

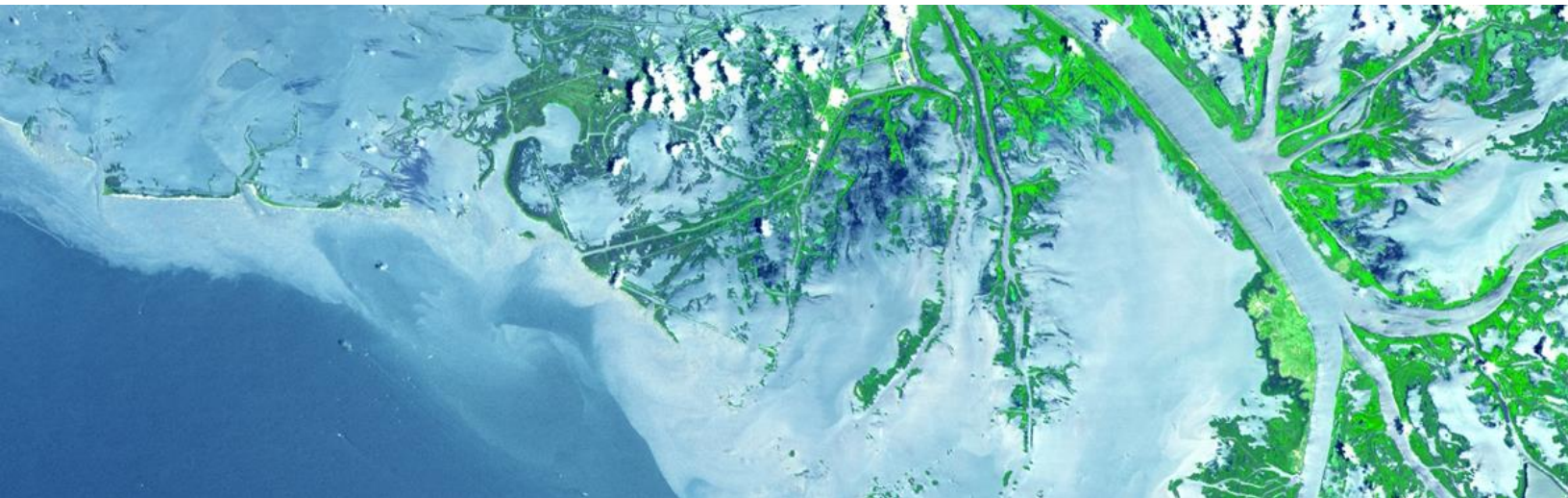


Environmental Data Science Innovation & Inclusion Lab

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## ESIIL Stars Program Cohort 2 2024

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# Introduction

The ESIL Stars Program aims to build a cohort of highly sought-after professionals who can efficiently harness emergent data and tools to address societal challenges, support data-driven decision-making and planning, accelerate scientific discovery and innovation, and bridge the data-to-knowledge gap. The ESIL Stars Program invites students from diverse backgrounds at schools serving communities that are historically underrepresented in STEM to participate in 6-months of Earth and Environmental Data Science (EDS) training and internship. Inspired by Earth Lab's Earth Data Science Corps (**IRB Protocol 20-0254**), ESIL Stars includes a combination of online data skills training for students and faculty, career-focused webinars, an open textbook that introduces novel analytics for environmental data, and project-based learning. Faculty training builds capacity to teach Earth and Environmental Data Science at partner institutions.

Student-focused goals of the program	Instructor-focused goals of the program
Encourage Student Persistence in STEM Through Earth and Environmental Data Science Career Development	Grow Earth and Environmental Data Science Teaching Capacity Through Instructor Training
Build Applied Earth and Environmental Data Science Skills	Develop Earth and Environmental Data Science Curriculum Capacity
Provide Mentorship & Community Support	Make Earth and Environmental Data Science Universally Accessible Through Open Education

This evaluation summarizes the findings from Year 2 of the ESIL Stars program at the University of Colorado Boulder. The ESIL Stars Program taught undergraduates from communities traditionally underrepresented in STEM skills at the intersection of data and Earth and Environmental science. The study assessed the ESIL Stars program's effect on student skill attainment and development, student self-confidence, student career interest, and student career persistence in STEM to understand progress toward the intended goals of the program. In addition, the study sought to understand how the

online learning environment and teaching approaches supported student learning and engagement in EDS.

The program included a suite of activities to empower students to pursue Earth and Environmental Data Science jobs and build sustainable Earth and Environmental Data Science educational programs at partner institutions. During the spring (March-May), faculty and students from each institution attend a series of data science workshops hosted by ESIL, aimed at teaching the foundations of Earth and Environmental data science. In the summer semester, students and faculty applied the scientific programming skills they have learned to a hands-on project through an immersive internship experience. Throughout the program there are peer and professional career development webinars and workshops on topics such as scientific communication, working in environmental data science, and building a professional online presence. All project educational materials are shared on Earth Lab's [open education portal](#) and [YouTube](#) channel.

### Questions Investigated

1. What are effective approaches, and critical components, that help build career persistence, increase self-confidence, science identity, and sense of belonging in Earth and Environmental data science for historically underrepresented groups in STEM?
2. How does participation in the ESIL Stars program contribute to long-term career persistence in Earth and Environmental data science for the general student population and for historically underrepresented groups? What factors of an immersive Earth and Environmental data science program lead to students pursuing careers in Earth and Environmental data science?
3. Does the proposed instructional sequence for the program lead to the development of student critical thinking skills, problem-solving, and “super skills” in Earth and Environmental data science?
4. What are effective approaches, and critical components in those approaches, for teaching and learning Earth and Environmental data science in an online format?
5. What are the success factors and challenges in learning Earth and Environmental data science in an online environment?

# Executive Summary

## Evaluation Findings



Students noted a **strong sense of belonging** to the science community and to science generally and **identified more as an Earth and Environmental data scientist** upon completion of the program.



Students expressed **increased confidence and comfort** in their technical skill development (e.g. Python-specific skills), general science skills and communication, and in science practices as well (e.g. knowing how to find the data needed to answer a research question).



Students came into the program with a **strong interest in gaining EDS skills** and had interest in **applying these skills to their degree programs** by the end of the program. Most students indicated that they would **consider a career in EDS**.



Found the **collaborative and supportive ESIL Stars environment** to be an important part of the program. Though students identified both opportunities and challenges when **working in teams** for their research project.



The majority of students did not have a preference for online or in-person instruction and found advantages and disadvantages to both modes of instruction. Overall, the students **appreciated the flexibility** that the online program offered.

\*"Collaboration" by Eko Purnomo, "Network" by Desi Aulia, "Network" by Iakonic, "Organization" by Sorem, "Research" by Eucalypt, "Communication" by Creative Stall pk, "connected" by Travis Avery, "summit" by Kemesh Maharjan np all from the [Noun Project](#).

## Suggestions for Program Improvement

- Students asked that the instructors **provide more scaffolding of content in the early notebooks** for those students who are coming in with no prior coding experience (e.g. introduce basic terminology and coding functions). The lack of coding experience also made using GitHub initially difficult. Students also suggested that instructors **provide more detailed tutorials on getting set up in GitHub**.
- Advanced interns would like **more clearly defined roles and expectations** communicated at the beginning of the program. One AI noted that they were very involved in the project phase but were uncertain about their role in the initial phase of the program.
- Faculty found difficulty with managing their teams this year. One noted difficulty getting students to work on projects and working with other faculty mentors as well as fitting in so many aspects of EDS in the time allotted. One mentor suggested providing **defined roles and expectations** for mentors to follow and providing student expectations to help **facilitate transfer of students from CU-based work to home institution project work with their faculty mentors**.

## Methods

The study received IRB approval from the University of Colorado, Boulder (Record # 23-0061) to examine student and faculty experiences and learning outcomes in the ESIL Stars program. Pre- and post-program surveys were designed to document student and faculty experiences, and both groups were invited to participate in one on one and/or group interviews at the culmination of the program.

Using a mixed methods approach, descriptive statistics and statistical tests (Wilcoxon signed-rank test or Rasch analysis when applicable for analyzing categorical data) were

conducted for quantitative data; and thematic analysis was conducted for interviews and written responses to open-ended questions.

## ESIIL Stars Participants

A total of sixteen students participated in the ESIIL Stars program. Of those, five of them were returning as Advanced Interns for the program. First-time students (all undergraduates) were affiliated with three different institutions and seven faculty joined the program as well. All first-time students participating in the ESIIL Stars program consented to participate in the evaluation study.

### First-time Student Interns in the 2024 Cohort

4 Metropolitan State University of Denver (MSU) students	<b>N=11</b>  <b>Students in the 2024 Cohort</b>
3 Oglala Lakota College (OLC) students	
4 United Tribes Technical College (UTTC) students	

### Number of Responses for Survey Instruments Administered 2024

March 2024	August 2024	Aug-Sept 2024
<b>Pre-program Survey</b> 100% response rate student interns 60% response rate advanced interns 86% response rate faculty	<b>Post-program Survey</b>	<b>Interviews</b> (First-time Interns and Faculty Only)
n = 14 first-time student interns <sup>#</sup> n=3 advanced interns n= 7 faculty	n = 4 first-time student interns n=4 advanced interns n=4 faculty	n = 1 intern

\* Sample sizes for each survey represent students who consented to participate in the study. <sup>#</sup>Interns dropped from the program leaving the final total of first-time student interns at 11 total.

The pre-program survey collected demographic information from students (both first-time and advanced interns) and faculty such as race and ethnicity, gender identity, first in their family to attend college, enrollment status, and degree pursuing (See table below). It also included questions related to program expectations, concerns, interests, awareness, EDS skills, career goals and experience with online learning.

There were slightly more women than men comprising the ESIL stars student respondents. Eight respondents identified as women (53%) and another five as men (33%) and 4 others were non-binary and/or gender non-conforming. Over half of respondents (8 of 15) identified as LGBTQ+. The majority of respondents were American Indian or Alaska Native (67%) and over a third of the student respondents (33%) were the first in their families to attend college. The majority of participants (80%) were pursuing bachelor's degrees in environmental science, geoscience, and natural sciences. Over half of the first-time interns (58%) indicated that they had life commitments outside of school and work but that those commitments did not affect the number of course credits they were taking for their degree.

#### Student Demographic Information (First-time (n=14) and Advanced Interns (n=5))

Gender Identity*		Race and Ethnicity*	
Woman	53%	American Indian or Alaska Native	67%
Man	33%	White, Caucasian, Euro-Euro American	27%
Non-binary	20%	Asian American, Asian	<10%
Gender non-conforming	<7%	African American, Black	23%
First In Family to Attend College		Degree Pursuing*	
Yes	33%	Associate's	13%
No	60%	Bachelor's	80%



Prefer not to say	<7%	Certificate	13%
<b>Enrollment Status (First-time Interns Only)</b>		Master's (Advanced Interns ONLY)	20% of Advanced Interns
Full time	75%	<b>Life commitments outside of school or job (First-time Interns Only)</b>	
Part time	25%	Yes, those commitments require me to take fewer course credits	0%
<b>Field of Study*</b>		Yes, but those commitments do not require me to taking fewer course credits	58%
Environmental Conservation Environmental studies	Sci, Bio, 60%	No, I don't have commitments that affect the number of credits I take	42%
Computer Science, GIS, Information Technology	20%	% calculated for total respondents	
Geoscience, Earth Science	13%		
Other: Indian Law	<7%		

\*Indicates respondent could respond to more than one response option. Percentages calculated over the total respondents.

## Findings about Science Identity and Belonging

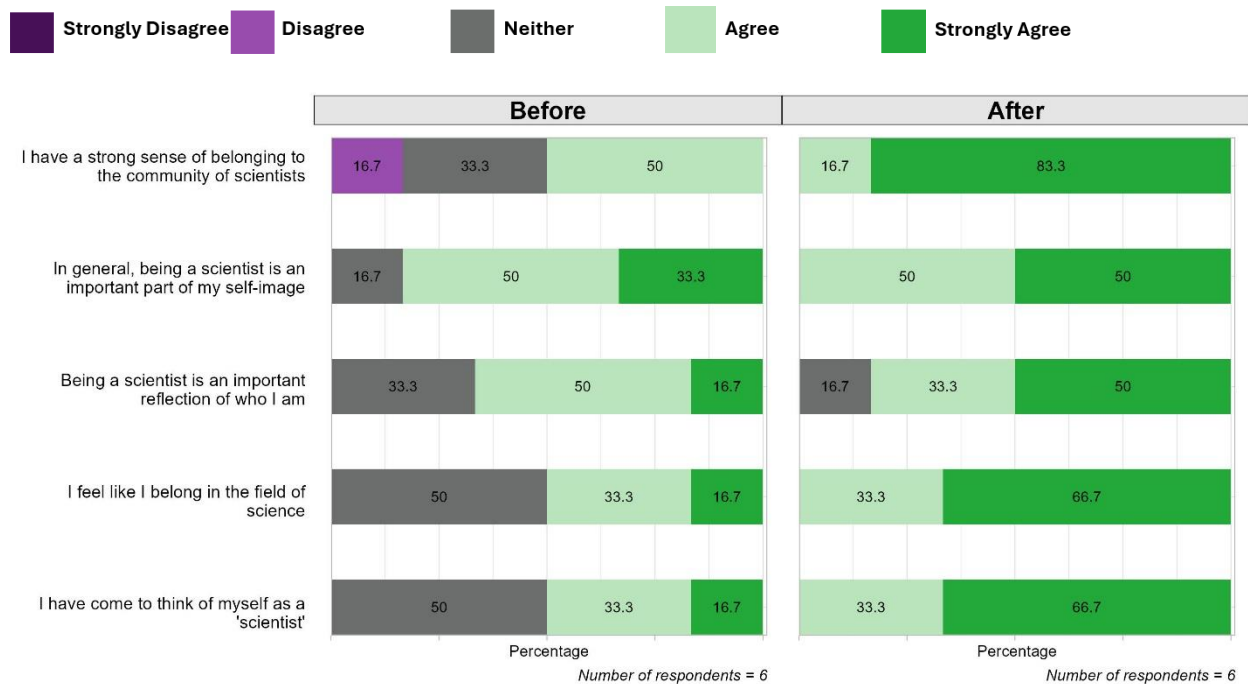
### Did students develop a science identity and a sense of belonging in science?

The study aimed to understand any programmatic effects on student identity and sense of belonging in science. Questions asked in the survey at the end of the program were taken from a validated instrument used to measure science identity and belonging (Chemers et al, 2011). At the end of the program, students responded retrospectively and were asked to reflect on their feelings after the program compared to before.

When comparing their feelings of belonging before the program and upon completion of the program, the students (both first-time interns and advanced interns), students indicated that they **felt a strong sense of belonging to the science community**

(50% agreed or strongly agreed with this sentiment before the program and 100% agreed or strongly agreed by the end, a significant change from pre- to post-program  $Z=2.17$ ,  $p=0.03$ ). Only 18% of students felt they belonged in science before the program, but that jumped up to 66.7% after ( $Z = 1.95$ ,  $p = .051$ ).

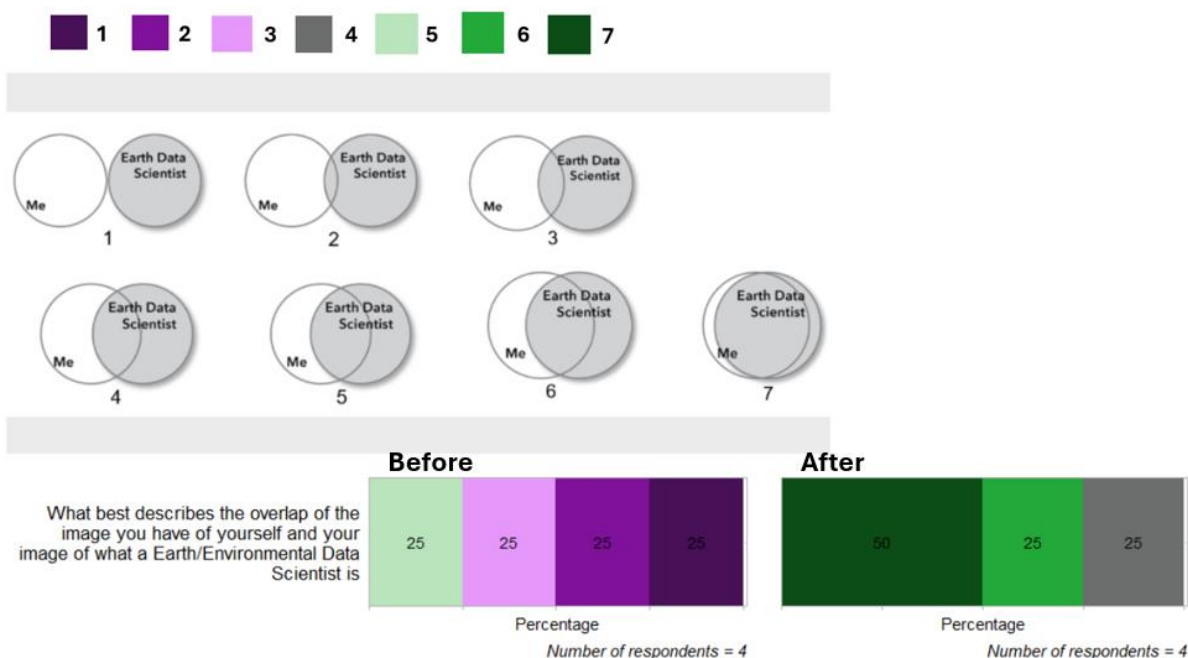
With respect to science identity, 66.7% of students strongly agreed or agreed with the statement that **being a scientist is important to who they are** prior to entering the ESIL Stars program and increased to 83.3% strongly agreed or agreed with that statement after the program (pre- to post-program  $Z=1.41$ ,  $p=0.16$ ). In general, students felt that **being a scientist was an important part of their self-image** both before (83.3% agreeing or strongly agreeing with this statement) and after (100% agreeing or strongly agreeing with this sentiment) ( $Z=1.72$ ,  $p=.09$ ). There was a large shift in the sentiment of **“thinking of myself as a scientist”**, with 50% agreeing or strongly agreeing with this before the program and 100% agreeing or strongly agreeing with this after the program ( $Z=2.17$ ,  $p=0.03$ ).



\*post-program survey

When asked to describe the overlap of their self-image with that of an Earth and Environmental data scientist, first-time interns and advanced interns alike noted increased science identity upon completion of the program. Taken together, **first-time interns' and advanced interns' reported changes to their science identity were statistically significant** (Wilcoxon-Pratt Signed Rank Test indicate  $Z=2.30$  and  $p=0.02$ ).

Those first-time interns who completed both the pre- and post-surveys ( $n=4$ ) came into the program with **no background in EDS and perceived it as complex**. Coming in, about half of the first-time intern respondents saw very little overlap in terms of their self-image and that of an ED scientist. After the ESIL stars program, **all of the respondents indicated that the overlap between self-image and that of an Earth and Environmental data scientist was at least half or more** (responses 4-7). Fifty percent of the students at the end of the program saw a lot of overlap with their self-image and image of EDS (response 6-7). (See figure below). Students came away from the experience with **a greater understanding** of what EDS entails, how it can be used to help the world, and **how they can use** it in their future work.

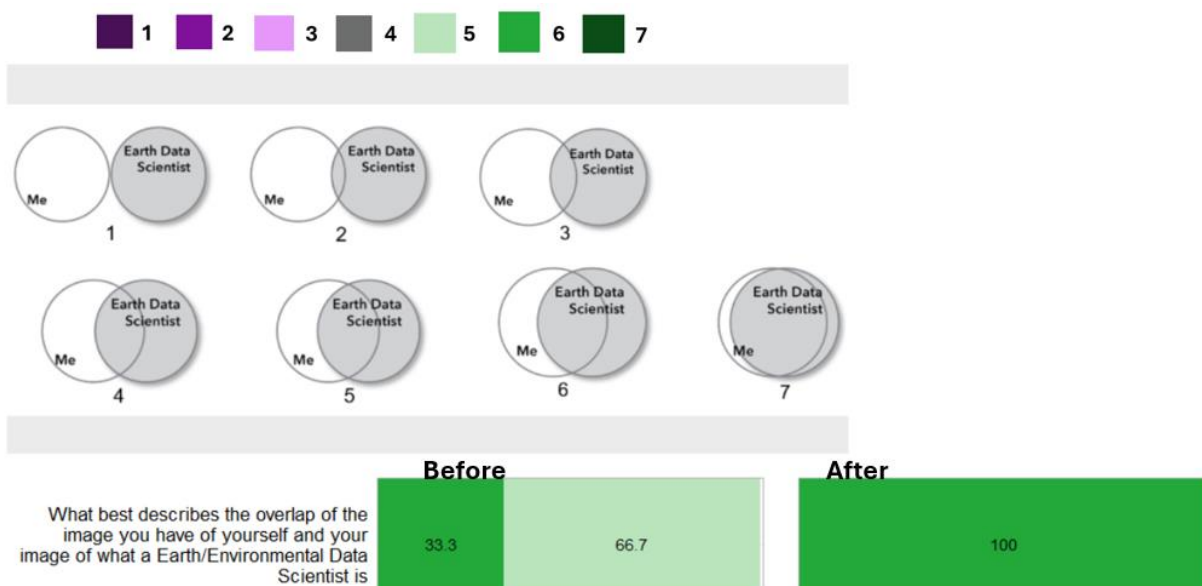


*\*post-program survey*

**First-time intern:** Before ESIL, I did not have any experience with earth data science and was kind of avoidant of anything related to it. After the program, I am much more comfortable with earth science data analysis and I don't get overwhelmed looking at them!

Advanced interns (n=3) **identified more strongly** with Earth and Environmental data scientists coming into the program (100% indicated overlap that was half or more) and **became more confident** with their participation in the ESIL Stars program. By the end of the program, 100% saw nearly strong overlap in their self-image and that of an ED scientist. (See figure below).

**Advanced Intern:** I chose 5 for "before" because I've had a few impactful opportunities to learn Earth data science skills in the past few years, but I still had some impostor syndrome. I chose 6 for "after" because I feel more comfortable with identifying or seeing myself as an Earth data scientist the more experience, exposure, and skills I gain.



\*post-program survey

## How did students develop a sense of belonging?

Understanding if students felt a sense of belonging in the ESIL Stars was an important part of comprehending underlying factors that affect student self-confidence and potentially student career persistence in related fields. In a post-program interview with one intern, they indicated that **they did feel “out of place” when comparing their research projects with other groups at the data party** and thought that what they had chosen as their topic **might not be “good enough”**. However, this student noted that being able to work with other data scientists and talk with other students **made the cohort feel like a close-knit group**. They appreciated that **the CU instructors were open and available** and that the relationships they developed with others in the cohort were key to their success. This sentiment regarding relationships is similar to those expressed by students in previous cohorts and is evidence of effective relationship building by the ESIL Stars team.

## Findings about Career Persistence

An outcome of the ESIL Stars program aimed for students in the program to develop an interest in Earth and Environmental data science career tracks, or to change their career track toward Earth and Environmental data science. For the purposes of program evaluation, we asked participating students questions in surveys and interviews about awareness of, interest in, and intent to pursue careers related to Earth and Environmental data science.

### Awareness of the Field of Earth and Environmental Data Science

#### Did students become more aware of the Earth and Environmental data science field?

The study analyzed and compared responses to the open-ended question on pre- and post-surveys which asked, “Please describe the type of work you think an Earth and Environmental data scientist does, and where they work.” The analysis looked for words that described Earth and Environmental Data Science-related fields and careers, and the degree of detail and specificity in written descriptions. Greater detail and specificity in the description would indicate a greater level of knowledge about related fields and

careers. Student responses from **before the program** indicate that most students named **analyzing data as a key component of what Earth and Environmental Data Scientists do**. Both before and after the program, students considered **EDS work to be done primarily on a computer or research lab and/or an office**. **Before and after the program** students noted Environmental Data Scientists **use data and apply their skills to solve problems and study the environment**. (See table below).

Type of Work Earth Data Scientists Do			Where Earth Data Scientists Work		
	Before n = 12	After n = 4		Before n = 12	After n = 4
Collects/Analyzes Data	10	1	Computer/ Research Lab	7	2
Solves problems/ Addresses issues	4	2	Office	5	1
Visualizes/Communicates Data	2	1	Government	3	0
Studies the environment/nature	2	2	In the Field	2	2
*A single student response can be categorized into multiple categories			Private Sector/Industry	2	0
			Academia/University	2	0
			Non-Profit	1	0
			Anywhere/Everywhere	1	1
			Remote	1	1

## Interest in the Earth and Environmental Data Science Field

### Did student interest in Earth and Environmental data science increase?

Coming into the program, students were asked about their interest in learning more about Earth and Environmental data science. Several themes came through in the first-time intern responses, including their interests in:

- **Science and Environmental Studies**
  - Existing interest in the sciences, but also a desire to explore and expand knowledge in environmental data science.
- **Skills Development in Data Science**
  - Learning data organization, management, and analysis.
  - Building skills in data interpretation and mapping using Python.
- **Environmental Challenges and Solutions**

- Applying data science to address environmental issues and remediation.
- Understanding and using past and present data for ecological improvement.
- **Blending Traditional and Modern Knowledge**
  - Integrating Indigenous and traditional knowledge with modern environmental science.
  - Honoring ancestral teachings while leveraging data science tools.
- **Professional and Academic Growth**
  - Gaining sought-after skills in environmental data science for career advancement.
  - Interest in learning new research methods and technologies.
- **Technology and Community Impact**
  - Using technology to improve community well-being and solve environmental challenges.
  - Exploring the intersection of technology and environmental sustainability.
- **Inspiration and Collaboration**
  - Inspiration drawn from peers and existing research.
  - Aspiration to expand upon or create novel research in environmental data science.

Advanced interns were asked the same questions and from their responses we saw interest in several themes as well, including their interest in:

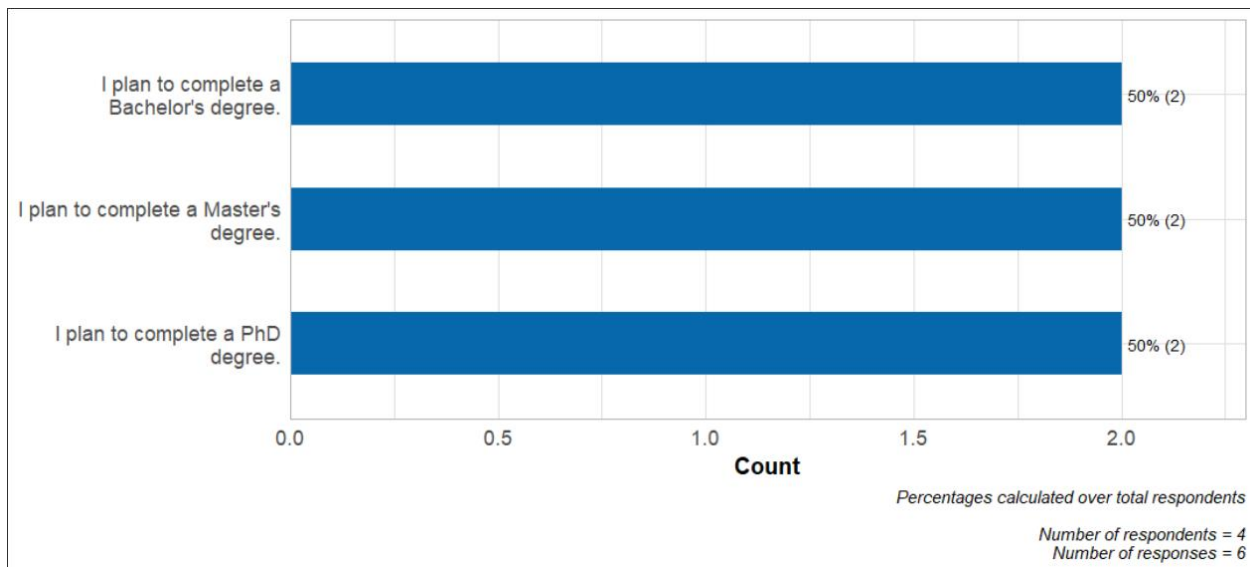
- **Learning and Skill Development:** A desire to deepen understanding of Environmental Data Science (EDS)
- **Passion for Collaboration and Mentorship:** Enthusiasm for coding and sharing knowledge with others, emphasizing team learning and mutual growth.
- **Storytelling with Data:** Viewing EDS as a powerful tool for narrating global phenomena and their impacts on society and nature.

- **Interdisciplinary Applications:** Highlighting the ability of remote sensing data to reveal connections between climate change, natural disasters, and human activity.

In general, the first-time interns had a broader set of interests coming into the program (including collaboration with others) while the advanced interns were more focused on application and skill building.

The majority of students coming into the program were pursuing bachelor's degrees in disciplines related to **Computer Science, GIS and Information Technology as well as Geoscience and Environmental Science**. Upon completion of the program, students were still focused on achieving this goal, but a handful indicated that they were planning on completing advanced and/or professional degree programs (see graph below), primarily within the same disciplines that they are currently pursuing. For these interns, there was **high interest in Earth and Environmental data science coming into the program and an interest in applying it in their existing degree programs**, thus the program appears to **sustain their interest in EDS**, but not change their plans for future study directly. In speaking with one first-time intern after the program, they indicated that they would like **to continue working in EDS** and is planning to pursue further certification in GIS. In particular, they mentioned interest in continuing to do **scientific research** and doing work that **"makes a difference"**.





## Intent to pursue an Earth and Environmental Data Science Career or Pathway

**Did students intend to pursue an Earth and Environmental data science career or pathway?**

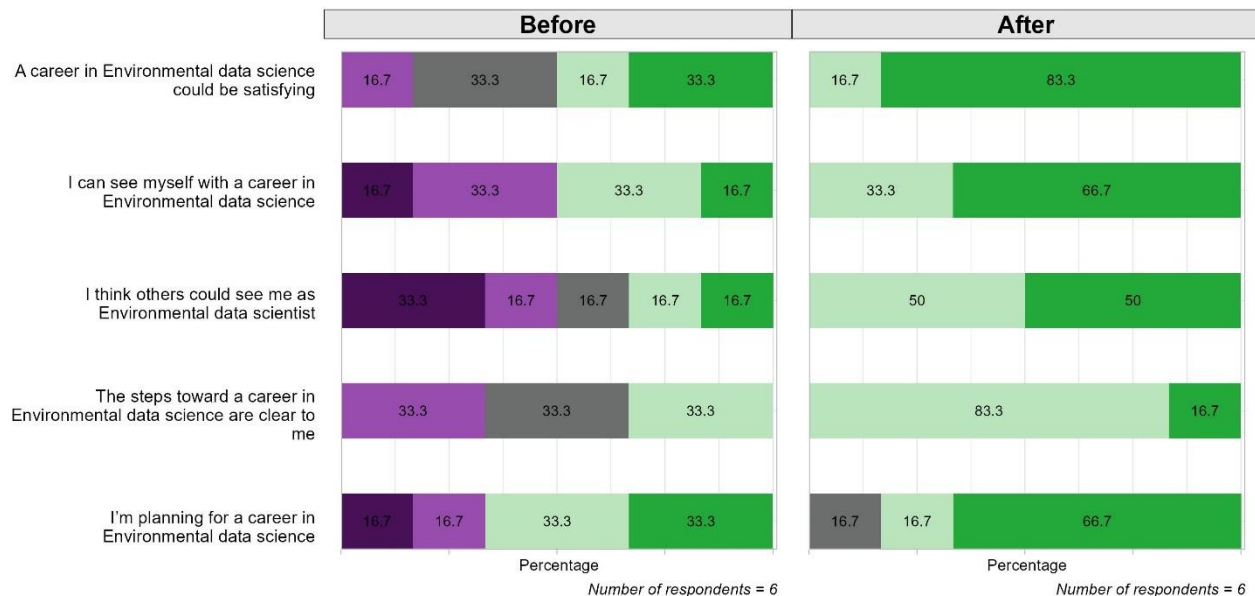
### The Program Met Student Expectations for Skill Building and Career Readiness

Students were asked at the beginning of the program, “How does participation in the ESIL Stars program support your career goals?” and then asked at the end of the program how the internship may have affected their career goals. The table below shows the number of responses for each thematic category. Depending on the complexity of the response, each response was coded for one or two thematic categories. When comparing responses to both questions side by side, **the program met the students expectations related to exploring their career interests**. Some new themes that emerged were that some students stated that the experience of the **program increased their confidence and helped them refine their career goals**.

Expectations for the program supporting career goals (n=12)		How the program affected career goals (n=4)
6	Skill Building/Using Programming	1
9	Career Readiness/ Research Experience	1
5	Explore Career Interests	2
Increased Confidence: 3	*A single student response could be categorized into multiple themes	Narrow/solidify career path: 2

Students explored and became more interested in Earth and Environmental data science careers and in opportunities to apply their new skills.

First-time and advanced interns were asked a series of questions about their thoughts on careers in Earth and Environmental data science before the program compared to after participating in the program. **100% of both first-time interns and advanced interns survey respondents would consider a career in Earth and Environmental data science** upon completion of the ESIL Stars program. Students also reported having **an interest in working in both the private sector** (e.g. research) (n=2) and **public sector** (e.g. government agency) (n=2).



*\*post-program survey*

More specifically, from their responses to a set of before and after questions we see that there is increased agreement with the sentiments related to future careers in EDS. **Over 80% of survey respondents strongly agreed that a career in EDS could be satisfying after the program.** Over half (67%) of students strongly agreed that they could see themselves with a career in EDS and 50% strongly agreed that others could see them as an Environmental data scientist. Only 17% of the students strongly agreed that the steps toward a career in EDS were clear to them (although 100% all agreed to some extent) and 83% of students agreed or strongly agreed that they were planning for a career in EDS . **All five questions related to careers showed statistically marginally significant to significant increases in agreement from their feelings before the program ( $Z > 1.95$ ,  $p < .06$ )** In fact, before the program, half of students strongly disagreed or disagreed that they could see themselves in an EDS career and 33% were not planning on a future career in EDS. By the end of the program, no students “strongly disagreed” with any of these statements related to career paths.

## Findings about Skill Development

The ESIL Stars program sought to build student comfort and confidence with technical and non-technical aspects of Earth and Environmental Data Science through the combination of technical workshops and project-based learning that included an immersive Earth and Environmental data science internship. Student comfort and confidence with Earth and Environmental Data Science skills were assessed using Likert survey instruments. At the conclusion of the program, participating students were asked to complete surveys that included items designed to give students the opportunity to respond retrospectively to questions about their comfort, confidence, and agreement with prompts related to different technical and non-technical components of the workshops and internship. Here students were asked to report the level of comfort or confidence they had in a certain area prior to participating in the program and then once again after their participation was complete. Results are reported using a series of horizontal bar plots, organized by trial (BEFORE/AFTER) for easy comparison.

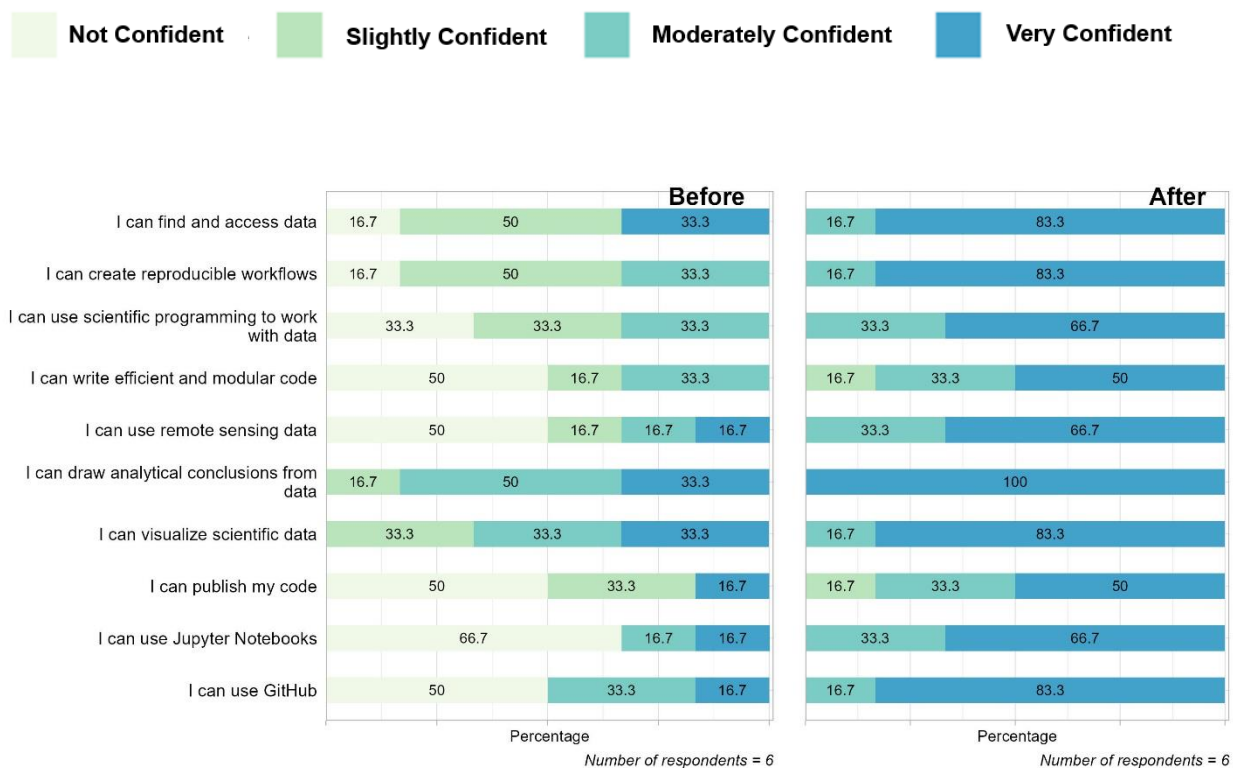
These findings are organized into two broad categories. The first is focused on technical skill development which includes comfort and confidence with data science generally, and programming with Python specifically. The second category explores “super skill” development, including students’ ability to communicate science findings, think critically, solve problems with data, and work collaboratively with others. This second category includes an assessment of students’ perceived ability to engage with different practices of science.

### Student Technical Skill Development

#### Did participants develop confidence in their technical data science skills?

**First-time interns and advanced interns had marginally significant to statistically significant gains in confidence in their coding skills after completing the program (see below).** Before the program, half or more of the students were not confident in their skills regarding writing efficient and modular code, publishing and creating reproducible workflows, using scientific programming, and remote sensing data, and using Jupyter

Notebooks and GitHub. Upon completion of ESIL Stars, 50% or greater of the student participants noted being “very confident” in **publishing code** ( $Z=2.12$ ,  $p=0.03$ ) and “confident” in **writing code** ( $Z=2.3$ ,  $p=0.02$ ), **creating reproducible workflows** ( $Z=2.13$ ,  $p=0.03$ ), **using GitHub** ( $Z=2.12$ ,  $p=0.03$ ), **finding and accessing data** ( $Z=2.0$ ,  $p=0.05$ ), using **scientific programming to work with data** ( $Z=2.23$ ,  $p=.03$ ), using **remote sensing data** ( $Z=1.95$ ,  $p=.05$ ), **draw analytical conclusions** ( $Z=1.96$ ,  $p=.05$ ), **visualizing scientific data** ( $Z=1.72$ ,  $p=.09$ ), and **using jupyter notebooks** ( $Z=.212$ ,  $p=.03$ ).

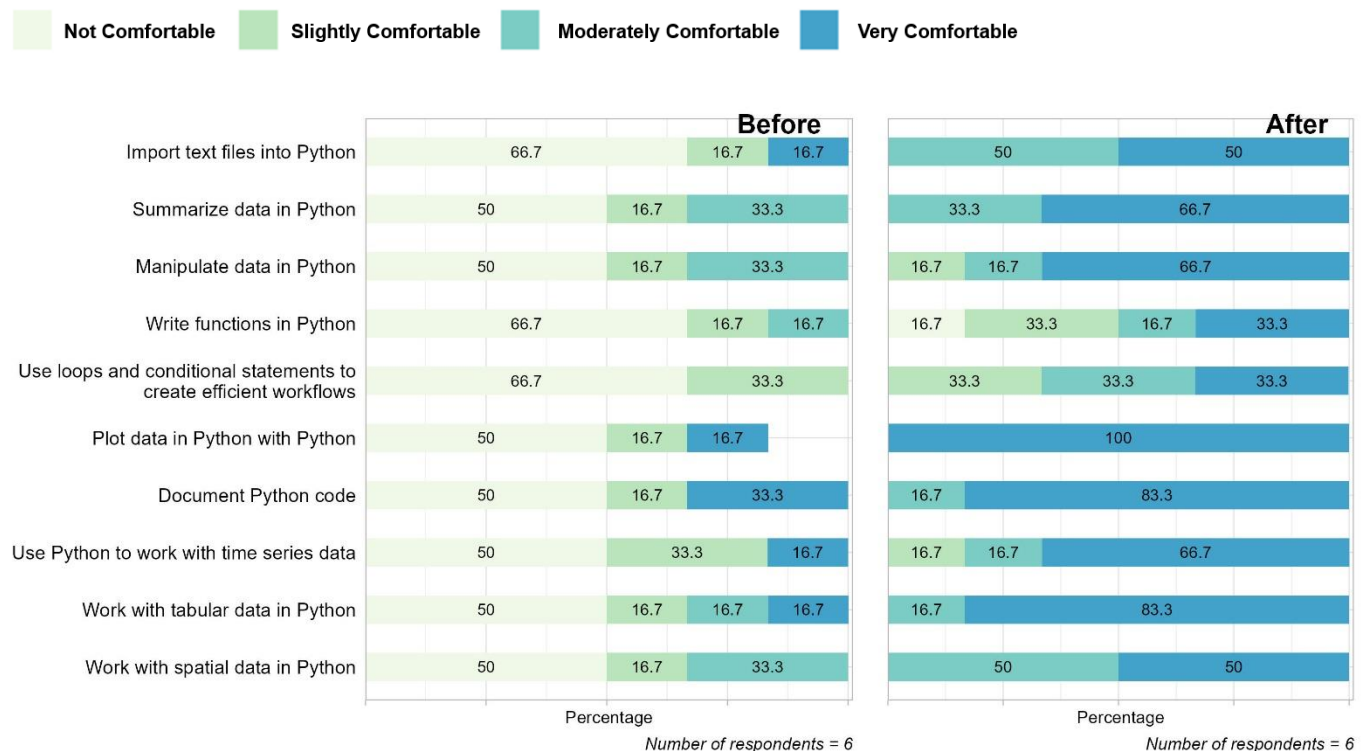


*\*post-program survey*

### Did participants develop comfort with their technical Python skills?

Across the board, the majority of participants coming into the program were not comfortable with their Python skills (see below). Across all skills, half or more of the students were “not comfortable” with any of the ten Python-specific skills used in the ESIL Stars program. By the end of the program, over 50% of respondents were very comfortable plotting data in Python with matplotlib ( $Z=1.94$ ,  $p=.05$ ), Importing text files

into Python ( $Z=2.12$ ,  $p=0.03$ ), working with time series data ( $Z=1.95$ ,  $p=.05$ ) working with tabular data ( $Z=2.12$ ,  $p=0.03$ ), working with spatial data ( $Z=2.12$ ,  $p=.03$ ), documenting Python code ( $Z=1.96$ ,  $p=0.05$ ), summarizing data ( $Z=2.23$ ,  $p=.03$ ) and manipulating data in Python ( $Z=2.27$ ,  $p=0.02$ ). Students were slightly less comfortable – but still very comfortable to moderately comfortable 50% of the time or more - with using loops and conditional statements ( $Z=2.12$ ,  $p=0.03$ ) and writing functions in python ( $Z=1.95$ ,  $p=.05$ ).



*\*Post-program survey*

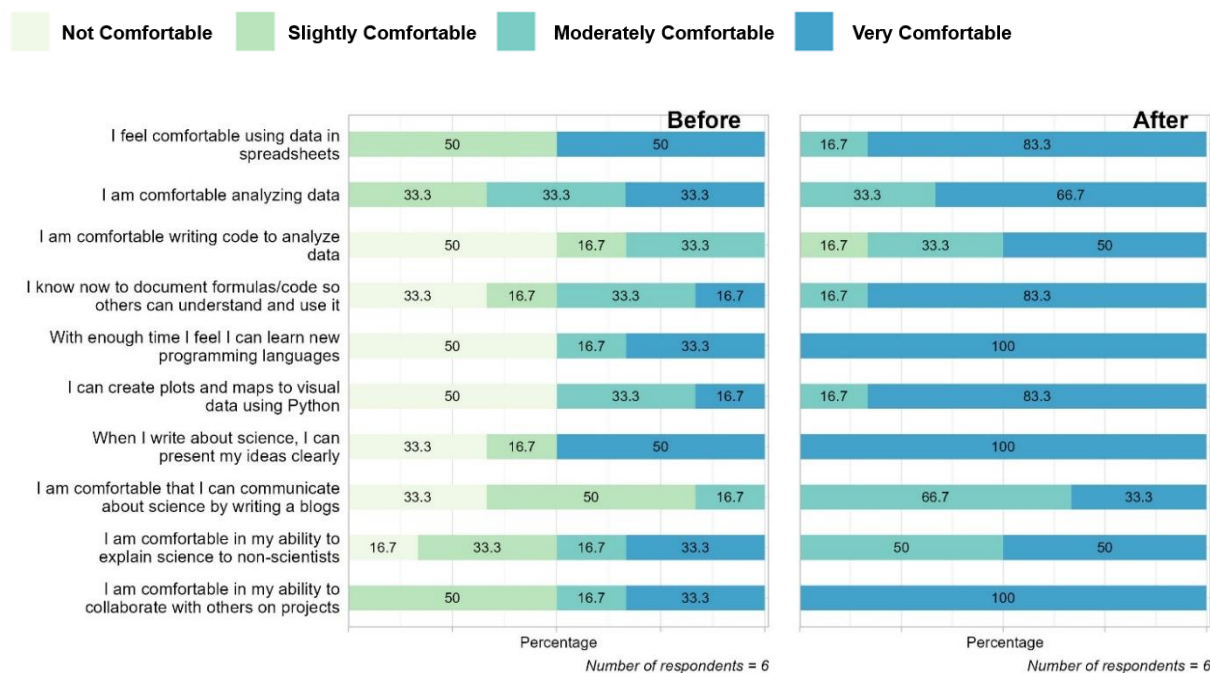
## Student “Super Skills” Development

**Did participants develop comfort and confidence in their general data and communication skills?**

Before the program, 50% or more of students did not feel comfortable with any of the skills except analyzing data. Post program, students were almost exclusively very comfortable or moderately comfortable with all general data skills. 100% of students were moderately to very comfortable with using data in spreadsheets, analyzing data,

documenting code for others, and learning new programming languages. 84% of students felt moderately comfortable to very comfortable writing code to analyze data. **By the end of the program, all of the students made statistically significant or marginally significant gains in their comfort with general science skills. Nearly all of the students felt moderately to very comfortable with each of the general data skills: using spreadsheets ( $Z=1.72$ ,  $p=0.09$ ), analyzing data ( $Z=1.72$ ,  $p=0.09$ ), writing and documenting code ( $Z=2.26$ ,  $p=0.02$ ;  $Z=2.12$ ,  $p=0.03$  respectively) and learning new languages ( $Z=1.96$ ,  $p=0.05$ ) (100% of the students were moderately to very comfortable with these skills).**

In terms of communication skills, again, students had a variety of comfort levels coming into the ESIL Stars program. **Before coming into the program, half of the students felt comfortable with presenting their science ideas clearly, explaining science to non-scientists creating visuals in Python and with collaborating with others on projects.** They were less comfortable communicating science in blog format. By the end of the program, marginally significant or significant **gains in comfort were seen across general communication skill categories**, particularly in **creating visuals in Python** ( $Z=2.12$ ,  $p=0.03$ ), **explaining their science to non-scientists** ( $Z=1.72$ ,  $p=0.09$ ) and **working collaboratively** ( $Z=1.96$ ,  $p=0.05$ ), writing clear data ( $Z=1.72$ ,  $p=.09$ ), and writing blogs on science ( $Z=1.72$ ,  $p=.09$ ).



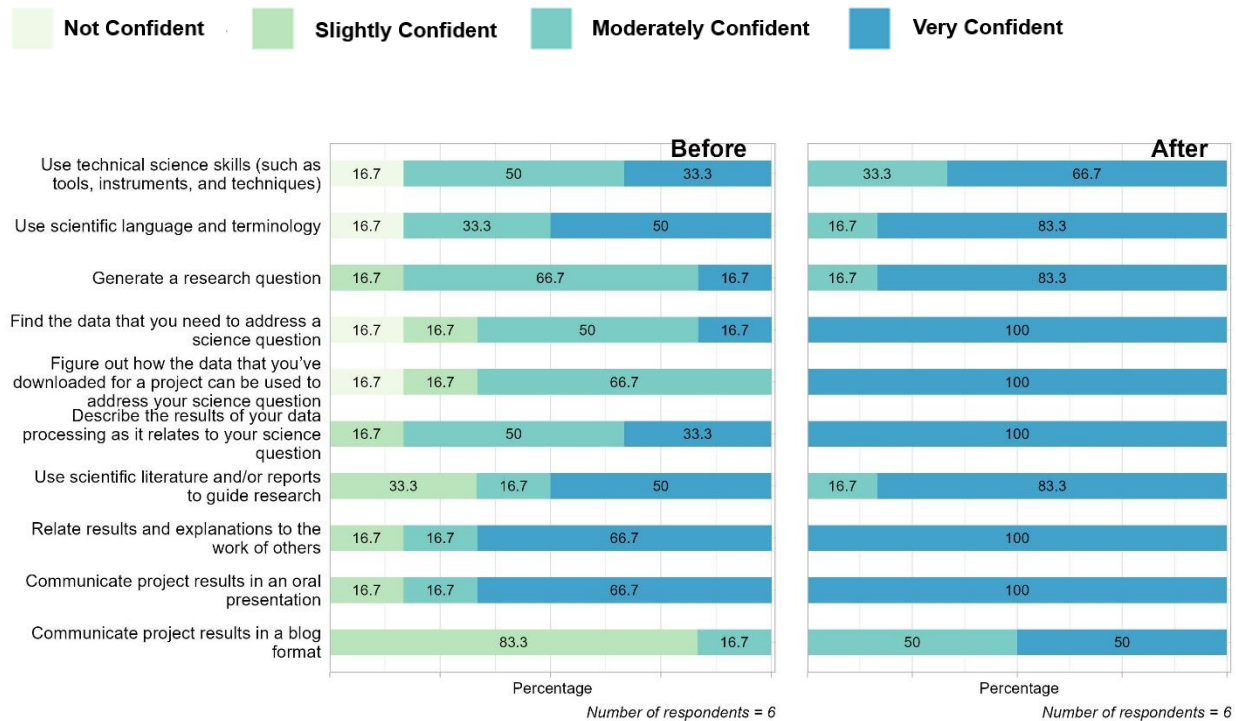
*\*post-program survey*

## Did participants develop confidence in their ability to engage with different science practices?

Students were asked to also reflect on ten prompts about their confidence in performing practices carried out by members of the science community. **By the end of the program, 100% of students were very confident or moderately confident in the skills below. Students showed statistically significant increases in their confidence in science skills upon completing the program compared to before (see below). Greatest gains** could be seen in **knowing what data that you need** to address a science question ( $Z=2.13$ ,  $p=0.03$ ), communicating via a blog ( $Z=2.14$ ,  $p=.03$ ) and **with addressing a research question with data** ( $Z=2.26$ ,  $p=.02$ ). Students did not significantly change their reported confidence levels with using scientific language and terminology ( $Z=1.41$ ,  $p=0.16$ ), using scientific literature and reports to guide research ( $Z=1.41$ ,  $p=0.16$ ), communicating results orally ( $Z=1.41$ ,  $p=.16$ ), and relating results to others' work ( $Z=1.41$ ,  $p=.16$ ). Significant changes were seen regarding generating a research question ( $Z=1.96$ ,  $p=0.05$ ) and describing how data was processed as it relates to a research question ( $Z=1.96$ ,  $p=0.05$ ) and a marginal change with using technical skills



( $Z=1.72$ ,  $p=.09$ ), with a majority of students selecting 'very comfortable' for these questions.

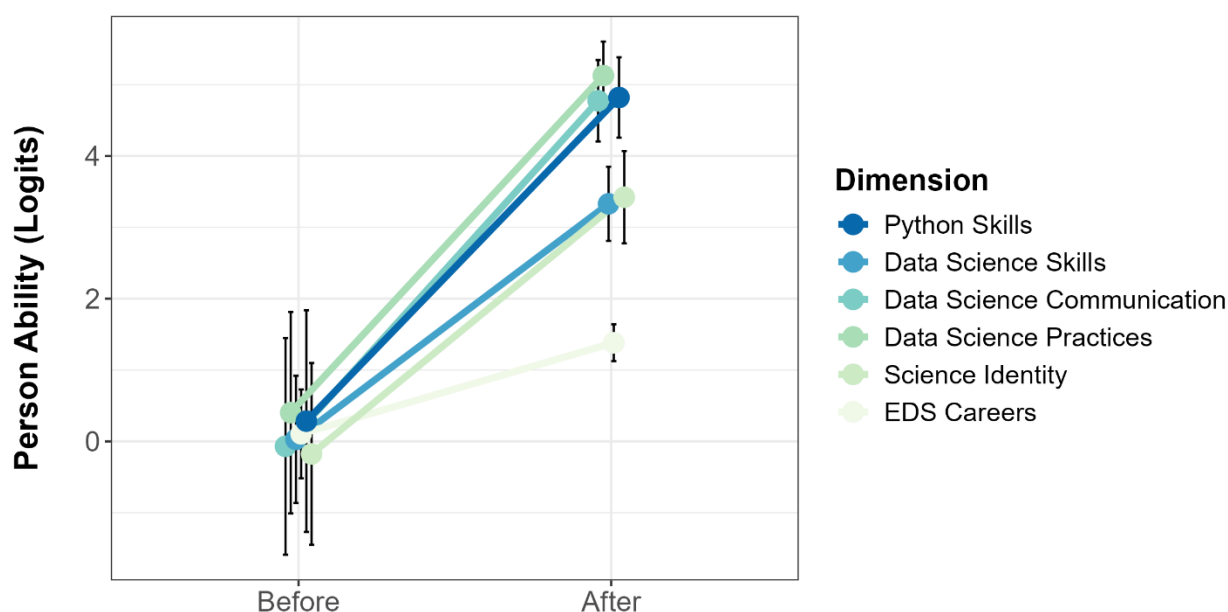


## Overall Student Confidence In Earth and Environmental Data Science Skills

Rasch analysis (Boone, Staver & Yale, 2013)<sup>1</sup> was used to model student responses to Likert survey items, providing numerical values of item difficulty and person ability that are measured on a common ratio scale. Measures of student ability from Rasch modeling corresponding to perceived confidence, comfort, or agreement were compared across two time points (pre-program [Before] vs. post-program [After]) representing a measure of student growth in these five different areas: Science Identity, Confidence in Python and Data Science Skills, Data and Communication Skills, and Science Practices (individual questions in each dimension described in above section).

## Students Show Significant Growth in Intended Program Objectives

The pre- and post-program comparison indicates growth across all five dimensions of program outcomes related to skills and identity. The greatest gain is related to specific Python skills, with smaller gains seen in the areas of data science skills, data analysis and communication skills and science practices more generally. The smallest gain is related to science identity.



In the post-survey, first time interns and advanced interns highlighted the importance of acquiring practical skills for **navigating and analyzing data**, particularly through tools like **Python** and leveraging online resources such as **ChatGPT**. Respondents emphasized the value of **learning to access and extract public data, import and analyze it, and communicate scientific findings** effectively. They also noted the significance of transferable skills such as **remote teamwork, self-discipline, mentoring, and setting professional boundaries**. These experiences have **built confidence** in coding, data science, and professional communication, providing a strong foundation for future career growth in data-driven fields.

## Findings on Student Online Learning Experiences

First-time student interns were asked before entering the ESIL stars program about their experiences with learning online. They were asked for their preference for online or in-person learning, what holds their attention and what does not, how they evaluate their progress and identify when they are falling behind. **Of the twelve respondents, four preferred to learn online, another four preferred in-person instruction and the rest indicated that both modes had their advantages and disadvantages.** Those who preferred in-person instruction noted that it was easier to “get connected with professors and classmates”. Those who preferred online learning liked its flexibility, the ability to re-watch lectures, and saving time/resources without having to commute.

In learning online, students identified characteristics that **held their attention best** including: **course interactivity, seeing other people’s faces online, ability to ask questions and share their screen, multimedia including videos, slideshows, and group discussion, well-organized materials, visual aids, and short breaks every hour.** When asked to describe the best parts of the ESIL Stars experience, students identified a number of activities and content that were enjoyable, including:

- **Working with/learning from others**
- **Learning to code** and using it to **analyze and visualize data**
- **Working with their team and applying their skills** to a project, using it for meaningful research
- The **encouraging atmosphere** from instructors and **the directions and videos for support**

All of the students indicated being “very satisfied” with the communication during the program, but slightly less so with mentors from their home institutions (1 of the 4 students indicated only being somewhat satisfied with their communication with their mentors while the other 3 were “very satisfied”).

The students identified challenges to learning online as well which included **collaborative coding**, as many felt they lacked sufficient skills to effectively analyze the data they gathered. Additionally, **reaching a consensus** on the research question posed difficulties, reflecting challenges in teamwork and decision-making. Some participants also **struggled with using GitHub independently** in self-created repositories, which they felt weren't included in the tutorials provided. Overall, the responses suggest that both **technical proficiency in coding and practical skills in collaborative tools like GitHub** were key hurdles during the internship.

## Recommendations for Program Improvements

### More scaffolding in early parts of the program for students new to coding

- Similar to last year, the students mentioned that the most challenging aspect of the internship was the coding. The evaluation suggests that program leaders scaffold the information a bit more in the first few weeks to help students get up to speed (like spending more time on basic coding terminology and functions).
- Provide more training or dedicated tutorials on how to set up their individual GitHub spaces. Students mentioned that the existing tutorials did not provide enough detailed information on this process.

### More facilitation of student groups when determining their research project

- A few students mentioned having difficulty coming to consensus on what topic their group would research over the summer. For groups struggling to get a start, they may need a bit more assistance in talking through their ideas. This could already be the role of the faculty advisor, but perhaps having more time or more facilitation by the CU ESIL Stars instructors could help.

### More clarification of roles and expectations

- Advanced interns and faculty indicated that they needed more clarification on their roles and expectations at certain times in the project. Als needed more

guidance early on (before the projects) and faculty indicated that students needed to have the roles and expectations clarified as they transitioned from CU work to home institution work over the course of the project. Perhaps build this into some orientation/training materials for AIs prior to the start of the program and perhaps draft a roles and expectations for students as they transition to their group work at their home institutions.

## Conclusions

**The overarching goal of the ESIL Stars program is to increase diverse participation in Earth and Environmental Data Science career pathways.** To achieve this goal, the program has identified focused student support, increased confidence in skills, and greater awareness and interest in Earth and Environmental data science as key outcomes for the program. The findings identified by the evaluation indicate that students are feeling supported in the program through the welcoming and supportive environment created by the program leaders and the access to assistance from advanced interns, faculty mentors and the program leaders at CU. Students report having an increased sense of belonging to the scientific community and to science more generally.

In terms of skill development, the student participants show statistically significant gains in confidence and comfort across four different dimensions: data science skills, python skills, data and communication skills as well as general science practices. Furthermore, the evaluation identified that students came away with increased interest in applying data science skills to their current degree programs and seeking graduate degrees and careers in Earth and Environmental data science. Collectively, the findings indicate that the ESIL Stars program lays the foundation necessary for students to find Earth and Environmental data science career pathways.

## References

- Boone, W. J., Staver, J. R., & Yale, M. S. (2013). *Rasch analysis in the human sciences*. Springer Science & Business Media.
- Chemers, M.M., Zurbriggen, E.L., Syed, M., Goza, B.K. and Bearman, S. (2011), The Role of Efficacy and Identity in Science Career Commitment Among Underrepresented Minority Students. *Journal of Social Issues*, 67: 469-491.  
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## Appendix

[Pre-program survey \(for students, advanced interns, and faculty\)](#)

[Post-program survey \(for students, advanced interns\)](#)

[Post-program survey \(for faculty\)](#)