Promoting Undergraduate Student Self-Efficacy in Research through Participation in a Multidisciplinary Science Communication Fellowship

Miss Kamryn G. Zachek, University of New Mexico

Kamryn Zachek is a junior undergraduate student at the University of New Mexico studying Economics and Philosophy. She is a Regents scholar and the student lead for the Grand Challenge Water Science Communication fellowship at UNM.

Prof. Anjali Mulchandani, University of New Mexico

Dr. Anjali Mulchandani is an Assistant Professor in the Department of Civil, Construction and Environmental Engineering at the University of New Mexico. She leads the Environmental Resource Sustainability group, which studies themes related to environmental and water resources engineering, atmospheric water harvesting, waste-to-energy technologies, and environmental remediation. Her work integrates and highlights science communication and community needs-based research. Her passions include designing hands-on learning tools and leading public outreach initiatives for STEM awareness and engagement among all levels of learners.

Sydney Donohue Jobe, University of New Mexico

Sydney Donohue Jobe works as the Outreach Coordinator and Education Specialist for the Center for Water and the Environment and the Accelerating Resilience Innovations in Drylands Institute at the University of New Mexico. She holds a Master of Water Resources degree from the University of New Mexico and a B.A. in Ecology from the University of Georgia.

Promoting Undergraduate Self-Efficacy Through an Interdisciplinary Science Communication Fellowship

Abstract

The objective of this work is to understand how a multidisciplinary undergraduate science communication fellowship impacts early-stage students' confidence and self-efficacy in research. Student self-confidence has shown to have a positive relationship with student success and professional development, but increased academic rigor at the collegiate level can negatively shift students' subjective judgement of their own ability. The research question was: To what extent does participation in undergraduate research affect students' self-efficacy and confidence to succeed in undergraduate level academia/research? The Grand Challenges Undergraduate Water Science Communication Fellowship was created at an R1 Hispanic-Serving University in the American Southwest in 2022 and is offered annually in the Spring semester. Students were paired with a mentor who is conducting a water-resource related study at the University of New Mexico and were tasked with creating a communication project based on the mentor's work. Example communication projects include infographics, songs, paintings, posters, time-lapse graphs, 3-D models, ceramics, and animations. Projects were accompanied by an oral presentation, given at the University of New Mexico's Undergraduate Research Conference. Participating students and mentors came from diverse disciplinary backgrounds, including mechanical engineering, environmental science, political science, international studies, economics, environmental engineering, and computer science. To determine the impact of the Fellowship on student's self-efficacy, we conducted pre- and post- participation surveys. Likert-scaled questions were organized into three content groups: confidence, identity, and ownership as a researcher, and mean responses of the cohort were compared. Results showed significant increases in cumulative confidence responses with more than one standard error increase for the group after the Fellowship ended. These results suggest that multidisciplinary undergraduate science communication fellowships with a cohort model may increase students' confidence and self-efficacy in research. Other qualitative successes included students continuing their extracurricular involvement in career-focused work after the program ended. The next step for this research study is to conduct interviews with the students from prior cohorts to gain additional insight into the potential broader impact of the program on student's confidence within academia and in preparation for their future profession. We will continue to collect survey data on future cohorts to grow our data set and get a more comprehensive look at the impacts on student self-efficacy. Those outcomes will be used to scale and tailor the program to address additional research topics across disciplines at the University of New Mexico.

1. Introduction

1.1. Undergraduate Involvement in Interdisciplinary Research

Undergraduate participation in interdisciplinary research opportunities enriches educational experiences through the development of critical thinking skills, personal development, exposure to practical application of academic knowledge, and overall increased academic performance [1][2]. Tangible benefits of early-stage research involvement of college students can be observed through increased test scores, enhanced retention of class material, and the development of professional relationships in the student's field of interest. By taking knowledge gained in a formal academic setting and applying it to professional careers, students are better prepared to succeed post-graduation [3].

Although the practical skills and multifaceted development cultivated by participation in undergraduate research has been observed across disciplines, the impact on student's self-efficacy and confidence remains uncertain [4]. Student self-confidence affects student engagement in their learning, pursuit of professional-based goals, and success in college [5]. Increased academic rigor at the collegiate level can negatively shift students' subjective judgement of their own ability, especially when surrounded by intellectually capable peers [6]. Compounded with the social transition to the traditional collegiate learning atmosphere which negatively impacts the overall mental health of incoming students, undergraduate students are at risk of decreasing levels of self-esteem. These changes in self-efficacy and confidence experienced in the early undergraduate experience can have a lasting effect on student's academic careers, impacting them well into their professional development [7]. Increases in student self-efficacy and confidence have shown to have a positive relationship with the attainment of individualistic goals within a relative timescale [8].

In the present study, we observe how participation in an interdisciplinary research fellowship impacts student's self-efficacy and confidence to succeed in academia at a R1 Hispanic serving University in the American Southwest. The research was guided by the following question: To what extent does participation in undergraduate level research affect student's self-efficacy and confidence to succeed in undergraduate level academia/research? Students' confidence and self-efficacy was measured using a Likert-scale survey. Responses were compared before and after participating in the program to determine whether students' confidence improved. We used SPSS for statistical analysis of data which focused primarily on changes to mean response values. Following the conclusion of the Fellowship, interviews of the students were conducted via email to gain further qualitative data on the impacts of the research experience.

1.2. The Grand Challenges Water Science Communication Fellowship

The Grand Challenges Water Science Communication Fellowship was developed to increase undergraduate involvement in research pertinent to one of the leading geographical issues faced in New Mexico, sustainable water resources. Water shortages, inequitable distribution of the water supply, and increasing water demand with a growing economy are all complex issues faced by the state. This issue has been designated a "Grand Challenge" by the University of New Mexico, meaning it is relevant on a regional, national, and global scale and requires

interdisciplinary communication to implement solutions [9]. The Fellowship was designed to platform research being conducted at the University to address this Grand Challenge while simultaneously broadening opportunities for participation in undergraduate level research.

Students were given the option to pursue one of two "tracks" when applying for the Fellowship. The "Track 1" Fellows were paired with faculty mentors conducting water resource-related research at the University and were tasked with creating a communication project based on their work. The "Track 2" Fellows indicated that they had conducted water resource related research themselves and were to complete a communication project with this work as the basis. Track 2 students were still paired with a faculty mentor to assist them during the semester. Students were not limited to traditional modes of research communication and were encouraged to choose project mediums that communicated the research in a way that exemplified their individual strengths. Projects from the 2023 cohort included posters, infographics, songs, animations, mosaics, paintings, 3-D models, and GIFs [10]. Student recruitment took place in the Fall semester, mentor-student pairings were made over Winter break, and student participation in the Fellowship began in the Spring semester. Over the Spring semester, students met weekly with a cohort of their peers to discuss their progress and obstacles. They also participated in communication skills building exercises for public speaking [1].

2. Methods

2.1. Recruitment and Student Application Process

The Fellowship program was initially designed with the intention of creating an opportunity for undergraduate students to get involved in research. The first Fellowship cohort in Spring 2022 was deemed successful in terms of qualitative feedback from both students and undergraduate research support groups at the University. Therefore, we offered the Fellowship again in Spring 2023 and coupled it with a research study to measure the impact of the Fellowship on students. The present study is an analysis of the first year of survey results collected from the second overall cohort of students to participate in the Fellowship. Following the conclusion of the first-year cohort (Spring 2022), the recruitment strategies for students were modified from the previous year to include more departments within the University, making the Fellowship opportunity accessible to as many undergraduate students as possible [1]. The first year of the program (2022) there were 10 students in the cohort. In the second year of the program (2023), there were 12 acceptances students in the cohort.

Mentor recruitment was conducted primarily through email listservs, specifically targeting departments likely to be conducting water-resource-related research. Outreach to mentors emphasized that inclusion of an individual's research in the program was a great way to bring awareness to their work while assisting in the research development of an undergraduate who is interested in their work. The University faculty who were part of the Grand Challenges Leadership team and mentored students from the first-year cohort were contacted directly with the mentorship opportunity. Many of the mentors from the first-year cohort continued their participation in the Fellowship in the second year. Other University faculty and graduate students who were known to be conducting water resource related research by members of the Grand Challenges team were contacted personally to notify them of the opportunity for mentorship.

Strategies for student recruitment into the Fellowship included printed advertisements, in-person presentations, and targeted outreach through department email listservs. The printed advertisement included information on who was eligible to apply with links to the online application, presented as both a QR code and a web link. The advertisement also featured the $1000 stipend for each student accepted into the program (Appendix II). The University departments which were specifically addressed in the recruitment efforts included: Economics, Civil, Construction, Environmental, and Chemical Engineering, Psychology, International Studies, Biology, Chemistry, Computer Science, Communication, Political Science, Environmental Science, and Physics. Professors from these departments, including those who offered to be mentors for the upcoming cohort, were urged to advertise the Fellowship to their students. For faculty interested in having the Fellowship presented to their students, the Grand Challenges team offered a short presentation and handed out flyers to their classes.

Both student and mentor applications were collected in Google Forms. The mentor application included a section for the applicant's department, field of study, a description of their research, and an optional link to their faculty website if applicable. The mentor's responses were recorded and organized into a spreadsheet so students who applied would have a reference for the type of research that would be featured in the Fellowship. The student application asked for limited demographic information, which "track" they were pursuing, a brief project proposal, and a list of their top three preferred mentors. The application included links to previous student projects and a list of mentors and a description of their research for reference.

2.2. Fellowship Participant Population

After the one-month recruitment period ended in December 2022, there were 19 applicants. The Fellowship organizing team selected 15 students and paired each with a mentor. Pairings were made mainly based on goodness of fit, with special consideration of the student's interests expressed in their written project proposals. Some students were paired with a mentor that was not listed on their preferential list, a possibility which was expressed to them in the application. Of the 15 students who received an acceptance email, 3 declined the offer to participate, citing scheduling conflicts. All data for this study was collected from the resulting sample of 12 students. **Table 1** shows the intended majors of the 12 participating students. There are more majors listed than participating students due to the fact that at the time of the post survey, 4 students indicated that they were pursuing a dual degree. **Table 2** shows the academic classification of the 12 participating students. While the Fellowship was targeted at early-stage undergraduate students, the cohort had students from each academic year.

Table 1: Intended majors of the 12 participating students.

Number of Students Pursuing Major	Intended Major
4	Civil Engineering
2	Environmental Science
2	Sociology
2	Sustainability Studies
1	Economics
1	Construction Management
1	Statistics
1	Computer Science
1	International Studies
1	German

Table 2: Academic Classification of the 12 participating students

Number of Students	Academic Classification
1	Fifth-year
5	Senior
3	Junior
2	Sophomore
1	Freshman

In the second week of the Spring semester, students were broken into 2 groups to accommodate schedules. These groups attended inaugural cohort meetings which were moderated by the Fellowship organization team's student lead. In these meetings, the students were asked what components of the Fellowship, if any, they held any reservations toward. Both groups mentioned the public speaking component as a primary concern, with multiple students citing that they had little to no experience speaking publicly. A secondary concern brought up by one of the groups was how best to approach contacting their mentors, specifically how to set up meetings with their mentors. The Grand Challenges team addressed these student concerns by setting up public speaking workshops, practice presentation events, and offering to review email correspondence with mentors.

2.3. Data Collection and Statistical Analysis

A survey was developed and administered through Qualtrics, and analysis was conducted through SPSS. The survey was comprised of approximately 50 Likert-scaled questions which were presented to the respondent with 7 response options (Appendix I). The survey was approved by the University of New Mexico's Institutional Review Board.

Students filled out a pre survey at the first cohort meeting in January 2023 and a post survey after presenting their projects at the University's undergraduate research conference in April 2023.

The post survey questions mirrored exactly that of the pre survey questions, with one additional opened-ended section where students could leave comments on how the Fellowship could be improved in the future. Responses were anonymous and linked to their post survey results through identification numbers.

The survey was broken into 3 blocks, where each block included questions designed to gather insight on specific characteristics of the participants. The characteristics of interest were confidence, ownership of the research project, and identity as a researcher [11]. These blocks were chosen with the intention of illustrating each student's self-efficacy in multiple dimensions so that a more nuanced discussion of the impact of the Fellowship on student self-efficacy could take place. The following are examples of questions addressing confidence, ownership, and identity. The full survey is included in Appendix I.

> *"How confident or unconfident are you that you can effectively communicate research to the general public?"*
>
> *"How important or unimportant was the research communication project that you described?"*
>
> *"How important or unimportant were the outcomes of the research communication project that you described?"*
>
> *"How much or little do you perceive yourself as being a future researcher?"*

Changes in the students' self-efficacy were measured by way of mean comparison of pre and post data for individuals and the group. To do this, the Likert-scale responses were coded in SPSS so that the scale of responses was presented numerically (e.g. 'very unconfident'=1, 'neither confident or unconfident'=4, 'very confident'=7). Changes in individual responses for each question were recorded so that analysis of individual experiences with the Fellowship could be observed. Aggregate variables of block questions were created to observe changes in overall confidence, identity, and ownership. Of the 12 student participants who completed the Fellowship, 11 post responses were recorded. The reason for non-response of the 12th student is unknown. Due to insufficient sample size, a paired t-test was not conducted. Instead mean values and accompanying standard errors were calculated for all variables so changes could be observed.

Following the conclusion of the Fellowship, the students were asked to fill out a Q and A via email to give the survey results qualitative context, the full list of questions is available to view in Appendix IV. The written response questionnaire was accompanied by a consent form instructing students that their name would not be disclosed with their responses. The Q and A was approved by the University of New Mexico's IRB and assigned protocol number 2301035624A002.

3. Results and Discussion

Figure 1 shows that all three blocks of variables, (1) confidence to execute different skills related to successful research, (2) ownership of projects they are participating in, and (3) identity as a researcher, saw an increase in mean value from pre to post evaluation. The "confidence" block experienced the most significant increase, with a greater-than one standard error increase in the post results. The ownership block also suggested a positive relationship between student's ownership of their contributions to research and participation in the Fellowship. The results from the identity block suggested that participation in the Fellowship would positively affect the student's relationship with their identity as a researcher, but the increase in mean value from the pre to post evaluation fell just short of one standard error. Specific results for each variable block are discussed herein.

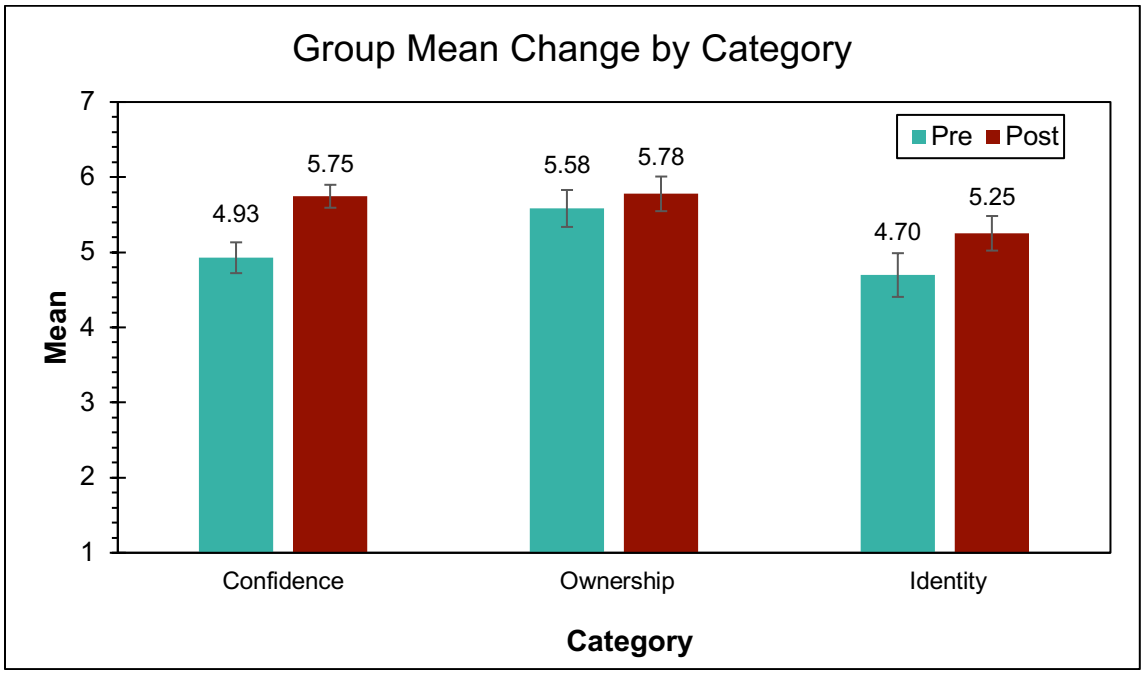

Figure 1: Changes in mean values from pre to post data for aggregate block variables with standard error bars. For both for 'Confidence' and 'Identity' n=11. For 'Ownership' n=4 for the pre survey and n=9 for the post survey. The individual survey questions corresponding to these blocks are found in Appendix I.

3.1. Changes in Student's Confidence

Of the three characteristics used to gauge changes in self-efficacy of students who participated in the Fellowship, confidence saw the greatest increase in the post survey mean results. (**Figure 1**) The pre survey average response value for the confidence block was 4.93, the post average was 5.75, with a greater-than one standard error increase in the post results.

The questions that saw a greater than a one Likert response point increase in their mean value include:

"How confident or unconfident are you that you can…"

- Communicate research to the general public? (+1.28)
- Explain analysis results? (+1.27)
- Communicate with professionals in their field? (+1.18).

The questions which expressed the smallest increase from the confidence block include:

"How confident or unconfident are you that you can…"

- Communicate with your peers? (+0.46)
- Use academic literature to guide your research? (+0.36)

The quantitative results suggest that Fellowship activities such as public speaking, professional communication, and communication of research to the general public, had a positive impact on confidence. **Figure 2** shows results from the pre and post survey for responses to questions on confidence. Results are shown on a Likert scale of 1-7, where low values correspond to 'very unconfident' and high values correspond to 'very confident.' We see a consistent change in response between pre and post survey that trend towards students becoming more confident in their research and communication skills. This can be observed in questions such as "How confident or unconfident are you that you can explain analysis results?" where all post survey results ranged from 5 (somewhat confident) to 7 (very confident). This suggests that consistently having to communicate individual progress with projects in cohort meetings likely contributed to the positive shift in results. Overall, the research skills addressed in the survey were foundational to the successful completion of the Fellowship program.

Qualitative results were obtained by means of a written questionnaire (Appendix IV). The following student quotes offer insight into the perspective of the Fellows on how the program personally affected them. The student quotes confirmed the Fellowship to be productive in increasing student self-confidence in pursuing and communicating research.

"Participation in the fellowship connected me with a professor with whom I completed more work for after the fellowship concluded. Because of this, I am more confident entering into research spaces and feel good about my ability to connect with faculty. My mentor was also extremely supportive, so this increased my confidence in my ability to produce good work and ask insightful questions."

-Third year Fellow majoring in Economics and German

"The hardest part was getting started at the beginning, choosing an idea and running with it, and then doing the public speaking at the end. But once my presentation was over I was so proud of myself that I did it! That was a learning experience in itself, and now I'm confident in my ability to capture an audience's attention and give a meaningful presentation.
When I first came to college, I wasn't sure what I wanted to do, to learn, or what I hoped to get out of the academic experience. But after I declared my major, got further into my studies, and got more involved in the department through Grand Challenges and other fellowships, I found a greater confidence in my ability to succeed. Opportunities like this are essential to feeling engaged and welcomed within the academic community."

-Third-year student majoring in Environmental Science

I feel my self-efficacy as a university student and researcher has increased in the sense that I am less afraid to try things out of my comfort zone. I know that whatever I put my mind to, I can accomplish it with effort and a positive outlook. I also feel more confident increasing the difficulty of the work that I want to do."

-Fourth-year student majoring in Sociology and Environmental Science

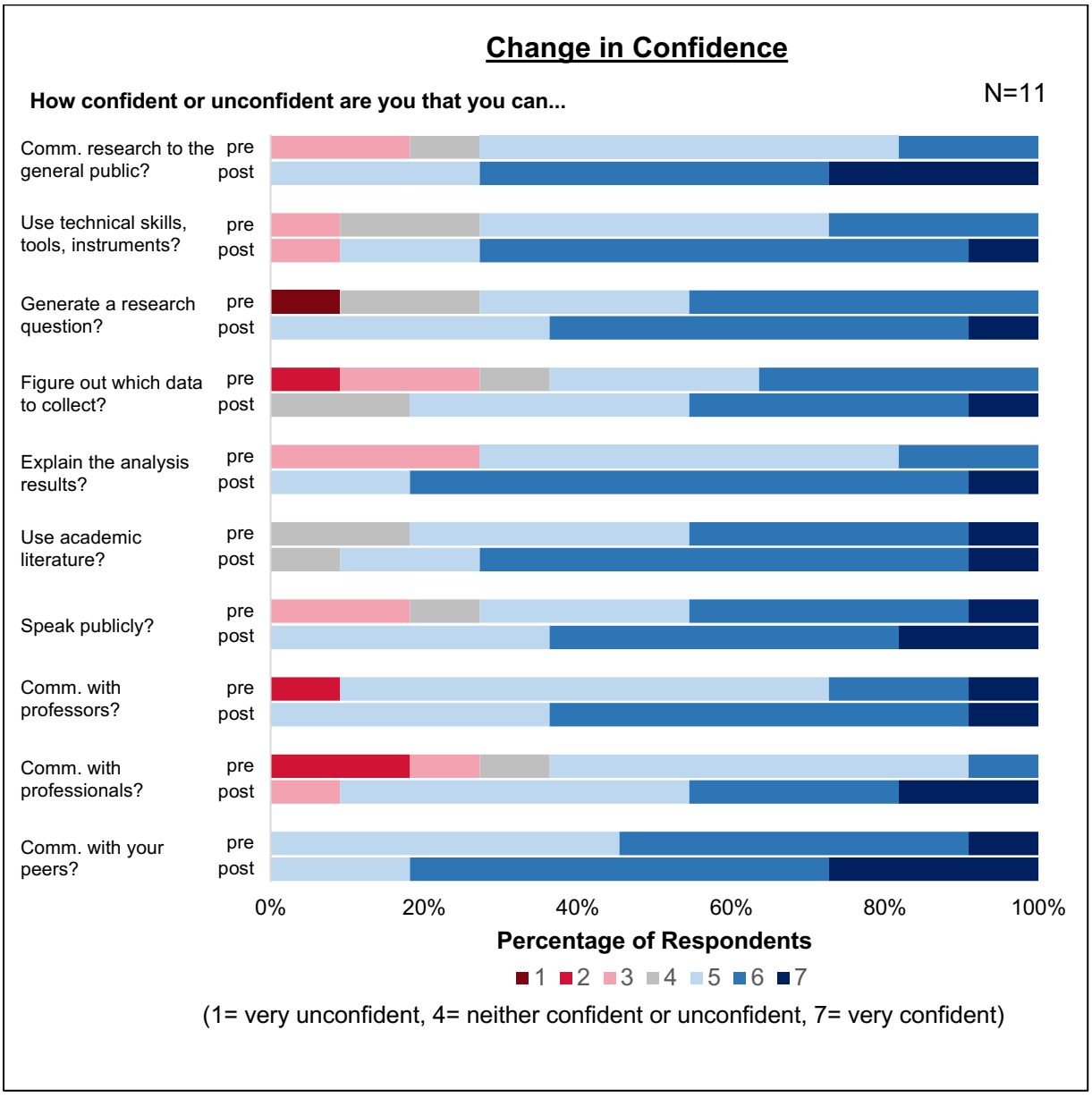

Figure 2: Detail graph of "confidence" responses. Questions are listed in the order which they were presented on the survey. "Comm." is an abbreviation for "Communicate". The individual questions which correspond to the 'Confidence' block can be found in Appendix I.

3.2. Changes in Student Ownership Over Research Project

Figure 3 shows change in "ownership" results between the pre and post survey. This block of questions addressed the students' comfortability in leadership positions, making decisions, and taking responsibility for their research, and their attitudes toward making progress, solving problems, and actively planning/directing the research [11]. The section was prefaced by the following statement, "Describe a prior experience you have had communicating research to your peers, your family or your communities. The research you communicated could be yours or that of another researcher. If you have had no such experiences, please write NONE in the box, and skip to the next page". Results are shown on a Likert scale of 1-7, where low values correspond to 'very low importance/responsibility/activity', and high values correspond to 'very high importance/responsibility/activity.'

The "ownership" block of questions was constrained by inconsistent reporting from students in the pre and post surveys due to confusion caused by the wording in the survey. It was communicated to the Fellowship organizing team that the use of the term "prior experience" in the post survey caused some of the respondents to fail to identify the completion of the Fellowship as a research experience they could use to assist in answering the questions. The issue of non-response in this block distorts comparison between pre and post results and narrows the sample size of students who responded to the questions in both surveys to 3-7, depending on the question. The survey will be modified in the future for clarification.

Although the variance in response rates from the pre to the post results in this section makes mean comparison less significant, a more general positive shift in the post results can be observed. The question, "How active was your role in planning/ directing?" yielded exclusively Likert scale 1 (very unimportant), 2 (slightly important), and 4 (neither important nor unimportant) responses in the pre results, a stark contract to the majority Likert scale 6-7 (somewhat important, very important) responses in the post results. This suggest that the students who did have previous research experience were not placed in an administrative or leadership role and the Fellowship provided most students with their first experience having autonomy over the direction of a research project. In contrast, we observe a substantial decrease in the question, "How responsible did you feel for coming up with your own ways to make progress?" where several post survey responses indicated 'not responsible' and 'somewhat not responsible.' One possible explanation for this outcome is the structure of weekly cohort meetings, where students were encouraged to express any roadblocks they were experiencing with projects so the group could offer suggestions on how to overcome these issues. In some ways, this took the individual responsibility off of the student when they felt they had stopped making progress with the understanding they could wait until the next cohort meeting to work through any issues they faced. Another factor which could have impacted these results is the influence of mentors on individual projects. Mentors were given the freedom to schedule as many meetings with their student as they felt necessary. This resulted in some students meeting with their mentor once a month over the course of the Spring semester while others met weekly. The students who had mentors who were more hands-on with their projects likely got more instruction on how to overcome roadblocks with their projects.

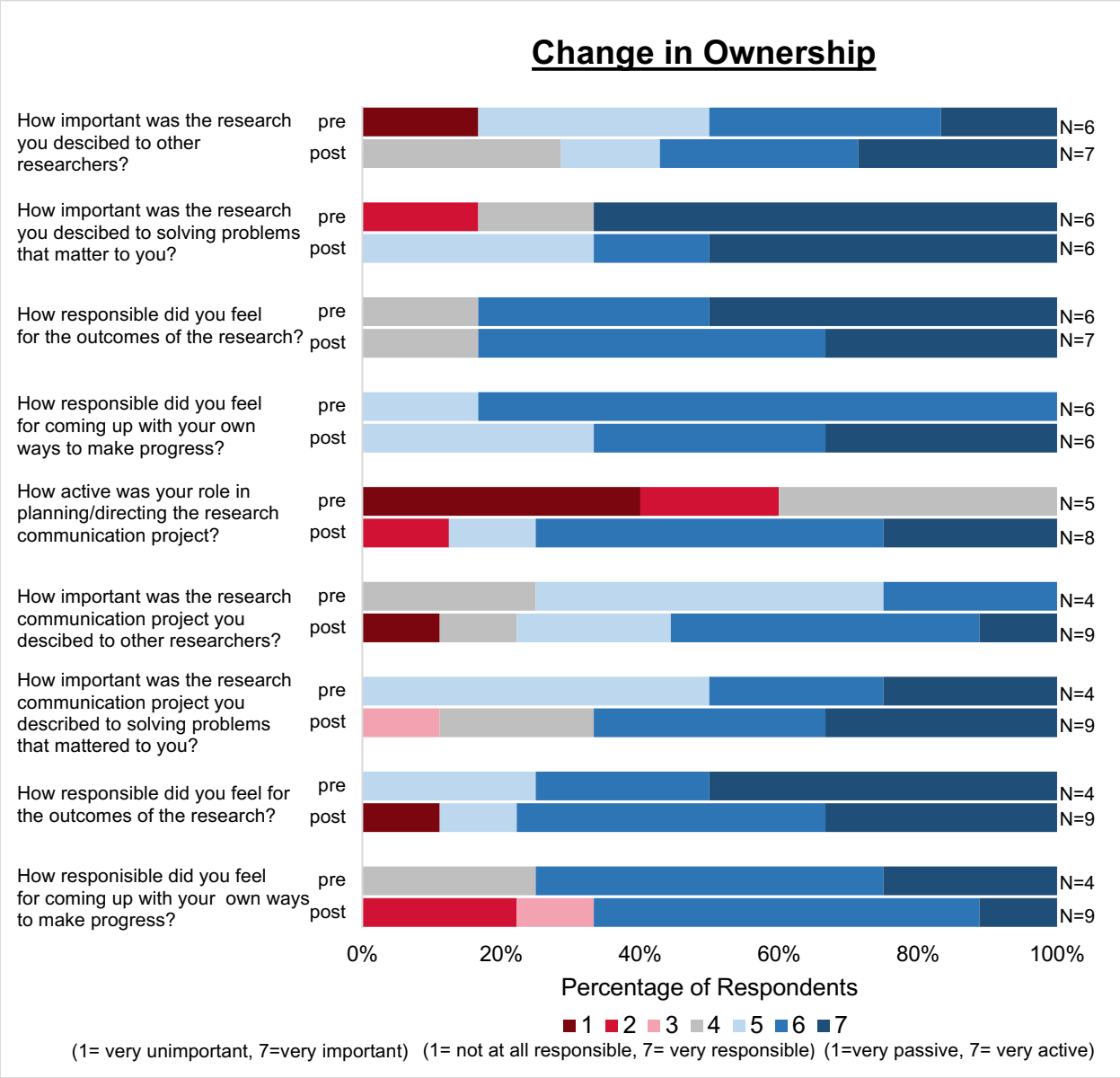

Figure 3: Detail graph of changes in "ownership" responses. Questions are listed in the order which they were presented on the survey. The individual questions which correspond to the 'Ownership' block can be found in Appendix I.

3.3. Changes in Student Identity

This section aimed to assess how participation in the Fellowship impacted the student's self-perception as a researcher and their intentions to persist in research opportunities. The questions addressed the student's identity in the research space and focus on the student's perception of

themselves as a current researcher, future researcher, belonging to a community of researchers, and their perception of the importance of their contribution to the project. Questions also addressed the student's intention to persist in their intended degree plan, in future research opportunities, and in courses that include a research component.

All questions from the "identity" block saw an increase in mean response value in the post survey. The average response in the pre results was 4.69 points and 5.25 points in the post.

The questions which experienced greater than a one Likert response point increase in their mean value include:

How much or little do you perceive yourself as…

- A researcher right now? (+1.55)
- Being a future researcher? (+1.09)

The questions which expressed the smallest increase from the identity block include:

How strong or weak is your intention to persist in…

- Your intended degree? (+0.18)
- Courses that include research? (+0.27)
- A research experience? (+0.27)

It was observed that the perceptions of research from a definitional standpoint were expanded after getting to experience different forms of research first-hand and understanding that the communication of research can take on many forms. This shift, among other changes in student identity in research spaces, is observed in quotes from the students:

"I was scared to apply at first because I thought things like this were for over-achievers to do. I wanted to get through my undergrad with my head down, not standing out. But then I did it and I was proud of myself for trying something that actually scared me because I was initially judgmental of it. Now that I've learned that lesson, all these new doors are open to me. Since then I've actually applied to another fellowship within my department and gotten it, mostly because of that initial confidence boost I got from the Grand Challenges Water Science Fellowship."

-Third-year student majoring in Environmental Science

"I do think participating in the Fellowship affected my confidence to succeed because it equipped me with skills that I could utilize throughout my career and made me realize that I am far from alone in the academic world. I often worried that everyone around me was doing hundreds of hours of research and work so I would never match up, but this Fellowship showed me that interest is all that is really needed to get into research. Some of my group members had more experience while others had less but there was a lot of support and an understanding that research is about expanding collective knowledge not about competing. This kind of environment grew my confidence over the semester that I worked with the other fellows."

-Fourth-year student majoring in Sociology and Environmental Science

Figure 4 shows results from the pre and post survey for responses to questions on identity as a researcher. Results are shown on a Likert scale of 1-7, where low values correspond to 'very weak/unimportant/little' and high values correspond to 'very strong/important/much.' Most of the participating students had no previous experience with research before the Fellowship, which offers an explanation for the increase in response for students' general perception of themselves as a researcher. Of the three blocks of interest, the lowest numerical responses (Likert response option 1-4) from students in the pre survey consistently came from questions in the "identity" section related to their identity as a researcher. Generally, in the post results the mean value of responses increased, but only about half of the respondents reflected a somewhat strong or better (Likert response options 5-7) relationship to the different components of research. The question which experienced a significant positive shift in the post results relating to identity as a researcher was: "How much do you perceive yourself being a future researcher?". One of the goals of the Fellowship as an interdisciplinary program was to broaden the participants definition of research, and the results of the post results for this question and the student quotes from above support the conclusion that the Fellowship accomplished this goal. Another question which yielded interesting results was: "How strong is your intention to persist in a research experience?" which had identical responses in the pre and post results. Most of the students in this cohort were 3rd, 4th, or 5th year students (**Table 2**), and the question with the greatest number of Likert scale 6-7 (i.e., high) responses in both the pre and post survey was: "How certain are you that you will earn a degree in your current major?". The academic classification and motivation to complete the intended degree of most of the cohort suggests that the participating students likely have a plan for the kind of extracurricular experience they want to gain during their collegiate experience. It is possible that that if the cohort were composed of students who were not as far into their degree and were unsure of what career they wanted to pursue, the Fellowship could have had a greater impact on their decision to pursue research experiences in the future.

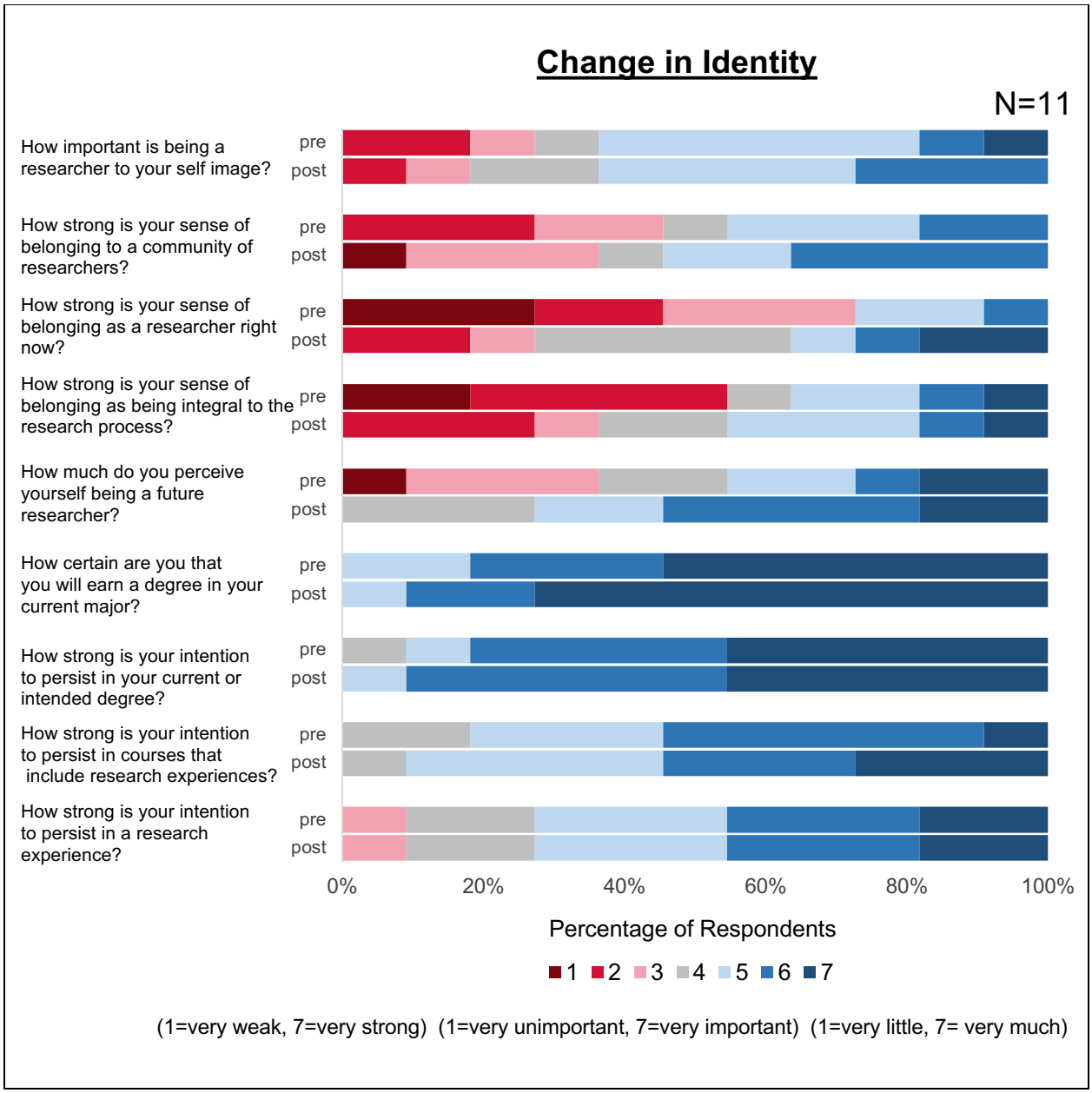

Figure 4: Detail graph of change in "identity" responses. Questions are listed in the order which they were presented on the survey. The individual questions which correspond to the 'Identity' block can be found in Appendix I.

4. Limitations

Although the survey results from this initial cohort provided useful insight into the effectiveness of the Fellowship, the study faced several key limitations. The sample size limited the scope of statistical analysis that could be performed on the data set, subsequently limiting the comprehensiveness of the conclusions drawn from the results. The Fellowship consisted of 12

students, but one student failed to respond to the post survey effectively limiting the sample to 11 complete responses.

The study exhibited several biases due to the nature of how the Fellowship was constructed. The Fellowship is open to all levels of undergraduate students and the results are not filtered by academic year. This lack of uniformity in participants makes comparison across student experiences difficult, as Fellows more senior in academic standing are likely to suffer from different self-efficacy and confidence related issues than first year students. The Fellowship also takes place over the course of a full academic semester, and without a control group, it cannot be said conclusively that the increases in confidence can be attributed solely to the Fellowship. Continued experience over the semester with college level courses and subsequent established familiarity could influence the post survey responses. By increasing recruiting efforts in scale and with the specified intention of reaching a wider scope of undergraduate students we can diversify the pool of applicants and begin to address the sampling bias.

5. Conclusion and Future Work

The preliminary results of the Fellowship show promising outcomes considering the goals of the Fellowship and the guiding research question. The survey data results tentatively reflect that participation in the Grand Challenges Water Science Communication Fellowship positively impacts the participating student's self-efficacy and confidence in academia and research. The Fellowship organizing team plans to continue to offer the Fellowship in upcoming years and will attempt to address current limitations and expand the nature of the cohort as discussed. Future iterations of this Fellowship may expand to other disciplines outside of Sustainable Water Resources and data may be compared between students studying water and other disciplines.

Acknowledgements

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Appendix I: Survey Instrument

Welcome to the Grand Challenge Water Science Communication Fellowship! We are excited to be a part of the beginning of your research journey. You are being asked to take a survey at the start and end of the program so that we can better understand the program's impact on your research identity and self-efficacy.

We understand that it is likely you do not have any previous research experience. Please know that will not impact your success in this program, and we are excited to have you!
For this purpose, research means investigating a question or problem where no one (including your instructor or other researchers) is certain what the answer will be or should be. Participation with research can be individual (where you independently investigate the question or problem), or social (where you collaborate with others, possibly including instructors and peers within your school or major)

To connect your survey responses before and after you participate in the program, we ask that you create a self-identification code. Please provide the last 5 digits of your University ID.

Section 1: Your Past Experiences Conducting Research

We would like to hear about any of your past experiences conducting research. Do not worry if you do not have previous experience.

1. Describe a prior experience you have had CONDUCTING research prior to this semester, either in college or high school. What was the goal of the research? What did you do? What course was this in? If you have had no such experiences, please write NONE in the box, and skip to the next page.

2. How important or unimportant was the research that you described...

	Very unimportant	Unimportant	Somewhat unimportant	Neither unimportant nor important	Somewhat important	Important	Very important
…to other researchers	○	○	○	○	○	○	○
…to solving problems that matter to you?	○	○	○	○	○	○	○

3. How responsible or not responsible did you feel…

	Not responsible at all	Not responsible	Somewhat not responsible	Neither responsible nor not responsible	Somewhat responsible	Responsible	Very responsible
…for the outcomes of the research that you described?	○	○	○	○	○	○	○

…for coming up with your own ways to make progress on the research that you described?	○	○	○	○	○	○	○

Section 2: Your Research Communication Experience

We are interested in hearing about your previous research communication experience. Do not worry if you do not have previous experience.

4. Describe a prior experience you have had COMMUNICATING research to your peers, your family or your communities. The research you communicated could be yours or that of another researcher. If you have had no such experiences, please write NONE in the box, and skip to the next page.

5. In the experience you described, how active or passive was your role in planning/directing the communications and selecting the medium (i.e., essay, podcast, video, poster), where very passive means carrying out instructions given to you by someone else? Leave blank if you have not had such an experience.

Very passive	Passive	Somewhat passive	Neither passive nor active	Somewhat active	Active	Very active
○	○	○	○	○	○	○

6. How important or unimportant was the research communication project that you described...

	Very unimportant	Unimportant	Somewhat unimportant	Neither unimportant nor important	Somewhat important	Important	Very important
to other researchers	○	○	○	○	○	○	○
to solving problems that matter to you?	○	○	○	○	○	○	○

7. How responsible or not responsible did you feel…

	Not responsible at all	Not responsible	Somewhat not responsible	Neither responsible nor not responsible	Somewhat responsible	Responsible	Very responsible
for the outcomes of the research communication project that you described?	○	○	○	○	○	○	○

for coming up with your own ways to make progress on the research communication project that you described?	○	○	○	○	○	○	○

Section 3: Your Identity as a Researcher

We are interested in learning more about your identity as a researcher.

8. How important or unimportant is…

	Very unimportant	Unimportant	Somewhat unimportant	Neither unimportant nor important	Somewhat important	Important	Very important
being a researcher to your self image?	○	○	○	○	○	○	○

9. How strong or weak is your…

	Very weak	Weak	Somewhat weak	Neither weak nor strong	Somewhat strong	Strong	Very strong
sense of belonging to a community of researchers?	○	○	○	○	○	○	○

10. How much or little do you perceive yourself as…

	Very little	Little	Somewhat little	Neither little nor some	Somewhat much	Much	Very much
a researcher right now?	○	○	○	○	○	○	○
being integral to the research process?	○	○	○	○	○	○	○
being a future researcher?	○	○	○	○	○	○	○

11. How confident or unconfident are you that you can…

	Very unconfident	Unconfident	Somewhat unconfident	Neither unconfident nor confident	Somewhat confident	Confident	Very confident

effectively communicate research to the general public?	○	○	○	○	○	○	○
use technical skills (use of tools, instruments, and/or techniques of your field of study) to do research?	○	○	○	○	○	○	○
generate a research question to answer?	○	○	○	○	○	○	○
figure out which data/ observations to collect and how to collect them?	○	○	○	○	○	○	○
explain the analysis results?	○	○	○	○	○	○	○
use academic literature to guide your research?	○	○	○	○	○	○	○
speak publicly to a broad audience?	○	○	○	○	○	○	○
communicate with professors/ faculty researchers?	○	○	○	○	○	○	○
Communicate with professionals in their field e.g., water managers, scientists, lawyers, etc.?	○	○	○	○	○	○	○
communicate with your research peers and fellow students?	○	○	○	○	○	○	○

Section 4: Your Perception of Water Research

We would like to hear about your perception of water research.

12. How much or little do you see these fields have a role in water resources research?

	Very little	Little	Somewhat little	Neither little nor some	Somewhat much	Much	Very much
Biology	○	○	○	○	○	○	○
Chemistry							
Communications							
Community, Regional and Urban Planning							

Economics							
Education							
Engineering							
Environmental sciences							
Geography							
Law and policy							
Mathematics							
Physics							
Political science							
Public health							

Section 5: Your Future Plans

We would like to hear about your future plans.

13. What is your current or intended major?

14. Do you have a minor, specialization, or concentration? If so, please enter it below.

15. At this moment in time, how certain or uncertain are you that…

	Very uncertain	Uncertain	Somewhat uncertain	Neither uncertain nor certain	Somewhat certain	Certain	Very certain
you will earn a degree in your current or intended major?	○	○	○	○	○	○	○

16. How strong or weak is your intention to persist in…

	Very weak	Weak	Somewhat weak	Neither weak nor strong	Somewhat strong	Strong	Very strong
your pursuit of your current or intended degree?	○	○	○	○	○	○	○
courses that include research experiences?							
a research experience, such as a summer program or working in a							

faculty or national lab?							

17. Do you think participating in a research experience is beneficial to you? Why or why not?

Section 6: Your Approach to Research

We would like to hear about your approach to research.

18. Imagine that you collected data based on your research question and conducted analysis. However, your results don't make sense. A professor whose research is related looks over your work and provides very critical feedback, including reference to your "lack of understanding" and "poorly described procedure," but also provides suggestions. You want to have an excellent research experience because you have clear career goals and you don't want to disappoint your family. Based on the scenario above, how likely or unlikely would you be to...

	Very unlikely	Unlikely	Somewhat unlikely	Neither likely nor unlikely	Somewhat likely	Likely	Very likely
work harder?	○	○	○	○	○	○	○
keep trying?	○	○	○	○	○	○	○
use the feedback to improve your work?	○	○	○	○	○	○	○
just give up?	○	○	○	○	○	○	○
think more about your strengths and weaknesses to help you work better?	○	○	○	○	○	○	○
give yourself encouragement?	○	○	○	○	○	○	○
seek encouragement from your family and friends?	○	○	○	○	○	○	○
try different ways to solve the problem?	○	○	○	○	○	○	○
feel everything was ruined and was going wrong?	○	○	○	○	○	○	○
begin to think your chances of success doing research were poor?	○	○	○	○	○	○	○
get depressed?	○	○	○	○	○	○	○

be disappointed?	○	○	○	○	○	○	○

19. Imagine that you presented a poster or talk on your research at a public undergraduate conference. The audience asked you insightful questions after your presentation and gave you feedback on future research you could explore. At the end of the conference, the Director of undergraduate research came up to you and personally congratulated you on your achievement. They asked if you were interested in continuing research and applying for a future graduate fellowship. Based on the scenario above, how likely or unlikely would you be to...

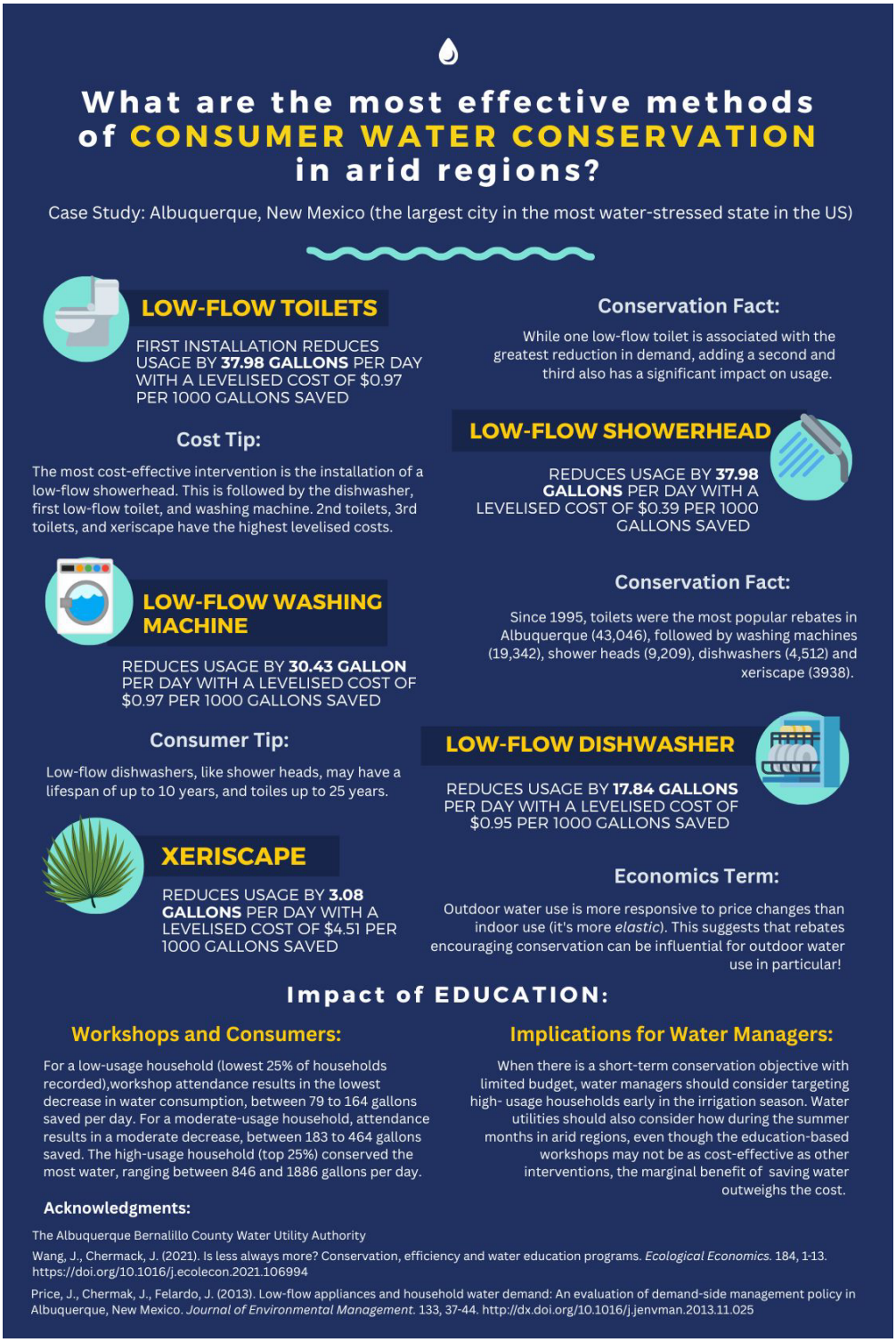
	Very unlikely	Unlikely	Somewhat unlikely	Neither likely nor unlikely	Somewhat likely	Likely	Very likely
work harder?	○	○	○	○	○	○	○
keep trying?	○	○	○	○	○	○	○
use the feedback to improve your work?	○	○	○	○	○	○	○
just give up?	○	○	○	○	○	○	○
think more about your strengths and weaknesses to help you work better?	○	○	○	○	○	○	○
give yourself encouragement?	○	○	○	○	○	○	○
seek encouragement from your family and friends?	○	○	○	○	○	○	○
try different ways to solve the problem?	○	○	○	○	○	○	○
feel everything was ruined and was going wrong?	○	○	○	○	○	○	○
begin to think your chances of success doing research were poor?	○	○	○	○	○	○	○
get depressed?	○	○	○	○	○	○	○
be disappointed?	○	○	○	○	○	○	○

20. Is there anything else you would likely to share before submitting your survey?

Appendix II: Student Advertisement

Advertisement used for student recruitment in the Fall semester (2022). The advertisement was printed out to be distributed as flyers around campus and attached as a PDF with clickable links in emails.

Appendix III: Examples of Student Projects



Student work example: Infographic created on the most effective methods for consumer water conservation in arid regions for the Grand Challenges Water Science Communication Fellowship. [10]

Student work example: Mosaic art-piece created illustrate diatoms collected from a local water source for the Grand Challenges Water Science Communication Fellowship.[10]

Student work example: Campaign ad featured on a website which brings awareness to proposed policy, and details consumer specific social changes that could reduce water usage in a water-stressed climate for the Grand Challenges Water Science Communication Fellowship. [10]

Appendix IV: Follow-Up Questionnaire for Students

Grand Challenges Water Science Communication Self-Efficacy and Confidence Questionnaire

General:

1) Please state your Major/Minor and year in school.
2) What are your academic goals? Career goals?
3) If your academic goals have changed since entering university, please explain how. Why did they change?
4) How would you define success as a student?

Confidence:

1) A) Are you confident in your ability to succeed as a university student? why or why not?
B) How has your confidence to succeed changed during your experience as a university student? Why or why not?
C) How do you think participation in the Fellowship may have impacted your confidence in your ability to succeed as a university student? Why or why not?
2) How confident are you in your ability to succeed in your chosen major? In a Master's or Doctoral program? In your desired career? Why or why not?

Self-efficacy: (For context) is a person's belief in their ability to complete a task or achieve a goal.

1) How do you feel your self-efficacy as a university student has changed since participating in the Fellowship? As a researcher? Explain in what ways.
2) A) What aspects of the Fellowship did you feel you struggled with the most? (i.e. public speaking, professional communication, time-management, etc..)
B) How has your relationship with your answer to part A changed since participating in the Fellowship?

Long-Term Impacts:

1) Are you still in contact with your mentor/ participating in the research you learned about during your project? If yes, please explain how.
2) Are you participating in any research following the conclusion of the Fellowship? If yes, please explain the work you are involved in.
3) If the Fellowship had any additional impact on you that you would like to share with the Grand Challenges team not covered in the previous questions, please discuss here.

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