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What Help Do Faculty Perceive Is Needed to Improve their Community Engagement through Outreach?

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What help do faculty perceive is needed to improve their community engagement through outreach?

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- A survey-based needs assessment at the University of Nebraska-Lincoln, a research-intensive land grant university, explored ways to meet the goal of increasing science, technology, engineering, and mathematics (STEM) outreach
- 40% of surveyed faculty reported barriers to doing STEM outreach
- Over 50% of faculty reported an inability to individually resolve barriers to STEM outreach in ways that ensure broader community engagement in their research through outreach
- Using a Sociological lens, the current study examined institutional-level barriers and enablers to faculty engaging in outreach
- Results suggest several institutional approaches to STEM outreach, including creating infrastructure with experts in science communication; providing science communication expert consultants; teaching courses in science communication; measuring and rewarding outreach (e.g., giving "popular" talks, writing letters to the editor, running after school programs).

The question we sought to answer: How can our university increase the scientific research impacts?

We are a team of scholars working in libraries, extension, evaluation, and the social sciences. We each independently collaborate with science, technology, engineering and mathematics (STEM) scholars to do outreach. Consistent with National Science Foundation (NSF) goals, we engage in science communication and community engagement that are often part of "Broader Impacts" work, defined as "the potential to benefit society and contribute to the achievement of specific, desired societal outcomes" (National Science Foundation, 2014). We also seek ways to increase diversity, equity, and inclusion in STEM fields. We came together to explore how to increase success with science communication

and community engagement that support the science outreach dimensions of broader impacts. We have benefitted from University of Nebraska supports for STEM outreach and community engagement and have been involved in carrying out such efforts (See Appendices A and B). We also sensed that there is considerable latent capacity among UNL faculty that could be activated to have more widespread and consistent STEM outreach and community engagement than currently exists (as of 2016).

We imagined creating a university wide serving central nexus that could support STEM scholars in their efforts to have meaningful outreach impacts by engaging their focal communities and successfully promoting diversity, equity, and inclusion in STEM. Few STEM scholars have training in communication, diversity, equity, and inclusion. Experts in several fields— such as communication experts, extension faculty, graphic designers, learning researchers, instructional designers, evaluators, and grant writers—specialize in the skills necessary to truly engage non-scientists across a broad range of demographics, yet *finding* the necessary expertise is often challenging. Many STEM scholars start from scratch rather than building on prior successful designs. Creating a more systematic approach to outreach at our institution could leverage evidence-based ideas that have worked in the past for proposals, Institutional Review Boards, and the University of Nebraska N2025 goal of increased community engagement. We also imagine creating evaluation measures and agreements, so everyone engaged in STEM outreach and community engagement would know whether their interventions did or did not work well. We wanted the public to understand emerging science in ways that enrich their lives and their communities.

Why should universities value successful STEM outreach?

University STEM outreach efforts may be motivated at the individual, societal or institutional level. At the individual level, faculty members often have personal motivations for engaging with the public and communicating about their research (Poliakoff and Webb, 2007; Marcinkowski et al, 2014). Individual faculty may be motivated to conduct science outreach by their own positive personal life experiences receiving STEM outreach programming or by a sense of social justice in remedying inequality in science knowledge and understanding for the public, particularly for groups historically excluded from engaging with STEM content and knowledge.   Some faculty are now able to convey their research to the public with "academic rigor and journalistic flair" by posting blogs on the webpage *The Conversation* (https://theconversation.com/us).

At the societal level, the concept of science capital provides a useful framework for understanding the value of STEM outreach. Science capital is situated in Bourdieu's theory of social reproduction (Bourdieu & Passeron, 1990; Bourdieu, 1977). Bourdieu theorized

that capital, which comes in different forms, is a legitimate, valuable and exchangeable resource that can generate forms of social advantage and disadvantage. There are several types of community and individual (e.g. economic, social, cultural or symbolic resources (Archer, Dawson, DeWitt, Seakins, & Wong, 2015; Mattos 2015)). Archer and colleagues (2015) argue that science related resources should be considered an important form of capital in modern society. They also argue that science-related resources are unevenly spread among social groups within society with "implications of this uneven spread for youths' access to, participation in, and engagement with science." (Archer et al., 2015 pp 940) It is helpful to also conceptualize science knowledge and skills a form of capital that is unevenly distributed and aligned with other forms of capital (Archer, DeWitt, Osborne, Dillon, Willis & Wong, 2012).

 Lack of science capital can create a wider social divide that perpetuates inequities. Archer's work provides a theoretical framework for understanding the benefits of bringing science research into communities and widening participation in science. Efforts that enhance science capital may benefit individuals and society as a whole by reducing social disadvantages. This perspective toward science capital provides a lens on the role of STEM in the continuation of educational and economic advantage and disadvantage in communities.

Inequitable access to STEM programming and resources for members of the public contributes to the inequities in science capital. In the U.S. there is a sharp divide in access to science capital between rural and urban youth (DeWitt & Archer, 2017; Wonch Hill, McQuillan, Hebets, Spiegel, and Diamond 2018). In urban areas there is also variation in science capital on neighborhood and family social class (Achinstein, Curry, & Ogawa, 2015; Buffington, n.d.). Urban areas have more access to STEM programming than rural areas (Eppley, 2017), and urban neighborhoods with higher socioeconomic status have more informal science opportunities than lower socioeconomic neighborhoods. There is evidence that access to authentic STEM experiences and exposure to STEM outreach programs, public lectures, and conferences can increase positive attitudes about science, science knowledge, and for K-12 youth, increase science career interest (Tai et al., 2006).

At an institutional level, state and federal governments plus taxpayers often want higher education institutions to justify government funding and to explain the relevance of their work (Paris, 2017). State and federal governments seek easily understandable evidence of the value of investments in research to justify continued funding (Paris, 2017). Effective communication and engagement with audiences beyond the university about STEM discoveries supports the value of investing in public universities and STEM efforts (Roberts, 2009). Like many others, our university aims to be an "engaged institution" (Laing, 2016).

What do funding agencies and members of the public expect scholars to do?
The National Science Foundation (NSF) has increasing expectations that investigators submitting grant proposals take science communication, broadening participation, and inclusion very seriously. In 2014, NSF Director France Cordova emphasized the importance of the broader impacts' criterion:

> "As a federal agency, we need to stay relevant with those who entrust us with
> taxpayer funds. We need to reach out to Congress and other
> stakeholders and be proactive in explaining what NSF is about and
> why we are vital to the nation's future… Not enough of our fellow
> citizens understand how relevant the research… conducted is to their
> daily lives… In both formal and informal venues, we need to engage
> the public in order to help improve understanding of the value of
> basic research and why our projects are worthy of investment."
> (National Science Foundation, 2014).

Communicating STEM knowledge benefits society and contributes to desirable outcomes such as increasing science literacy and broadening participation in STEM fields. Many constituents recognize that increasing public understanding of emerging science is a valuable goal (T. D. Sadler & Zeidler, 2009). Given the high importance and need for ways to increase public understanding of emerging science, how can STEM faculty and researchers who are experts in specific fields (e.g., genetics, lasers, addiction, food manufacturing, etc.) meet these expectations? Must scholars respond individually to NSF demands for high-quality broader impacts when the researchers' goals are impactful engagement with the general public through outreach? The challenge is that the skills required to be a successful researcher – to get grants and publish – are very different from those required to connect with local communities and communicate with a broad audience made up of a myriad of cultures and micro-cultures. Expertise in storytelling that can successfully accomplish public understanding of science tends to be concentrated in humanities, journalism, and the arts.

In some cases, exceptional faculty members can master emerging media, have skills in translating STEM knowledge for others, and know how to recruit, retain, and promote excellence through diversity. The key idea, however, is that these are exceptional faculty; most faculty have narrow expertise in a specific field and are not able to master all of the knowledge and skills necessary to successfully carry out highly impactful outreach efforts that broadly engage the community. Is it wise to expect individuals to meet national expectations to create high-impact engagement without institutional support? We think not. Instead, we argue that it is unreasonable for most scholars to individually figure out how to successfully plan community engagement efforts, such as outreach, or to create teams from scratch every time that they have emerging science to disseminate. We imagine creating institutional infrastructure to support efforts to create high-impact outreach.

The National Academy of Sciences recognizes that creating successful effective science communication with general audiences is challenging.

> "Communicating about science effectively with public audiences, however, turns out to be more difficult than it might at first appear. People communicate about science for diverse reasons, there is no single audience for scientific information, and the societal contexts surrounding different scientific issues can vary considerably. Communication approaches need to be adapted to reflect the circumstances that prevail. Moreover, the complexity of scientific methods and the ways in which science progresses can also make communicating science to the public quite difficult. This challenge can be particularly acute when the issue being discussed involves either a domain in which the societal implications of the science are controversial or substantial disagreement about the findings exists within the scientific community." (National Academy of Sciences, Engineering, and Medicine, 2017 p.8)

The growing momentum for researchers to communicate their findings with the public seems to assume that faculty implicitly know how to do this (Frodeman & Parker, 2009). Engaging the public through science outreach, educational activities, presentations or challenging discussions, however, requires skills and expertise that scientists rarely learn in graduate school. Is it reasonable to require university faculty to be experts in simultaneously conducting research, teaching undergraduates, training the next generation of scientists and translating their emerging research into a variety of media for audiences with varied levels of scientific literacy? Attaining these skills and developing effective science outreach has added to faculty workloads with limited institutional infrastructure (K. Sadler, Eilam, Bigger, & Barry, 2018)

Recommendations from the Advancing Research Impact in Society (formerly the National Alliance for Broader Impacts) address the growing challenge of advancing science and benefiting society through STEM (National Alliance for Broader Impacts, 2018). The report describes challenges which can be addressed by research universities similar to ours, including:

- Academic culture rarely rewards broader impact activities and dissemination
- There are few resources to support broader impacts at the individual, institutional, and national levels
- Universities, governmental representatives, and non-academic partners need better ways to understand and communicate about broader impacts internally and externally to demonstrate research value
  (National Alliance for Broader Impacts, 2018).

The infrastructure and cultures within our universities tend to prioritize research first, then teaching (Gappa, Austin, & Trice, 2007; O'Meara, Kuvaeva, & Nyunt, 2017), and rarely emphasize outreach or engagement with the public.

National research reports indicate that few researchers have opportunities to develop the skills and connections necessary to do effective STEM outreach, engagement, or evaluation of their efforts. How then can universities bridge the gap between the need for and availability of high-quality STEM outreach and evaluation of those efforts?

Many universities provide centers of support—teaching centers, offices of research, or technology transfer advisors—for the areas in which they want their faculty to be successful. Institutional infrastructures such as these help universities reach collective goals. Rather than expecting most faculty to master the skills necessary to excel with communicating science and community engagement, some universities have created centers for broader impacts (e.g., in Iowa, Missouri, and Oregon). These centers employ specialists who have expertise in communicating emerging STEM findings and in diversity and inclusion. The collective experience of these centers with writing, carrying out, and evaluating broader impacts efforts gives their institutions a competitive advantage. Centers for STEM outreach also help meet land grant missions to serve the people of their state (National Archives, 2002). Such centers, however, can be expensive and are not widespread.

Our challenge? Understanding reality: are there needs that aren't being met?
To get a more accurate assessment of what faculty at UNL need in order to successfully carry out STEM communication and community engagement, we conducted a needs assessment for the University of Nebraska-Lincoln. This university was established in 1869 and serves as both the land-grant and the comprehensive public university for the state of Nebraska.

In our needs assessment, we sought to identify the factors that facilitate or restrict STEM outreach by our university from the perspective of individual faculty members. In this document we report the results and describe our suggestions for how to improve the outreach efforts of UNL.

Identifying the challenges to engaging in outreach.
If engaging in outreach efforts help to research individual and institutional goals that also contribute to public goods, why do only some faculty engage in STEM outreach efforts? To answer this question, we did research. We focused on the question: What institutional supports are necessary to make STEM outreach routine and manageable within faculty workloads?

To get a more accurate assessment of what faculty at our university need to successfully meet outreach effort goals, we conducted a needs assessment for the University of Nebraska, and here focus on the results from the flagship campus in Lincoln (See Appendix C: Supplemental Materials for details about the data collection process). We sought to identify faculty perceptions of facilitators and barriers to STEM outreach. The survey included activities that are "meant to broaden STEM participation and knowledge through recruitment, mentoring, research events, learning opportunities, public education efforts, and partnership." (described in the STEM Needs Assessment survey sent to faculty).

What barriers did researchers face?

To learn what the faculty need, we conducted an online survey in February 2016 of faculty, staff and community partners who were identified as having potential or past experience with STEM outreach. For this article on the facilitators and barriers faced by faculty, we limited the analysis to responses from faculty at UNL, the flagship R1 campus (N=141). We attempted to get all STEM faculty to answer the online survey; 12% participated. Data from the other campuses and community partners differed enough to require separate research reports. Additionally, we limited the pool to faculty because we found most staff either engaged in outreach as part of their job, or as volunteers outside of work and therefore had different models of participating in STEM outreach than faculty.

Of the 141 University faculty who participated in the survey, 71.8% had conducted science outreach in the past (Table 1). Using a scale that goes from 1 (low) to 4 (high), overall participants had high interest in conducting STEM outreach in the future (mean=2.95). Forty percent of faculty, however, reported at least some barriers to conducting STEM outreach.

Table 1. Interest in and Barriers to Science Outreach	
	Faculty (N=141)
How interested are you in conducting STEM Outreach? (Range 1 (low) to 4 (high))	2.95
Science Outreach Experience	
No past Science Outreach/ Unsure Future Plans	11.3%
No Past Outreach /Future Plans	16.9%
Past Science Outreach	71.8%
Experienced Barriers to Science Outreach?	
Yes	40.1%

No	59.9%

Comments that indicated challenges with the school districts included the following:

"Finding the right avenue to implement the outreach activities and finding interested teachers."

"Finding the right partners. We have always worked in partnership."

"Getting district IRBs to approve what we want to do"

Comments indicating that the university or department does not value their work:

Lack of credit for efforts

My Dean and Chair offers little support for any service activity. Service is discouraged.

Oftentimes, the STEM outreach in which we engage is not recognized as such by UNL.

Most faculty who participated in the survey did not experience barriers to outreach (59.9%). Faculty who reported barriers (N=57, Table 2) were asked what types of barriers they faced (e.g., a lack of time, resources, volunteers, recruitment, etc.). On average, faculty reported facing 2.8 barriers to conducting STEM outreach. The most common barrier was not having enough time to do outreach (80.7%). Faculty reported that since STEM outreach was not part of their regular jobs, their efforts in this area came from their "own" time on top of their "regular" work.

Additionally, 66.7% of those who reported a barrier cited a lack of resources to conduct science outreach. Almost half (49.1%) reported trouble with recruiting participants for science outreach. Furthermore, over 40% of faculty reported that they had trouble finding volunteers to help conduct outreach, and 29% were simply unsure how to do science outreach altogether.

Slightly over half of faculty who faced barriers to conducting science outreach reported being unable to resolve these barriers (53%). Other faculty reported that they overcome these barriers in various ways through their individual efforts. How did they engage in science outreach? By doing the work on their personal time, seeking and eventually finding helpful collaborators, by doing less than they originally hoped with the resources that they had, and by doing the work even though it was not valued by their department. Departments that did not value STEM outreach created barriers for faculty who wanted credit for their work. Faculty also struggled with connecting with teachers and schools and finding collaborators interested in helping with outreach efforts.

Limitations of this survey include not asking faculty who reported they have not encountered science barriers about perceived barriers. Faculty who did not face barriers may have had grant money available to pay others to provide expertise and resources they did not have. In the future it would be useful to ask all respondents about perceived barriers in order to tease out if those who reported not encountering barriers truly were not aware of barriers or if they overcame, changed plans, or otherwise were able to negate barriers (and how they were able to do so) in order to provide science outreach.

Table 2. Faculty Barriers to Outreach	
Faculty (N=57)	
If "Yes" - Barriers (all that apply)	
Time	80.7%
Resources	66.7%
Volunteers	42.1%
Recruitment	49.1%
Not sure how	29.8%
Other	12.3%
Mean number of barriers	2.8
Were you able to Resolve Barriers?	
Yes	46.4%
No	53.6%

How institutional supports and barriers impact faculty STEM outreach efforts.

In the survey, one faculty member explained how policies and infrastructure can hinder STEM outreach efforts:

> "Faculty have no FTE appointment even though outreach activities take far more than the "service" allotment. ... Local participants are many, while recruitment of remote teachers/students/school districts bring logistic challenges."

The faculty member rightly points out that individual faculty not associated with Extension do not have a faculty apportionment specifically related to outreach. This leaves outreach to fall under the categories of service or research and creative activities when looking at apportionment of faculty's time. Institutional support for cross-college collaboratives and sharing resources from humanities, media, journalism and art with the sciences and social sciences would support STEM outreach and potentially increase community engagement.

What outreach supports did researchers want?
The survey suggested potential services that universities may provide to facilitate an increase in outreach. Approximately two thirds of respondents indicated that advertising to potential participants (62%) would be useful (see Table 3). Over half indicated they would like help with logistical/event planning (53%). Forty-three percent of faculty reported needing help with volunteer recruitment, and another 39% reported they needed help with evaluation.

Other potential services the faculty identified included:
- Communication about events to intended audiences.
- Coordination of all outreach activities from UNL
- Registration services and infrastructure
- Maybe solicit routine check-ups/-ins with the different groups and post on social media or in the existing newsletters and general outreach UNL already does

When asked about what type of service they would find useful, their top responses were:
- Having access to information about the STEM outreach activities being conducted by colleagues
- A service that helped advertise STEM outreach activities directly to teachers in Nebraska
- A service that helped with the logistical planning for STEM outreach activities on campus
- Seeing examples of funded grants with strong outreach components

Table 3. Faculty Identified Needs for Science Outreach	
	Faculty (N=141)
What services could UNL offer to help you with STEM outreach?	
Advertising to potential participants	62.0%
Logistical/event planning	52.8%
Volunteer recruitment	43.0%

Evaluation services	39.4%
How useful would you find…? (Range 1-4)	
A service that helped advertise your STEM outreach activities directly to teachers in Nebraska?	3.23
A service that helped advertise your STEM outreach activities to potential general public participants?	3.09
Have access to information about the STEM outreach activities being conducted by your colleagues?	3.3
Have access to information about the STEM outreach activities being conducted by your colleagues?	3.3
A service that helped advertise your STEM outreach activities directly to teachers in Nebraska?	3.2
See examples of funded grants with strong outreach components?	3.2
A service that helped with the logistical planning for STEM outreach activities on campus?	3.1
A service that helped advertise your STEM outreach activities to potential general public participants?	3.1
A service that helped with the logistical planning for STEM outreach activities on campus?	3.1
A service that helped write outreach components for grant proposals?	3.0
A service that helped write outreach components for grant proposals?	2.97
A service that helped recruit volunteers for STEM outreach activities?	2.94
A service that helped recruit volunteers for STEM outreach activities?	2.9

What do we think is happening?

There is an untapped potential at UNL in 40% of the faculty (Table 1) who are interested in conducting STEM outreach (2.95) but have experienced barriers in their attempts. Overall, results of the needs assessment suggest that many of the respondents would engage in STEM outreach if barriers were eliminated.

Connection was a recurring theme that encompasses researchers expressing a need for contact with others who engage in STEM communication. They want to be part of a community with others who share and support their interest in outreach and engagement.

Informal communities of practice can provide support and create opportunities for synergistic collaborations with other faculty members or departments when researchers are given the opportunity, time, and support to meet with a wide variety of like-minded individuals.

Access to information about STEM outreach conducted by others and examples of successful proposals were rated as the most useful support for researchers planning STEM outreach. At UNL there is a large number of disparate outreach efforts, so individuals are scarcely aware of the full range of programs and support the University offers. We also noted that many faculty requests resources that already exist, which suggests they do not know what resources are available.

Communicating with non-scientists was an area researchers identified that they needed to develop skills in.

The lack of recognition and support for outreach varies across departments; without clear criteria for evaluating outreach work for promotion and tenure, departments create barriers to STEM outreach.

Systemic changes are needed in order for the University's infrastructure and support to nurture and align with the shifting emphasis on outreach and community engagement. Faculty described what they need from the institution in terms of resources, support and recognition. These changes are needed, in part, because ad hoc evaluation efforts make it impossible to understand the total impact of the university's outreach efforts or make decisions about which STEM outreach models are most impactful. Additionally, the University needs to support connection, development of activities, and the value of STEM outreach in the promotion and tenure system. Many of the services that the faculty felt would be helpful are already available at UNL. But without coordination, it can be very challenging for individual faculty members to know what services are available and how to access them.

What would successful STEM outreach structures look like?
To accomplish the goal of outreach efforts, faculty must effectively communicate the goals, methods, results, and significance of their research to non-scientists. The public audience for these efforts includes policy makers, educators, politicians, parents and youth. Many people are eager to engage with information that is relevant to their interests and easily understandable (National Academies of Sciences & Medicine, 2017). At most institutions, scientists are expected as individuals to gain these skills and expertise without structured institutional support, and due to tenure structure and expectations of academic institutions, faculty are not always rewarded for outreach activities. Without changes in

cultures and in structures of universities, individual faculty efforts to broaden participation through science outreach are less likely to occur or to be successful and sustainable once funding ends (Nadkarni & Gaines, n.d.).

This is why we argue that the effort to provide effective STEM outreach, engagement and assessment requires support and resources at the institutional level. Mechanisms to build networks of collaborators; expertise to design and evaluate outreach efforts; and resources to produce written, audio, video, graphic, and other emerging communication for the general public are all required in this effort. Our team views this challenge as a collective problem which faculty at our university are attempting to solve at an individual level.

Trying to address a collective challenge individually has created frustration and redundancy. This frustration is not unique. In a recent AAAS webinar "Repairing Public Trust in our Federal Science Agencies" Corey Powell wrote, "In my experience, many scientists are happy to engage with the public but have no idea how to do it, or don't see how it connects to their careers. Institutional mechanisms that bring in the public (like Elias's council of public advisors) and that provide paths for scientists to address public groups could be a huge help" (2020). We propose that it would be more efficient and effective to coordinate expertise across the university to support faculty in planning and implementing broader impacts efforts.

Table 4. Structures that support STEM Outreach
What is
Individual effort
Disconnected projects
Small samples in project evaluations lead to results that are not generalizable
Scattered, localized impact

Fig. 1 What Could Be: Work Smarter Not Harder
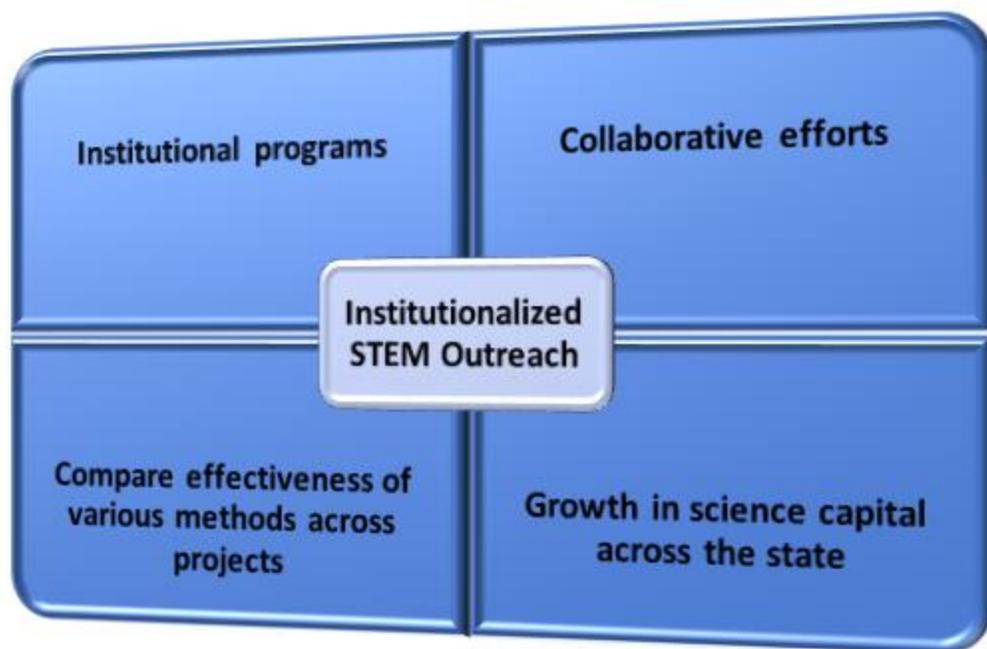
STEM communication and engagement with members of the public require skills such as building collaborations, designing and evaluating outreach activities, producing effective communication pieces on social media, sharing ideas via audio or video, among other innovative efforts.

The How: Moving from Theory to Action

There are multiple potential ways to use the information from the needs assessment to enhance university STEM outreach and community engagement. One approach is to create a centralized hub of information/resources as a single point of contact for researchers. Hub staff can provide point-of-need consultations and referrals to existing resources. Data collected can be used to advocate for future program and resource development.

The needs assessment made clear that there is value in framing the challenges of STEM outreach as institutional, not only individual. Many researchers see the challenges of STEM outreach as their own problem to solve and need to decide between efforts that are directly reworded in annual reviews and efforts that are "extra", Some faculty benefit from grant funding that provides resources to have expertise to conduct broader impacts efforts, but few faculty have such resources or expertise. Only extension faculty have specific apportionment for outreach efforts. To take advantage of the opportunities that outreach provides, the data in our needs assessment survey suggests the need for some changes in institutional infrastructure.

If part of the mission of the university is to have faculty engage in outreach, enhance the reach of their work beyond academia, and increase public awareness of the success of the institution, collective efforts will be useful

We found value in doing a needs assessment at our Research Intensive (R1) institution to discover possible institutional level supports for STEM outreach. We see our university as a microcosm of land-grant comprehensive research institutions. Because universities are a combination of generic and specific local dynamics, each one could do their own needs assessment to determine what would work best for them. Reporting these results and periodically replicating them could help faculty and university leaders to access how best to accomplish STEM outreach goals.

- The current data suggest that the following would be useful for increasing STEM communication and outreach: Provide a centralized hub of communication that helps researchers understand the potential partners and resources available at the university
- Training on or links to people with expertise in the skills to communicate effectively with non-scientists
- Partners and support for evaluating the effectiveness of STEM outreach and related activities
- Urge units to include formal recognition of the importance of outreach efforts in annual faculty evaluations
- Support faculty collaboration across disciplines and institutions and ways for departments to see cross-department or cross-college efforts (e.g. ask departments to provide guidelines for assessing cross-disciplinary work that may take longer to come to fruition)
- Create systems that allow for apportionment or rewards for public engagement (usually considered "service") at the same level as research publications, grant funding, and teaching will increase the level of effort researchers can contribute to engagement and help make efforts sustainable.

One of the two fundamental criteria for NSF funding is evidence of broader impacts that are explicit and clear. An important dimension of broader impacts is science communication and community engagement to reach the goals of serving our communities. Effective STEM outreach is in high demand thanks to increased funding for scientific research and grant requirements to engage with the general public. Increasing public understanding of emerging science is a valuable goal which has led NSF to place increasing importance on communicating the value of scientific research directly to the public (MacFadden, 2009). Universities that create effective systems and supports for science outreach will be better situated to reach ambitious research goals.

Changes within funding structures and professional organizations suggest these cultural shifts will occur in higher education. The most successful research universities will be prepared for these changes with faculty who have the skills to engage and communicate with non-scientists.

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APPENDICES

Appendix A: Examples of Science Outreach at UNL

Scicomm: https://news.unl.edu/free-tags/scicomm/

Science Education Partnership Awards
   https://worldofviruses.unl.edu/
   http://worldsofconnections.com/

SciPop: https://unl.libguides.com/scipoptalks

Science Slam: https://mrsec.unl.edu/science-slam

UNL Broader Impact Partners: https://research.unl.edu/broaderimpacts/unl-bi-partners/

UNL Broader Impacts Community Activities:
https://research.unl.edu/broaderimpacts/community-resources/

Image courtesy of Nathen Meier:

Appendix B: Examples of Resources for Science Communication and Broader Impacts at the University of Nebraska and in the State of Nebraska

- Agriculture and Environmental Sciences Communication Program
- Behlen Observatory
- Center for Civic Engagement
- Center for Digital Research in the Humanities
- Center for Science, Mathematics, & Computer Education
- Click2SciencePD
- Daugherty Water for Food Global Institute
- Department of Teaching, Learning, and Teacher Education
- Engineering Ambassadors Network
- IANR Science Literacy Community
- Johnny Carson School for Emerging Media Arts
- Kutak Center for the Teaching and Study of Applied Ethics
- Lied Center for the Performing Arts
- Mary Riepma Ross Media Arts Center
- Mueller Planetarium
- Nebraska 4-H
- Nebraska EPSCoR
- Nebraska Extension
- Nebraska Innovation Studio
- Nebraska Math
- Nebraska Science
- NUTech Ventures
- Office of Proposal Development
- Office of TRIO Programs
- Osher Lifelong Learning Institute
- Research Impact Coordinator (Office of Research and Economic Development)
- Sally Wei, College of Engineering
- SBSRC's Methodology and Evaluation Research Core Facility
- Sheldon Museum of Art
- STEM Trails Center
- STEM Ecosystems
- UCARE
- University of Nebraska Press
- University of Nebraska Public Policy Center (Lisa Pytlik Zillig)
- University of Nebraska State Museum
- University Libraries (Judy Diamond, Kiyomi Deards)
- Upward Bound Math-Science

Appendix C: Supplementary Materials

<u>Researchers</u>

The researchers were a subgroup of a collaborative group of investigators and partners made up of University system faculty and staff and community partners. All members of the collaborative group suggested research questions, individuals, and groups to be included in both the quantitative interviews and the system wide survey. Faculty and staff represented departments in education, engineering, extension, life and physical sciences, and social sciences. These individuals included staff, faculty and administrators. Community partners included representatives from the state Department of Education, after school programs, museums, gifted programs, and local non-profits. Researchers worked with the BOSR (Bureau of Sociological Research) at the University of Nebraska-Lincoln to develop quantitative interview questions, the results of which were used to inform the development of the STEM Outreach survey.

<u>Quantitative Interview Methods</u>

In order to better understand faculty conducting STEM outreach, researchers worked with the BOSR to develop quantitative interview questions whose information would be used to better inform the development of a system wide survey. Two sets of questions were developed: one targeted at faculty conducting STEM outreach and one targeted at disseminators of knowledge/community partners. Interviewees were asked about:
- Past and current STEM outreach activities and collaborations
- STEM outreach collaborations, and challenges faced in these collaborations
- If challenges were overcome, how were they overcome

Interviews were conducted May 1, 2015 and August 31, 2015. Fifteen potential participants were selected based on personal knowledge of the researchers. Twenty-two people were approached to participate: fifteen faculty and seven community partners. All participants were recruited and interviewed by BOSR personnel in order to minimize pressure to participate in the interviews and to encourage those who chose to participate to give honest and forthright answers. BOSR personnel sent emails to interviewees, with a follow up phone call approximately one week later if no response was received, to invite researchers to participate in the study. Nine faculty and five community partners agreed to participate in the research for a total of fourteen participants. The average interview length was approximately 30 minutes.

<u>Qualitative Interview Script</u>
Qualitative Interview Instrument
[Note: This is a semi-structured interview. Additional probes/follow-up questions may be asked of each participant]

Thank you for taking the time to discuss your experience with science, technology, engineering, and mathematics (STEM) outreach activities with me today. My name is ___, a project manager at the Bureau of Sociological Research. The interview will be brief, taking 30 to 45 minutes to complete. We will be talking mostly about STEM outreach and activities today. By STEM outreach and related activities, we mean outreach and activities meant to broaden STEM participation and knowledge through recruitment, mentoring, research, events, learning opportunities, public education efforts, and partnerships.
You were asked to participate because you have been identified as either a researcher who connects with community partners to disseminate STEM knowledge, or as a community partner who may network with researchers to make that knowledge publicly available. The purpose of the interview is to gather information to better understand what types of partnerships and collaborations you have been a part of in the past, what makes such partnerships successful or not, and identify where there are gaps in needs in order to improve these collaborations in the future.

Today we will be discussing your experiences and your opinions of these partnerships and collaborations. There are no right or wrong answers, and your participation totally voluntary. This is strictly a needs assessment project, and your participation does not help or harm your relationship with the university (if faculty/researcher include: your department, your colleagues or your students). In our later reports no names will be attached to comments, but we may talk about your organization or department in our report. You may be assured of confidentiality as much as we possibly can. This study has been reviewed and approved by the [redacted] Institutional Review Board [redacted]. If you have questions about your rights as a participant, you may contact them at [redacted].

Do you agree to participate?

"Producers" of knowledge—Faculty

1. Please describe your past and current involvement with STEM outreach and related activities. What did/do these partnerships and collaborations look like? To what extent were you involved in these activities?
2. What motivated you to do outreach and related activities (faculty service, grant requirements, etc.)?
3. Who are your colleagues on campus that do this type of outreach? Probe: who would you go to if you were to need advice or connections to get a project done?
4. Please think about your most recent project. What were the goals of your outreach and related activities?

5. Who have you worked with as community partners in the past? (Probe- For example, have you worked with teachers, Extension, the YWCA, Community Learning Centers, schools, school districts, camps, clubs, the general public, museums, coffee shops, bars, radio stations, TV stations, state government, state agencies, non-profits, national organizations, etc.?)

6. Thinking about the STEM outreach and related activities that you've been involved in in the past and/or are currently involved in, what does a "successful partnership" mean to you? Can you describe partnerships or elements of partnerships you've been involved in that you would describe as successful? (If haven't had successful partnerships, what would you envision a successful partnership looking like? What would be necessary for it to be successful?)

7. Now thinking about unsuccessful partnerships you've been a part of, or less successful elements of partnerships you've experienced, what kept them from succeeding? What barriers or challenges did you encounter?

8. What evaluation, if any, has been conducted on the STEM outreach and related activities that you've been a part of? Who has conducted evaluation for you? How involved have you been in this process?

9. If a Center was created to specifically foster partnerships between researchers and their education and public outreach partners, what kinds of services do you think it should have that would be beneficial to you in current and future activities? What would be beneficial to fostering and improving those collaborations? What help or resources do you need to have more successful partnerships? Would you want to know what other UNL researchers are doing and who they are working with for STEM outreach? Would you want to see funded grant proposals with strong STEM outreach and evaluation components?

"Disseminators" of knowledge/community partners--Museums, School Personnel, etc.

1. Please describe your past and current collaborations and/or partnerships with university faculty and researchers. What did/do these partnerships look like? What was involved in the STEM outreach? What was your part and what was the researchers' part? What kind of STEM outreach resulted from these partnerships?

2. What are the goals of these partnerships? What do you hope to gain from working with university researchers?

3. Thinking about the collaborations and partnerships you've been involved in in the past and are currently involved in with faculty and researchers, what does a "successful partnership" mean to you? Can you describe partnerships or elements of partnerships you've been involved in that you would describe as successful? (If [you] haven't had successful partnerships, what would you envision a successful collaboration with university researchers looking like? What would be necessary for it to be successful?)

4. Now thinking about the unsuccessful partnerships you've been a part of, or less successful elements of partnerships you've experienced, what kept them from succeeding? What challenges or barriers did you encounter?

5.   What evaluation, if any, has been conducted on the STEM outreach that resulted from your collaborations and partnerships with university researchers? How involved have you been in this process?

6.   If a Center was created to specifically help foster partnerships between individuals such as yourself and university faculty and researchers, what services should that Center offer that would be useful to you in current and/or future outreach endeavors? What would be beneficial to fostering and improving those collaborations? What help or resources do you need to have more successful partnerships?

STEM Outreach and Related Activities Survey Methods

       Researchers worked with the BOSR to develop survey questions based on the quantitative interviews. The Nebraska State Department of Education (NSDE) had recently assessed the needs of teachers within the state. BOSR communicated with the NSDE on our behalf in an effort to better align the survey questions to elicit information about local needs. The current survey includes both close-ended and open-ended items about past experiences and current needs of those conducting and participating in STEM outreach activities. The survey was administered and managed by BOSR to ensure participant confidentiality.

       Email addresses were collected from the public websites of the state-wide University system by researchers and BOSR staff. Staff and faculty in STEM departments, the social sciences, medicine, and STEM-related centers were also gathered and included because a variety of people in faculty and staff positions do STEM outreach. We also invited community stakeholders to participate in the survey in response to community feedback that they often felt excluded from discussions about STEM outreach in higher education. In order to address concerns that some individuals or organizations may not have been identified, individuals were given the chance to email BOSR and recommend individuals and groups that the survey should be sent to, or to volunteer to participate if they had not received a survey invitation. The total population surveyed was 3,638.

       In February 2016, web surveys were sent out solely in English using LimeSurvey (https://www.limesurvey.org/), an open-source survey application hosted on secure servers by BOSR, with data collection ending in March 2016. Lime was chosen to send out survey invitations because it allowed researchers to limit follow-up emails to respondents who had not yet filled out the survey. Two follow-up emails were sent out to non-responders at one-week intervals. Of 3,638 individuals, 134 emails were undeliverable and 705 responded, for a response rate of 19.4%. The response rate adjusted for undeliverables is 20.1%. Of the STEM faculty at the University of Nebraska, 12% responded. Other system respondents included adjunct professors, emeritus professors, extension educators, graduate students, guest lecturers, and postdoctoral researchers. The current analyses focus on the faculty at UNL in order to identify actions that the university could take. We do not know much about the difference between those who responded and those who did

not, therefore we describe responses and recognize that perspectives from those who did not respond (e.g., because they did not see the topic as relevant, because they were too busy, because there was an error in their email, or for some other reason).

Survey Instrument

[Redacted] at the [redacted], acting on behalf of [redacted], is trying to understand the needs of individuals within [redacted] in conducting STEM outreach and related activities and to assess the availability of resources to help with STEM outreach and related activities. By STEM outreach and related activities we mean outreach and activities meant to broaden STEM participation and knowledge through recruitment, mentoring, research, events, learning opportunities, public education efforts, and partnerships.

As a person potentially involved with STEM outreach and related activities through the [redacted] System or a community partner in [redacted], we are asking for your help with the STEM Outreach Needs Assessment Survey. The survey is short, about 20 questions, and should take you only about ten minutes to answer. This survey is being conducted for research purposes and may be published as part of a white paper, scholarly article, or book chapter. You may skip any questions you are not comfortable answering. Your participation is voluntary.

The Bureau of Sociological Research (BOSR) at the University of Nebraska-Lincoln will use the free version of the web survey program, Lime to collect the results of the survey. The data are sent to BOSR's secure server room in Oldfather. Only upper level IT staff have access to this server room. This server also has a security certificate. The data are not shared with Lime or any other third-party. The IP address is not collected. Each respondent will be assigned a unique token under which they will complete the survey. This token will be tied to identifying data in order to limit reminder e-mails to nonresponders. After data collection, the tokens will be replaced with sequential ID numbers. No identifying information will be included in the final dataset. The reminders will be sent to nonresponders only.

The responses will only be reported in aggregate form. You can refuse to participate or withdraw at any time without harming your relationship with the researchers or the [redacted], or in any other way receive a penalty or loss of benefits to which you are otherwise entitled. If you have any questions regarding the survey or technical issues, please contact the Bureau of Sociological Research at bosr@unl.edu or 402-472-3672. This study has been reviewed and approved by the [redacted]. If you have questions about your rights as a participant, you may contact them at [redacted].

Please print a copy of this page for your records before moving forward.

By clicking the "next" button below, you are indicating that you agree to participate in this survey.

1. Have you conducted STEM outreach activities?
· Yes
· No

1a. If no, are you interested in conducting STEM outreach activities in the future?
· Yes
· No
· Don't know

1a. If no, How interested are you in conducting STEM outreach activities?
· Not at all Interested
· A little interested
· Somewhat interested
· Very interested

2. Have you faced any barriers in conducting STEM outreach?
· Yes
· No

2a. If yes, please indicate which of the following barriers you have faced. Yes/No
     Lack of time
     Lack of resources
     Lack of volunteers
     Issues recruiting participants
     Not sure how to start an outreach activity
     Other, specify

2b. [Only for those that reported at least one barrier] Were you able to resolve the barrier(s)?
· Yes -> how?
· No -> what would have helped you resolve the barrier(s)?

3. What, if any, resources have you used through the [redacted] System to help you with STEM outreach? (open)
· [redacted]
· Center for [redacted]
· [redacted] Engineering Center
· Other, specify:

4. What resources have you used in the broader community to help you with STEM outreach? (open)

5. What services could [redacted] offer to help you with STEM outreach? (open)
· Volunteer recruitment
· Logistical/event planning

- Advertising to potential participants
- Evaluation services
- Other, specify
6. What services could the broader community offer to help you with STEM outreach? (open)
7. Have you recruited volunteers for your STEM outreach activities?
- Yes
- No

7a. If yes, How have you recruited volunteers for your STEM outreach activities? (open)
8. Have you advertised your STEM outreach activities?
- Yes
- No

8a. If yes, How have you advertised your STEM outreach activities? (open)
9. What have been your goals for STEM outreach activities?
- Recruitment to [redacted]
- Recruitment to department
- Required for grant
- Education of general public
- Recruitment of students into STEM generally
- Other, specify
    10. How do you evaluate your STEM outreach activities? Open, with button for "none"
11. Do you have someone or someplace you can go to get help with STEM outreach activities?
- Yes -> If yes, what people or places do you get help from?
- No
12. If a mentorship program was created to help encourage STEM outreach activities, what features should the mentorship relationships have: (yes/no)
- One-on-one meetings for mentors/mentees
- Hands-on experience for mentees working with mentor's outreach activities
- Matching mentor/mentees based upon academic discipline
- Mentor assisting mentee with grant writing for STEM outreach activities
- Mentor assisting mentee with evaluation of STEM outreach activities
- Other, specify
13. Based on the above possible components for a mentorship, how interested are you in having a colleague who would act like a mentor to help you conduct STEM outreach activities?
- Not at all Interested
- A little interested
- Somewhat interested

· Very interested
14. (If you have conducted STEM outreach activities before), how interested are you in being

a mentor to a colleague to assist them in conducting STEM outreach activities?

· Not at all Interested
· A little interested
· Somewhat interested
· Very interested
15. Would you be willing to travel within the state of [redacted] to conduct STEM outreach

activities?

· Yes- how far?
· No
16. How useful would you find a service that helped write outreach components for grant

proposals?

· Not at all useful
· A little useful
· Somewhat useful
· Very interested
17. How useful would it be to see examples of funded grants with strong outreach

components?

· Not at all useful
· A little useful
· Somewhat useful
· Very interested
18. How useful would it be to have access to information about the STEM outreach activities

being conducted by your colleagues?

· Not at all useful
· A little useful
· Somewhat useful
· Very interested
19. How useful would you find a service that helped recruit volunteers for STEM outreach

activities?

· Not at all useful
· A little useful
· Somewhat useful
· Very interested
20. How useful would you find a service that helped advertise your STEM outreach activities to

potential general public participants?

·   Not at all useful
·   A little useful
·   Somewhat useful
·   Very interested

21. How useful would you find a service that helped advertise your STEM outreach activities directly to teachers in [redacted]?

·   Not at all useful
·   A little useful
·   Somewhat useful
·   Very interested

22. How useful would you find a service that helped with the logistical planning for STEM outreach activities on campus?

·   Not at all useful
·   A little useful
·   Somewhat useful
·   Very interested

23. If a center was created through the [redacted] System to help [redacted] researchers to

    connect with community partners to conduct STEM outreach activities,
    how useful would you find it?

·   Not at all useful
·   A little useful
·   Somewhat useful
·   Very interested

24. Of the following possible services, which would be most useful to you?

·   a service that helped write outreach components for grant proposals
·   examples of funded grants with strong outreach components
·   access to information about the STEM outreach activities being conducted by your colleagues
·   a service that helped recruit volunteers for STEM outreach activities
·   find a service that helped advertise your STEM outreach activities to potential general public participants
·   a service that helped with the logistical planning for STEM outreach activities on campus

25. Of the following possible services, which would be next most useful to you?

·   a service that helped write outreach components for grant proposals
·   examples of funded grants with strong outreach components
·   access to information about the STEM outreach activities being conducted by your colleagues
·   a service that helped recruit volunteers for STEM outreach activities

· find a service that helped advertise your STEM outreach activities to potential general public participants

· a service that helped with the logistical planning for STEM outreach activities on campus

26. Of the following possible services, which would be least useful to you?

· a service that helped write outreach components for grant proposals

· examples of funded grants with strong outreach components

· access to information about the STEM outreach activities being conducted by your colleagues

· a service that helped recruit volunteers for STEM outreach activities

· find a service that helped advertise your STEM outreach activities to potential general public participants

· a service that helped with the logistical planning for STEM outreach activities on campus

27. Are you affiliated with the [redacted] System?
    No -> Go to Q28
    Yes -> Go to Q 27A

27A. What is your affiliation with [redacted]?
        Staff
        Research Professor
        Tenure track Professor, rank: (open)
        Other

28. What is your organizational affiliation and position?

· Organization: (open)

· Position: (Open)