Personal Dimension**

The personal dimension pertains to an individual's personal factors that impact their engagement in an activity. We considered relevant theoretical frameworks and reviewed prior literature in science communication to propose four factors within the personal dimension that may impact faculty members' engagement in science communication activities: (1) their subjective knowledge of science communication methods, (2) their attitudes toward science communication, (3) their perceived personal ability to communicate science, and (4) whether English was their first language (Poliakoff & Webb, 2007; Ruth et al., 2020; Bennett et al., 2020; Parrella et al., 2022). The impact of faculty members' knowledge of science communication methods is predicted to influence their engagement. Knowledge was operationalized in this study as self-perceived (i.e., subjective) knowledge, which may also provide implications regarding confidence (Ruth et al., 2020). In prior research, scientists who perceive themselves as knowledgeable of how to communicate their science were more likely engage in science communication activities (Poliakoff & Webb, 2007; Ruth et al., 2020). Rogers (2003) attribute of perceived complexity of an innovation may also provide insight into faculty members' felt ability to engage in science communications. As such, we hypothesized a negative relationship between faculty members' perceived complexity of communicating their science and their engagement in science communication activities.

Per Azjen's (1991) Theory of Planned Behavior, an individual's attitude toward performing a behavior may influence their likelihood of engaging in that behavior. In the context of the current study, we hypothesized faculty members' attitudes toward science communication would have a positive relationship with their engagement (Azjen, 1991; Bennett et al., 2020; Besley et al., 2015; Besley et al., 2018; Parrella et al., 2022). Besley et al. (2015) and (2018)

evaluated scientists' perceptions of public engagement in science and found those who believed that public engagement in science makes a difference were more likely to support science communication training. Lastly, based on qualitative inquiry with faculty members at our current university, we predict faculty members being English as a second language (ESL) speakers would negatively impact their engagement in science communication activities.

### **Professional Dimension**

The professional dimension includes context-based factors that impact engagement (Rampold et al., 2017; Wade & Demb, 2009). Faculty members' professional context, such as rank, tenure, appointment, and discipline can impact science communication engagement (Jensen et al., 2008; Ruth et al., 2021). Tenure and promotion considerations can result in other activities being valued more than faculty members' engagement in science communication activities (Washburn et al., 2021). Other factors include the importance placed on grant funding and publication, and perceptions of their professional role (Barham et al., 2017; Brüggerman et al., 2020; Ruth et al., 2021). Lastly, since the professional dimension pertains to characteristics about faculty members area of study and departmental culture or characteristics, we considered Rogers (2003) attribute of compatibility when designing our study to further explore factors within this dimension. We hypothesized that faculty members who perceived engaging in science communication as being compatible with their job role would be more likely to participate in such activities (Rogers, 2003).

### **Institutional Dimension**

The institutional dimension pertains to university characteristics that impact faculty engagement in science communication. We can consider institutional mission statements or other statements of value pertaining to science communication as institutional dimension factors, but it may be more beneficial to evaluate authentic support of science communication engagement in terms of how it is perceived by faculty (Ruth et al., 2021). Prior research has found that institutional support is a significant factor in determining faculty engagement in targeted activities (Rose et al., 2019). However, some faculty members have reported a lack of institutional support for science communication, particularly in comparison to the value placed on other activities in tenure and promotion decisions. In a study by Washburn et al., (2021), agricultural science faculty members reported feeling a lack of value in their communication activities and felt those activities were especially downplayed by administration compared to academic activities, such speaking at academic conferences. Leadings scholars have, therefore, called for more authentic support in terms of resources and recognition provided for science communication engagement (Besley, 2020; Huberman, 1983; Jacobson et al., 2004; Johnson, 1980; Washburn et al., 2021).

### **Purpose and Objectives**

There is a need to enhance research faculty members engagement in science communication activities. This study was conducted identify factors that influence their engagement. Research of this nature can help identify and justify recommendations for providing training or other support measures to facilitate effective engagement among our faculty. Three objectives guided this study:

1. Describe faculty members' engagement in science communication activities.
2. Describe faculty members' personal dimension characteristics (attitudes, complexity, ESL), professional-dimension characteristics (perceived social pressure, compatibility, academic rank, and tenure), and institutional dimension characteristics (perceived institutional support) predicted to be related to their science communication engagement.
3. Examine the influence of personal, professional, and institutional dimension factors on faculty members' science communication engagement.

## **Methods**

### **Population and Sample**

The targeted population consisted of University of Tennessee Institute of Agriculture tenure-track faculty members who conduct research in either a formal or informal capacity (i.e., includes both those with a formal research appointment, as well as those who do not have a formal research appointment but still conduct research). To collect responses, an email was distributed across the University of Tennessee Institute of Agriculture listserv, and listserv members were provided details regarding study eligibility and asked to self-select themselves for participation. Filter questions (e.g., "are you a tenure-track faculty," and "do you conduct research") were also included to ensure respondents were within the targeted population frame. Three follow-up reminder emails were distributed once a week for three weeks following the initial invite to participate in the study. Responses were collected from 139 listserv members. Seventy respondents were removed for not meeting the parameters of being a tenure-track faculty member who conducts research, which resulted in a total sample size of 69 out of 205 tenure track faculty members for a response rate of 34%. However, it should be noted that the true response rate is likely higher when considering "conducts research" as a parameter measure of the overall targeted population. We are unable to report the exact response rate to the inability to determine the exact number of faculty members within the institute who do research in some capacity, which is a limitation of this study.

### **Instrumentation**

The researchers developed an original survey questionnaire 193 for the data collection for this study. To ensure content validity, a review of literature was conducted to identify individual items included in the instrument's constructs. Further, the Faculty Engagement conceptual framework (Wade & Demb, 2009; Rampold et al., 2017), Azjen's (1991) TPB, and Rogers' (2003) Diffusion of Innovations were consulted to guide the instrument development. The questionnaire was then reviewed for face and content validity by an expert panel that consisted of five faculty members with collective expertise in agricultural communications, instrument development, and developing and leading science communication workshops for research faculty. After the panel review, five items were added to the list of science communication to ensure a comprehensive measure of engagement in such. Lastly, post hoc internal consistency reliability estimates for the instrument's constructs were calculated using Cronbach's alpha.

Six sections of the questionnaire were used for data analyses in this study: (a) engagement in science communication activities; (b) science communication knowledge; (c) attitudes toward science communication; (d) perceived complexity of science communication;

(d) perceived compatibility of science communication; (e) normative beliefs; and (f) personal and professional demographic characteristics of faculty members. The first section of the instrument was designed to measure faculty members' degree of engagement in science communication. Respondents were provided a list of 13 activities and asked to check all they had participated in to communicate with the public about their science. Responses were coded 0 = *unchecked* and 1 = *checked*, and a summated score was computed to represent faculty members' degree of science communication engagement.

The next section of the instrument was designed to measure respondents' attitudes toward engaging in science communication. Responses were collected using a 7-point scale between seven sets of bipolar descriptors (e.g., good/bad, useless/valuable, unimportant/important, harmful/beneficial). Responses were coded from - 3 to +3, and a construct mean was computed to represent overall attitude (Al-Hindawe, 1996). The internal consistency reliability estimate for this scale was  $\alpha = .93$ .

Respondents' science communication knowledge was assessed in terms of their subjective knowledge of communicating their science. Subjective knowledge as operationalized in the current study refers to self-perceived knowledge, rather than objective knowledge about a topic. This section included 8 items reflective of the previously identified activities that constitute science communication engagement (e.g., "I know how to live stream videos from my lab," "I know how to write about my science in lay terminology that can be understood by public audiences," "I know how to conduct news interviews that can be understood by public audiences," "I know how to develop a webpage to share my scientific work.>"). Responses were collected using a 5-point Likert scale: 1 = *strongly disagree*; 2 = *disagree*; 3 = *neither agree nor disagree*; 4 = *agree*; 5 = *strongly agree*. A composite mean was computed to represent respondents' overall degree of subjective knowledge about science communication. The internal consistency reliability estimate for this scale was  $\alpha = .82$ .

The next two sections of the instrument were designed to measure respondents' perceptions of how complex science communication is and how compatible it is with their current jobs/roles (Rogers, 2003). Complexity was measured using four items (e.g., "communicating my science takes too much time," "I do not have the technical skills needed to communicate my work to public audiences," "engaging in public science communication is easy for me." Positively worded items were reverse-coded (i.e., higher overall construct value represents higher perceived complexity) and a composite mean was computed. Compatibility was measured using six items (e.g., "my scientific works involves topics that are easy to communicate to the public," "my day-to-day work structure lends itself to science communication activities," "the professional connections I have allow me to communicate my science to the public"), and a composite mean was also computed. Responses to items in both constructs were collected on the same, previously mentioned 5-point Likert scale. The internal consistency reliability estimates for the complexity and compatibility scales were  $\alpha = .64$  and  $\alpha = .73$ , respectively.

Normative beliefs (Ajzen, 1991) were assessed using five items intended to measure respondents' felt social pressure or perceived expectations to engage in science communication (e.g., "my department head expects me to communicate my science to the public," "other faculty in my department expect me to communicate my science to the public"). The same previously mentioned Likert scale was used to collect responses, and a composite mean was calculated. The internal reliability estimate for this scale was  $\alpha = .90$ .

The final section of the instrument included personal and professional demographic questions about respondents. The questions used for analysis included academic rank and whether English was their first or second language (ESL). Both ESL and academic rank were dummy coded for regression analysis.

## Data Analysis

Data were analyzed using the SPSS statistical software package. Objectives one through three were achieved using descriptive statistics to generate means, standard deviations, frequency counts, and percentages. For objective four, multiple linear regression was employed using standard entry method with overall science communication engagement as the dependent variable. Prior to regression analyses, Pearson product-moment correlations were used to investigate the associations among all variables intended for entry into the model. The associations were interpreted using Davis' (1971) convention with .01 to .09 indicating a negligible relationship, .10 to .29 indicating a low-level relationship, .30 to .49 indicating a moderate relationship, .50 to .69 indicating a substantial relationship, and greater than .70 indicating a very strong relationship. Histograms, scatterplots, and residual scatterplots were examined to test the assumptions of linearity, normality, and homoscedacity (Field, 2013). No assumptions were violated. Correlation coefficients were calculated to examine multicollinearity. No correlations between predictor variables exceeded .70, indicating the assumption of multicollinearity had not been violated (Field, 2013).

## Findings

### Objective One

Objective one was to describe faculty members' engagement in activities to communicate their science to public audiences. Respondents' overall science communication engagement scores ranged from 1.00 to 12.00, with a mean score of 5.73 ( $SD = 3.20$ ). Of the activities listed, more respondents had participated in having one-on-one conversations with members of the public ( $f = 52$ ; 81.3%) and presenting scientific work at non-academic conferences ( $f = 50$ ; 78.1%). See Table 1 for full frequency distributions for science communication items.

**Table 1**

*Percentage of Respondents Who Had Participated in Select Science Communication Activities*

Activity	<i>f</i>	%
Participated in one-on-one conversations with members of the public	52	81.3
Presented scientific work to non-academic audiences	50	78.1
Been interviewed by a reporter	41	64.1
Developed one-pagers, graphics, or other easy to read documents about my work for lay audiences	37	57.8
Posted or discussed scientific work on social media platforms (e.g., Twitter, Facebook)	37	57.8
Spoken during a public forum/panel	37	57.8
Presented a hands-on demonstration	34	53.1
Created a webpage that highlights my scientific work	26	40.6

Posted scientific content on YouTube for public viewership	14	21.9
Engaged in public discussion boards about my scientific work	13	20.3
Streamed live video from my field or lab for public viewership	13	20.3
Created a blog or written a blog post about my scientific work	9	14.1
Talked at a science café	4	6.3

## Objective Two

Objective two was to describe faculty members' personal dimension characteristics (attitudes, complexity, ESL), professional-dimension characteristics (perceived social pressure, compatibility, academic rank, and tenure), and institutional dimension characteristics (perceived institutional support) predicted to be related to their science communication engagement. Personal dimension factors examined included attitudes, perceived complexity, knowledge, and ESL. Respondents' overall attitudes ranged from -1.75 to 3.00, with an average of 2.54 ( $SD = 1.05$ ) which indicates more positive than negative attitudes toward communicating their science with the public. Respondents' mean score for perceived complexity of science communication was 2.89 ( $SD = .70$ ). Regarding their knowledge, respondents' perceived knowledge scores ranged from 1.50 to 4.75, with an average score of 3.45 ( $SD = .70$ ). Lastly, regarding their native language, 50 respondents (78.1%) indicated English was their first language, while only seven (10.9%) indicated English was their second language. The professional-dimension characteristics examined included their perceived social pressure to engage in science communication, how compatible they feel science communication is with their jobs, academic rank, and tenure status. Regarding felt social pressure, respondents' average score was 3.61 ( $SD = .87$ ). As for how compatible they perceive science communication to be within their roles, the mean score among respondents was 3.43 ( $SD = .63$ ). Further, six (9.4%) held the rank of assistant professor, 10 (15.6%) held the rank of associate professor, 25 (39.1%) were full professors and 28 (40.5%) chose not to answer the question. Lastly, of those who responded, 29 (45.3%) were tenured and 6 (9.4%) were not (responses for demographic characteristics do not add up to 100% due to missing responses from some respondents on these items). The institutional-dimension factor examined in this study was perceived institutional support and resources for engaging in science communication. Overall, respondents had a mean score of 2.89 ( $SD = .85$ ).

## Objective Three

Lastly, objective three was to examine the influence of personal-, professional-, and institutional-dimension factors on faculty members' overall engagement in science communication with public audiences. The regression model was significant,  $F(8, 54) = 5.20, p < .001$ , Cohen's  $f^2 = .51$ , and predicted 35.1% of the variance on respondents' overall level of engagement in science communication (see Table 2). The statistical power of this test was .99, which exceeded the minimum recommended threshold of 80%. A significant and positive relationship was observed between respondents' knowledge of science communication and their engagement in science, while a significant and negative relationship was observed between their perceived institutional support and their engagement. Science communication attitudes, perceived complexity, perceived compatibility, normative beliefs, being tenured, and having English as a first language were not significant predictors of science communication engagement.

**Table 2***Best-fit Linear Regression Model of Predictors of Science Communication Engagement*

Variables in Regression Model	B	SE	t	Std. $\beta$	p
Constant	1.64	3.98	.411	--	.68
SC Knowledge	1.14	0.57	2.01	.25	.05*
SC Attitudes	-0.44	0.41	-1.07	-0.14	.29
SC Complexity	-0.90	0.63	-1.43	-0.20	.16
SC Compatibility	1.44	0.83	1.73	0.29	.09
Normative Beliefs	0.93	0.53	1.75	0.25	.09
Institutional Support	-1.83	0.5	-3.45	-0.49	.001**

\* $p < .05$ ., \*\* $p = < .001$   $r^2 = .351$  ( $F = 5.20$ ,  $p < .001$ )

Note. B are unstandardized regression coefficients and  $\beta$  are standardized regression coefficients

### Conclusions, Discussion and Recommendations

Overall, the science communication engagement among faculty members in this study was low; there were few activities in which more than half of the faculty had participated and, for most activities, one-third or less indicated having engaged in that particular activity. The activities more faculty members had participated in than other activities included one-on-one conversations with members of the public, presenting scientific work to non-academic audiences, and being interviewed by a reporter. These activities are those that may be relatively more commonplace or be what we might consider “low hanging fruit.” The activities relatively fewer faculty members had engaged in were streaming live video from their field or lab for public viewership, creating a blog or writing a blog post, and talking at a science café. Some of these activities, such as live streaming from a lab, may not be applicable to all faculty and therefore may be lower in frequency counts. The low level of science communication engagement among faculty members highlights the need for increased efforts to support and enhance science communication training. Science communication training should focus on the activities that faculty members are most frequently engaged in and on enhancing researchers’ knowledge of science communication.

We examined variables nestled within the personal, professional, and institutional dimensions (Rampold et al. 2017) to better understand faculty members’ degree of engagement in science communication activities. The results regarding the ability of our selected independent variables to predict engagement were surprising and future research is warranted. While attitudes toward public science communication, perceived compatibility of science communication with their current job, and perceived complexity of engaging in science communication were significantly correlated with engagement, they were not significant predictors when built into the regression model. The only significant predictor variables were self-perceived knowledge of how to conduct science communication activities and perceived institutional support.

Our findings pertaining to knowledge contribute to the mixed nature of research on knowledge as a predictor of engagement in a targeted behavior. While knowledge has been identified in prior research as a significant and positive predictor of science communication engagement (Poliakoff & Webb, 2007; Ruth et al., 2020), the knowledge deficit model has received some criticism in the field, perhaps due to the inconsistency of results indicating

knowledge as a predictor variable (Besley et al., 2018). Due to knowledge being operationalized as self-perceived knowledge in this study, these results may speak more to faculty members' confidence than their objective knowledge and abilities. However, developing concrete science communication skills cannot be overlooked in future training considerations. Faculty members in prior research have placed high importance on skill development as a component of science communication training programs (Washburn et al., 2021). Regarding continued study of faculty members' knowledge, future research should be conducted to better understand the impact of objective versus subjective knowledge measures on faculty members' science communication engagement. Specifically, experimental research should be designed to evaluate the impact of science communication education on faculty members' engagement following the educational program. Research of this nature could help expand recommendations for developing authentic professional development for faculty, as well as direct the development of undergraduate/graduate coursework and certificates that could be employed to ensure future scientists are knowledgeable about science communication prior to entering the workforce.

The negative association observed between engagement and perceived institutional support also warrants further investigation. This research should be replicated with a larger sample across multiple universities to evaluate this phenomenon. A possible explanation may be that faculty members who engage in science communication are the ones who have enough familiarity with it to know that they could use more resources and support from the institution. Those who do not engage in science communication may be less aware of such needs.

Future research should also seek to explore the relationship between faculty members' attitudes toward science communication and their engagement in related activities. Behavioral theory and prior research in this area and supports the postulation that faculty with more favorable attitudes toward science communication would be more likely to engage (Azjen, 1991; Bennett et al., 2020; Besley et al., 2015; Besley et al., 2018; Parrella et al., 2022). However, attitude was not a significant predictor of engagement with the sample in the current study. Research in this area may benefit from a systematic review of literature to identify methods of how "attitudes" has been operationalized and applied in studies across the literature. A study of this nature may help contribute to more comprehensive models that can be used for replication across studies to grow the body of research.

Lastly, this study should be replicated within institutes of agriculture across multiple universities to obtain a sample size need to run inferential statistics with adequate statistical power. Data sampling is a common barrier in our field, and multi-state collaboration can help alleviate that barrier and provide opportunity to rigorously examine models to explain science communication engagement among science faculty. Studies of this nature would also better allow for measure of institutional dimension factors by comparing institutional differences against faculty members' science communication engagement. While we were particularly interested in food, agriculture and natural resource faculty members, research conducted with scientific faculty in other areas would also be beneficial to help make comparisons across disciplines. For example, agricultural faculty may have Extension appointments in which they are required to engage with public audiences about agricultural science topics to some degree as part of their tenure and promotion considerations. Future research that includes such professional dimension characteristics can help tailor professional training opportunities for faculty in different disciplines.

While this research is not without limitations, this study offers an organizational framework for examining faculty members' engagement in science communication. This study was largely exploratory, but was grounded in prior literature and theoretical perspectives during data collection. We recommend this model be used to guide future inquiries that seek to deconstruct barriers into personal, professional, and institutional dimension. Such an approach can be beneficial in garnishing support from university administrators when seeking to implement professional development opportunities for university faculty members. This approach may also allow for easy organization for further exploration of relationships between variables within each dimension, especially if data is collected across a larger population frame. Regarding practice, this study contributes to the body of knowledge on challenges we may be able to address to help agricultural scientists enhance their engagement in science communication and actualize the mission of the land-grant system.

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