Motivations and Barriers to Participation in Community Outreach and Engagement among Environmental and Water Resources Engineering Students

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Abstract

Universities serve as a hub for the advancement of water science and engineering knowledge and innovations. Communities outside of academia hold equally valid expertise on water and environmental topics. However, there is a lack of avenues for knowledge exchange between academia and non-academic communities including homeowners, industry professionals, policy makers, and K-12 students and teachers. Many universities and research centers attempt to enhance knowledge sharing by organizing broader impact outreach events such as lab tours, demonstrations, hands-on activities, and public presentations. This work studies water-focused students who we define to be students from all disciplines (engineering, biology, sociology, geography, planning, etc.) that study water resources, quality, treatment, and management. Anecdotally, we have seen that of a pool of approximately 100 water-focused students, only the same small subset participates in every event while over 70% of those invited never volunteer. Therefore, there is a need to assess why we see this occurrence. This study aims to survey undergraduate and graduate student water scholars' motivations and barriers for participating in volunteer broader impact outreach events outside of their degree requirements. This study collected quantitative and qualitative data. Quantitative data were collected through Likert-scale type responses to motivating and hindering factors. Qualitative data were collected through written responses to questions on specific positive or negative student experiences and attitudes. Four main outreach trends emerged: 1) Students enjoy attending outreach events and find it helpful to themselves and to society; 2) Attending events leads students to want to participate in more; 3) Lack of time is by far the top hinderance; 4) Students are motivated by mentor support. Study findings suggest three possible steps to implementing a targeted strategy for broader impact student outreach that aligns with student desires at university research centers: 1) Choice of outreach events should emphasize the contribution to society; 2) Outreach recruitment should emphasize skills students will gain; 3) Faculty mentors should genuinely support their students' outreach endeavors including finding relevant outreach opportunities.

1.0 Introduction and Background

For hundreds of years, universities have held a commitment and responsibility to enhance societal needs and work towards a common good through community engagement. [1] All public and private universities indicate a commitment to service and education via their institution's mission statement. Simultaneously, universities often create research centers to solve transdisciplinary grand challenges. These university research centers are often funded by the National Science Foundation (NSF). In 1997 the NSF changed their criteria for proposals to include "broader impacts" requiring research scientists seeking funding to address societal outcomes within their research discipline. [2] Therefore, research centers now also serve as a conduit to connect the research, education, and service missions of a university. [3]

Meanwhile, communities outside of academic institutions are generating knowledge by studying their local problems. Communities hold a rich database of traditional wisdom and lived experiences that lead to finding solutions to local problems. [4] For example, community-based

water management, where communities collaborate together to gain decision making power over their natural resources, leads to favorable technological solutions to problems as well as inclusion and perceived fairness of resource allocation. [5]

Academia and communities can effectively co-create and share their knowledges through outreach efforts such as lab tours, demonstrations, hands-on activities, and public presentations. [6] In order to successfully run outreach efforts, personnel must be available to plan, facilitate, and conduct the outreach events. Most university outreach programs rely on volunteer student engagement to facilitate interactions with community members. However, while outreach programs generally contact large pools of potential student volunteers, they see low levels of participation. [7] There is a need to understand students' attitudes toward outreach in relation to this behavior. Only then can solutions be found to address the dissonance between intention and action to increase participation and ultimately help facilitate more effective interactions between academia and community.

One major limitation is evident within the body of outreach literature. The vast majority of outreach literature has historically addressed outreach in a top-down manner where academia is delivering knowledge in a one-way exchange to recipients. Relatively recently, the research has been reflecting the validity of the knowledge and expertise non-academic communities already hold and that outreach should be a two-way exchange of knowledge. [8], [9]

Additionally, most outreach studies focus on outcomes surrounding the recipients of outreach events. [10] We aim to focus on the other side of outreach: those who participate in facilitating the outreach. This will act as a first step to creating an environment that is welcoming and accessible for students in a research center to participate in outreach, and ultimately, increase knowledge sharing avenues between academic and non-academic communities.

This study specifically concentrates on water-focused university engineering students, as most studies regarding university outreach combine all STEM disciplines. [11] Academic major choice often reflects students' world view and values. [12] University students pursuing a degree in an environmental or water-focused field might hold attitudes that are motivated by increasing environmental awareness and feel a desire to contribute or help society. We aim to investigate if increasing environmental awareness is a top motivating factor for water-focused students. This study aims to expand upon STEM outreach knowledge by exploring undergraduate and graduate students specifically studying environmental engineering topics, as their beliefs and experiences may differ from studies that combine all STEM disciplines together.

The goal of this study is to create and test methodology to capture the voices of university environmental and water resources engineering students regarding their attitudes and experiences in outreach participation. This goal will be achieved by the following objectives:

    1) Gather quantitative data on what motivates students to volunteer to participate in outreach events outside of their degree requirements

    2) Gather quantitative data on what barriers are impeding their ability and desire to volunteer

    3) Gather qualitative data on specific experiences and attitudes identified by the literature as important factors in influencing participation

We aim to survey undergraduate and graduate student scholars to examine motivations and barriers for participation in volunteer broader impact outreach events outside of their degree requirements. We anticipate that the results of the survey will provide an evidence-based strategy to help university research centers understand what students need in order to more effectively engage with broader communities. While our long-term goal is to increase knowledge sharing between academia and community through increased student involvement, the scope of this project will focus on understanding student motivations and attitudes as a first step.

2.0 Methods

2.1 Audience
The target population for this study was undergraduate and graduate students attending a university and studying or researching environmental topics. For the purpose of this paper, we only focused on participants who self-identified that they specifically study engineering with an environmental focus. Future papers will analyze the data sets that include other environmental academic majors (e.g., biology, chemistry, sociology).

We recruited participants from two existing research center pools: the Center for Water and the Environment at the University of New Mexico and the Intermountain West Transformation Network. Participants were contacted via email listservs for their respective research center.

The Center for Water and the Environment (CWE) is an NSF Center for Research Excellence in Science and Technology (CREST) funded research center at the University of New Mexico established in 2014. CWE is focused on increasing the participation of underrepresented minorities in science, technology, engineering, and math (STEM) professions while conducting cutting-edge research into technological and engineering-based solutions to problems with water and the environment. The center is organized around 3 research themes: Watersheds and Wildfires, Water Treatment Technologies, and Water and Energy.

The Intermountain West Transformation Network (TN) is an NSF Sustainable Regional Systems (SRS) funded research network comprised of 8 universities across the western United States and was established in 2021. The University of New Mexico serves as the host institution; partner institutions are University of Arizona, New Mexico State University, Colorado State University, Washington State University, Utah State University, Northern Arizona University, and New Mexico Tech. TN aims to build capacity for adaptations and guided transformations towards sustainable regional systems through innovative and equitable solutions. The TN team is advancing understanding of resilient headwaters, food-energy-water systems, and innovative and equitable governance models.

Both CWE and TN have a designated Outreach Coordinator. This is a staff position that serves as a liaison between the research center and the community. They seek and facilitate events, create and maintain demonstrations and activities, and recruit and teach student volunteers.

2.2 Survey Development

Data were collected using an anonymous online survey platform and took approximately 20 to 30 minutes for participants to complete. Participants were compensated for their time taken to complete the survey in the form of $10 gift cards.

The survey was created in a University of New Mexico Qualtrics account. The survey is split into 4 main sections: 1) Background on the survey taker; 2) Likert-style questions to assess factors that may motivate the participant to volunteer for outreach events; 3) Likert-style questions to assess factors that may be barriers for participation in volunteering for outreach events; and 4) Questions that qualitatively assess the participant's previous experiences and attitudes about outreach.

Survey questions (Appendix A) were developed based on the context of our research objectives and adapted from relevant literature to appropriately investigate each of the four sections. The University of New Mexico Institutional Review Board approved this study and assigned it the IRB number 2210020153.

Section 1: Background on the Survey Taker has well-developed, standard best practices. [13] We included demographic information to determine if gender identity, research center affiliations, degree program name, and degree program level impacted responses. Additional questions included types of outreach the students had previously participated in. The list included outreach events offered previously by the centers (e.g., K-12 youth education, community education or meetings). Future versions of this survey will place demographic questions at the end.

Section 2: Motivations uses Likert-type style questions to evaluate the level of impact the specific motivating reasons have on participation in outreach. Nine possible motivating factors were identified from literature. [7], [14], [15], [16] For the purposes of this study we define motivations as potential reasons for activation and direction of behavior, in this case willingness to invest personal resources to participate in outreach. [17], [18] We also included an open text box option for students to voice other motivating reasons for participation. Since our pool of participants were all environmentally-focused, we added a possible motivating factor of "increasing environmental awareness". We also asked students to select a primary and secondary motivator from the list.

Similar to Section 2, *Section 3: Barriers* used Likert-type style questions to evaluate the level of impact specific barriers have in hindering their participation in outreach. The nine possible barriers were identified. [7], [14], [15], [16] For the purposes of this study we define barriers as something that restricts or blocks achievement towards a behavior, in this case participating in outreach. [19] We also included an open text box option for students to voice other hindering factors for participation. Additionally, we asked students to select a primary and secondary hinderance or barrier from the list.

Section 4: Experiences and Attitudes used Likert-type scale questions to explore attitudes. Attitudes can range from negative to positive emotions, experiences, and thoughts towards overall evaluations. For the purposes of this study, we define attitudes through the tripartite model which represents the individual's overall evaluation of the statement based on a combination of affective (emotions), behavioral (experiences), and cognitive (thoughts)

components. [20] Section 4 was unique in that it included open text boxes and asked participants to elaborate on why they chose the Likert response. Quotes included in the discussion section were selected by visually coding for common sentiments in Section 4 responses. Questions aimed to understand influence of research advisor support and previous participation in outreach on motivations and barriers. Previous studies show that students who want to participate in outreach often report facing both implicit and explicit negative reactions from their research advisors or academic departments. [14] Several studies have found that scientists believe that engaging in public outreach impedes their ability to conduct research or publish research papers. [21] Meanwhile, previous positive experiences participating in outreach tends to enable further participation. [16]

3.0 Results
This study analyzes data from a total of 19 students who participated in the survey and identified as an engineering student. All were students within the CWE or TN with a study or research focus on environmental topics. Specific degree programs included Civil Engineering, Chemical Engineering, and Computer Engineering from three universities- the University of New Mexico, the University of Arizona, and Washington State University. 10/19 (53%) participants self-identified as women. 4/19 (21%) participants were undergraduate students, 9/19 (47%) were Master's students, and 6/19 (32%) were Doctoral students.

Results are summarized and illustrated in Table 1, Figure 1, and Figure 2. Table 1 shows the top 3 motivators and barriers to outreach participation based on the Likert-scale mean. The top three motivators, which all had a Likert-scale mean of above 4.00 as shown in Figure 1, were Desire to contribute/ Help society, Increasing environmental awareness, and Improve teaching and/or communication skills. The following four motivating factors, which all had a Likert-scale mean between 3.00 and 4.00, were Serving as a role model, Fun or enjoyment, Advisor or departmental encouragement, and Advisor or departmental requirements. Finally, the motivating factors that had the least impact with a Likert scale mean of below 3.00 were Experience in the past as a recipient and Funding requirement.

The top barrier with a Likert-scale mean of a 4.42 was Lack of time. The other nine barriers had means below 3.00 that range from 2.88 to 1.65 (Figure 2). In order from greatest to least importance, these barriers were Lack of: Details about outreach opportunities, Outreach opportunities that interest me, Information about outreach opportunities, Knowledge or skills to perform outreach, Relevance to my work, Comfort doing outreach, Interest and Desire, Value and purpose in outreach, and Support from advisor or department.

Table 1: Motivations and barriers to student outreach participation in deceasing order of importance

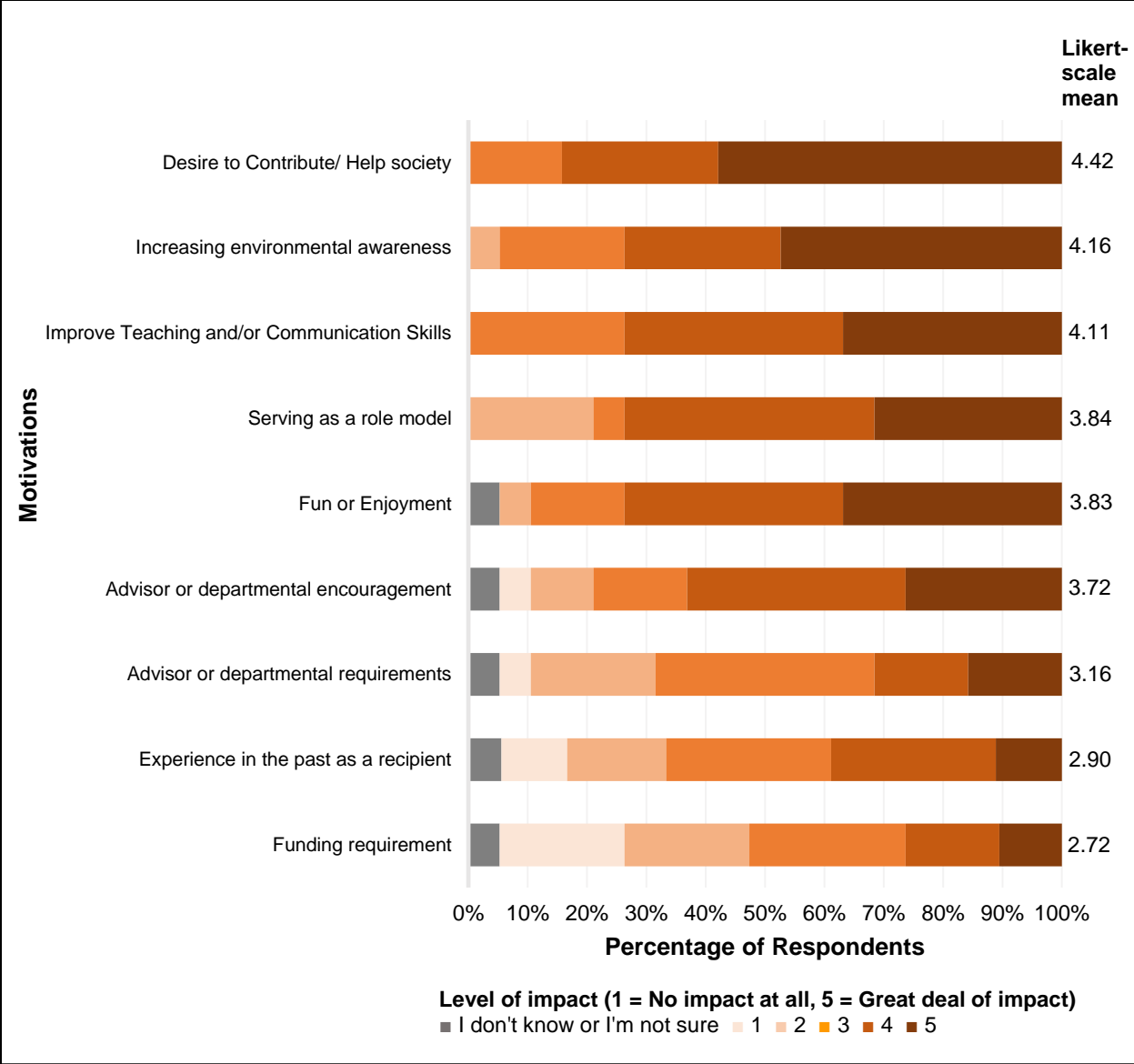| Top Motivators	Top Barriers
1. Desire to contribute/ Help society	1. Lack of time
2. Increasing environmental awareness	2. Lack of details about outreach opportunities
3. Improve teaching and/or communication skills	3. Lack of outreach opportunities that interest me

Figure 1: Motivations for Participating in Outreach. In descending order of greatest impact based on Likert-scale mean, participants' responses to the question "using a scale of 1 to 5 where 1 is 'no impact at all' and 5 is 'a great deal of impact' please evaluate the level of impact the following reasons have in why you participate in outreach." Each section of a bar represents the percentage of respondents who chose a given answer for each question. To the right of each bar is the Likert-scale mean. Total number of respondents = 19.

Figure 2: Barriers to Participating in Outreach. In descending order of greatest impact by Likert-scale mean, participants' responses to the question "Using a scale of 1 to 5 where 1 is 'no impact at all' and 5 is 'a great deal of impact' please evaluate the level of impact the following factors have in hindering (impeding) your participation in outreach." Each section of a bar represents the percentage of respondents who chose a given answer for each question. To the right of each bar is the Likert-scale mean. Total number of respondents = 19.
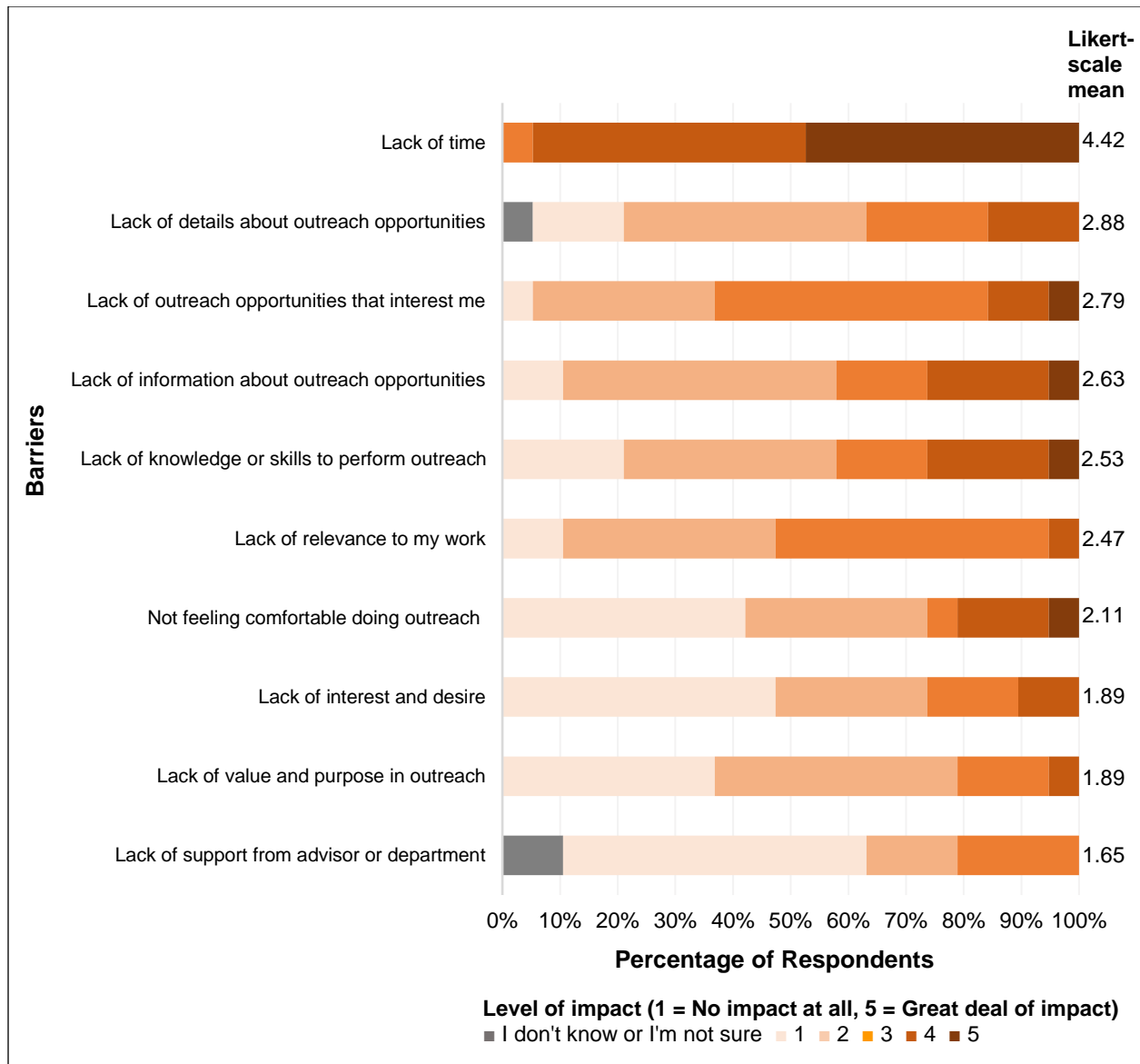
4.0 Discussion

Findings from both the Likert-style motivations and hindrances questions as well as qualitative analysis on students' experiences and attitudes exhibit four main trends.

Outreach Trend 1: Students enjoy attending outreach and find it helpful to themselves and to society

All 19 (100%) respondents reported that improving teaching or communication skills had an impact on their volunteerism (Figure 1). An engineering student said, *"It is important to*

understand how to present your [research] field to many diverse groups." 17/19 (89%) of participants reported "Fun or Enjoyment" having an impact on why they volunteer for these broader impact outreach events. 16/19 (84%) students believe that participating in outreach will help them in their future careers. For example, one student said, *"By participating in events, you meet people that you would probably never meet otherwise which is a great networking opportunity and also helps your public speaking skills."* From these data, we gather that students enjoy participating in outreach, find that events are helpful for developing communication skills, and will help them as they pursue careers after graduation. 15/19 (79%) respondents disagree that there is a lack of value or purpose in outreach. Not only are water-focused engineering students participating in broader impact outreach and enjoying doing so, but they also believe that their volunteer outreach participation has societal importance. One student reflected, *"When outreach goes well, it is highly rewarding and leads to a sense of fulfillment."*

Outreach Trend 2: Attending events leads students to want to participate in more
15/19 (79%) Respondents report that having participated in an outreach opportunity previously led them to want to participate in more. One student reported, *"I love to participate in outreach more because of my past experiences."* Positive experiences participating in outreach can make committing to additional events more accessible. For example, another student stated, *"The more outreach that I participate in, the more comfortable I become."* These results may explain our anecdotal evidence as to why the same 30% of students continually volunteer to participate for multiple events.

Based on this trend, one method to encourage participation is to require attending at least one event early on in a student's program. However, from these study results, students report that funding requirement (i.e., removing research funding if students do not participate) is not a top motivating factor in why they participate. Instead, students who have already participated may serve as leaders in recruiting students who have yet to volunteer to participate.

Outreach Trend 3: Lack of time is by far the top barrier
13/19 (68%) students listed lack of time as their primary barrier. All students (100%) said lack of time had at least somewhat of an impact on their decision not to participate in outreach (Figure 2). For example, one student said, *"To do [outreach] right requires follow-through, which is a time commitment that conflicts with the limited and unpredictable schedule of a graduate program."*

It is worth noting that students think participating in outreach does not hurt their ability to conduct research. Only 4/19 (21%) participants believe that participating in outreach impedes their ability to conduct research. From this we infer that students may feel that lack of time is a barrier in relation to other aspects of their lives besides conducting research. One student reflected, *"I love…helping out with the new outreach events but I can only do this a couple times a semester because of my current school/ work schedule."* This finding is consistent with similar literature on STEM outreach participation. Andrews found that lack of time was the top barrier for both graduate students and faculty. [7]

Interestingly, we note that Outreach Trend 2 contradicts Outreach Trend 3. While attending one event leads to desire to participate in more, students must balance their time and prioritization of

school, research, outreach, and personal life. Perhaps students who attend one event may choose to prioritize outreach in their schedule due to the other perceived benefits discussed in Outreach Trend 1 (e.g., helping society, improving environmental awareness, and improving teaching and communication skills).

Outreach Trend 4: Students are motivated by mentor support
Most interestingly, contrary to much literature, the participants in this survey demonstrate feeling supported by their advisor or research mentor in their decisions to participate in outreach. Andrews found "lack of support from advisor or department" was a top barrier and the third most important hindrance. [16] On the contrary, we found the opposite effect; students are motivated to participate in outreach because of their advisor's support.

Not a single environmental engineering student disagreed with the statement "my mentor/advisor supports me participating in outreach." In fact, quotes provided by the students demonstrate the opposite; their advisors are supportive of outreach participation which leads to the student wanting to participate more. For example, students reported,

> *"I believe that my mentors' enthusiasm for outreach has rubbed [off] on me, and I now share a similar level of motivation and excitement for outreach."*

> *"Most of the outreach I've done in my field during my degree program was either brought to my attention by my advisor or done with their support."*

> *"[My mentor] shows up to the events himself when he can and shows how much he supports me and other students being a part of it."*

This student experience is quite unique and may be in part due to the specific community-focused missions of the centers in which students are situated. Both research centers in which we recruited participants were founded with explicit broader impact missions. Perhaps faculty mentors in these research centers decided to join community-focused centers because they share the sentiment of supporting broader impact outreach work.

4.1 Limitations
While this study contributes to the overall understanding of academia's involvement in community outreach, it is preliminary and serves as a first step into further analysis. One major limitation of this study is the small pool of survey respondents. All survey participants are student members of research centers with an already established outreach program and a relatively strong emphasis on the importance of outreach. Perhaps results may differ in academic institutions without an outreach coordinator or with less of an emphasis on community interactions. Additionally, students who voluntarily chose to participate in this survey may be the same pool of students who regularly chose to participate in outreach events.

Future analysis on these same methods will include data from water-focused students from multiple other academic disciplines like geography, sociology, biology, etc. This will allow for a larger pool for data statistics and examination into the interdisciplinarity of water resources outreach.

5.0 Future Outlook and Suggestions
Preliminary findings from this study may provide insight into how to best engage university students in broader impact outreach efforts, which is a desire and often a requirement of research centers. Study findings suggest three possible steps to implementing a targeted strategy for broader impact student outreach that aligns with student attitudes at university research centers.

1. When deciding what outreach events research centers will engage in, **consider emphasizing events that contribute to society**. Similarly, for environmentally driven students, emphasize how the event contributes to environmental awareness. Perhaps research centers with other foci should emphasize how events will contribute to their field or students' possible world views.

2. In general, students may have a desire to participate but are impeded by their lack of time. Students' lack of time is not a barrier outreach coordinators or recruiters can easily remove. University students are pulled in many directions both in school and outside of the university, and forcing students to participate as a funding requirement does not seem to be an effective means to increase motivation and participation. When recruiting students to attend an outreach event, the outreach recruiter or coordinator should **emphasize skills that students will personally gain** (i.e., communication skills, teaching experience, networking) and why participation in outreach is a good use of their time.

3. Students are highly influenced by their professors, mentors, or research advisors. These role models for students seem to be one of the most effective ways to overcome outreach participation barriers. Research centers that want to increase outreach participation should **encourage mentors to support their students' outreach endeavors** and even find and advertise relevant outreach opportunities to their students. One suggestion is for research mentors to attend outreach events with their students at the start of the student's program as a sign of encouragement and commitment to broader impacts.

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Appendix A: Survey questions as they appear to participants

How do you describe your gender identity?
How do you describe your racial identity?
Are you 18 years old or older?
What university do you attend?
What is your current degree program level? • Undergraduate • Master's • PhD • Postdoc • Other (please elaborate)

Which Centers/projects are you affiliated with? (select all that apply) • Intermountain West Transformation Network (TN) • Center for Water and the Environment (CWE) • None of the above
How many Fall and Spring semesters have you been affiliated with the Center(s) listed above? (include undergraduate, MS and PhD semesters)
Does your work as a student (studies, research, etc.) involve water, water resources, and/or water engineering?
What is the name of your degree program (I.e., Civil Engineering, Natural Resources, Water Resources, etc.)?
Does your degree program have a subspecialty (I.e., Environmental Engineering, Policy & Management, etc.)? If so, please list it below.
How many Fall and Spring semesters have you been in your current degree program? (if you just started your degree program but have been at the same university previously, do not count those previous semesters here. Those apply to the next question.)
How many Fall and Spring semesters have you been in graduate school? (include all Master's and PhD semesters at any combination of universities)
The National Science Foundation defines Broader Impact as "potential [for your research] to benefit society and contribute to the achievement of desired society outcomes." *We define Outreach as an organized effort to share specialized knowledge and practices with the general public.* *For the purposes of this survey, we will use the terms "broader impact" and "outreach" interchangeably.*
Have you participated in a volunteer outreach activity during your time as an undergraduate or graduate student?
Have you participated in a volunteer outreach activity during your current degree program?
Which type(s) of outreach have you participated in during your time as an undergraduate and/or graduate student? (select all that apply) • formal presentations at a university setting outside of your degree requirements • formal presentations outside a university setting (voluntarily) • K-12 youth education • adult education • tutoring/ mentoring • acting as a judge (science fairs, conferences, etc.) • giving tours • governmental engagement (including tribal) • virtual engagement (social media, videos, etc.) • partnering with industry • engagement in the media • community education or meetings • engagement with teacher(s) • other (please specify)

Approximately, how many outreach events do you typically participate in per Fall or Spring semester?

Using a scale of 1 to 5 where 1 is "no impact at all" and 5 is "a great deal of impact" please evaluate the level of impact the following reasons have in why you participate in outreach.	I don't know or I am not sure	no impact at all	very little impact	somewhat of an impact	quite a bit of impact	a great deal of impact
Desire to Contribute/ Help society						
Fun or Enjoyment						
Improve Teaching and/or Communication Skills						
Advisor or departmental requirements						
Advisor or departmental encouragement						
Funding requirement						
Experience in the past as a recipient						
Serving as a role model						
Increasing environmental awareness						
Other (please elaborate)						

Select your primary (your top) motivator from the motivations list
Select your secondary (your next choice) motivator from the motivations list (if applicable)

Using a scale of 1 to 5 where 1 is "no impact at all" and 5 is "a great deal of impact" please evaluate the level of impact the following factors have in hindering (impeding) your participation in outreach.	I don't know or I am not sure	no impact at all	very little impact	somewhat of an impact	quite a bit of impact	a great deal of impact
Lack of time						
Lack of information about outreach opportunities (lack						

of advertisement of the opportunities)						
Lack of details about outreach opportunities (where, when, who, etc.)						
Lack of outreach opportunities that interest me						
Lack of value and purpose in outreach						
Lack of interest and desire						
Lack of relevance to my work						
Not feeling comfortable doing outreach (feeling nervous, shy, etc.)						
Lack of knowledge or skills to perform outreach						
Lack of support from advisor or department						
Other (please elaborate)						

Select your primary (your top) hinderance from the hinderances list
Select your secondary (your next choice) hinderance from the hinderances list (if applicable)

On a scale of 1 to 5, where 1 is "strongly disagree" and 5 is "strongly agree" to what extent do you agree or disagree with the following statements?	I don't know or I am not sure	Strongly disagree	disagree	Neither agree nor disagree	agree	Strongly agree
I have the knowledge and skills to successfully participate in outreach (please elaborate on your selection)						
Participating in outreach will help me in my future career or provides professional development (please elaborate on your selection)						
I feel that publishing research papers contributes to broader						

impact efforts for the public (please elaborate on your selection)					
Participating in outreach <u>impedes</u> (hurts) my ability to conduct research (please elaborate on your selection)					
Participating in outreach <u>impedes</u> (hurts) my ability to take and/or be successful in classes for my degree program (please elaborate on your selection)					
Having participated in an outreach opportunity previously, led me to want to participate in more (please elaborate on your selection)					
Having participated in an outreach opportunity previously, led me to <u>NOT</u> want to participate in more (please elaborate on your selection)					
There are enough outreach opportunities presented to me for me to attend (please elaborate on your selection)					
I wish I could attend more outreach events (please elaborate on your selection)					
My mentor/advisor supports me participating in outreach (please elaborate on your selection)					

Please use this space to add any elaborations, comments, or questions about the survey or the questions above.

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