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Fitting College to Students (not Vice Versa): A Certificate Program on Environmental Stewardship of Indigenous Lands

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ABSTRACT

Colleges and universities are creating programs to expand Indigenous student participation. This study reports the backgrounds, experiences, and outcomes of students participating in one such program at the University of Colorado Denver, called Environmental Stewardship of Indigenous Lands (ESIL), that offers an academically transcripted certificate. Applying the principles of Collective Impact, the goal of ESIL is to develop a Community of Practice including Indigenous community representatives, faculty, students, and alumni. This community works to deliver a culturally responsive academic certificate program that combines coursework, workshops, internships, and mentoring. Using evaluation data comprising journey mapping, student surveys, and alumni interviews, we identify seven factors that bring students into the program, three key aspects of their experience within the program, and show that the ESIL program has changed knowledge and attitudes by



providing a safe space for students to engage in Indigenous worldviews within the context of their own academic experiences. These elements advance a positive expansion of science, technology, engineering, and mathematics (STEM) education.

Key words: Indigenous. Native American. Journey Mapping.



GRAPHICAL ABSTRACT

INTRODUCTION

The *Declaration of Native Purpose in Higher Education* calls for colleges and universities to ensure the access, visibility, and success of Indigenous students (American Indian College Fund 2019). One approach, taken at many institutions, is to practice land acknowledgments that recognize First Nations and the Indigenous Peoples on whose land the institutions are built (U.S. Department of Arts and Culture, n.d.). Another approach is to develop programs whose goals are not only to broaden participation by Indigenous students, but to reinvent programs, curricula, and campuses that are student-ready (rather than working to make students college-ready). Stated another way, the goal of these programs is to exercise flexible educational practices (Chee et al., 2019). Some of these programs focus on science, engineering, technology, and mathematics (STEM), which present unique challenges and opportunities.



What are these unique challenges and opportunities? In the context of engineering education, the challenge is to broaden our understanding of engineering to a richer interpretation of public health, safety, and welfare. For example, reporting comments from a panel of engineers convened by the American Society of Civil Engineers (ASCE), Laurie Shuster writes: "The idea that infrastructure and the profession of civil engineering played—and continue to play—a critical role in social, racial, economic, and environmental justice is a relatively new concept for many" (Shuster, 2021). As a second example, engineers developing facial recognition technology have unintentionally created systems that reinforce bias (Swauger, 2020). These are just two of many possible examples from a growing body of evidence that engineering is not neutral, and indeed, engineering is just one example, as this applies throughout STEM careers and disciplines. But, like many challenges addressed by STEM professionals and engineers, these challenges also present opportunities to do better. And, in fact, the challenge to do better is codified in two of the seven engineering student outcomes articulated by the Accreditation Board for Engineering and Technology (ABET), which explicitly call for engineering programs to teach students to consider cultural, social, and environmental factors (Table 1). Another example comes from the American Association for the Advancement of Science (AAAS), which recently committed the Science journals "to publish research that raises awareness of how bias is unintentionally impacting scientific progress in fields such as artificial intelligence, medical device development and climate mitigation strategies" (AAAS, 2022).

Here we present a STEM-based certificate program designed to answer the call in the *Declaration of Native Purpose in Higher Education* and the challenge articulated in ABET's student outcomes. The name of this program is Environmental Stewardship of Indigenous Lands (ESIL, 2021). Before describing the program, however, it is helpful to articulate three key ideas that provide context.

The first idea is that patterns of environmental degradation have impacted and continue to impact tribal communities in North America, reflecting the larger pattern that pollution has disproportionate impacts on underserved communities (*e.g.*, Johnson and Cushing, 2020; Woodruff et al., 2023). For

Outcome 2	Description			
	"Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, <i>as well as global, cultural, social, environmental, and economic factors.</i> " [emphasis added]			
4	"Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions <i>in global, economic, environmental, and societal contexts.</i> " [emphasis added]			



example, during the Cold War, uranium mining on Navajo Nation created a decades-long legacy of health and environmental impacts that has yet to be fully resolved (Miles and Richards, 2019). More recently, the Tsleil-Waututh Nation has resisted a new oil pipeline that risked contamination to a coastal fishery (Spiegel et al., 2020). The list is long (*e.g.*, Hoover et al., 2012; Cantzler and Huynh, 2016) because there are systemic reasons for patterns of environmental degradation. For example, Zuni and Acoma scholars have documented how the structure of the landmark National Environmental Policy Act (NEPA) effectively blocks treaty rights, especially regarding tribal sovereignty (Dongoske et al., 2015).

The second idea is that Indigenous perspectives, and practices of knowledge acquisition and knowledge generation can add value to STEM fields (Rice and Mays, 2022). For example, Indigenous engineering is evident in cultures around the world, such as the water supply and drainage infrastructure of Machu Picchu (Wright et al., 1997) and the hydraulic and agricultural engineering of clam gardens in the Pacific Northwest (Clam Garden Network, 2023). Beyond engineering, case studies illustrate the value of Indigenous knowledge for stewarding caribou with traditional Inupiag hunting methods (Barnhardt and Kawagley, 2005) and stewarding forests with traditional Miwok controlled burns (Jensen, 2020). Some steps have been taken to formally recognize Indigenous knowledges in STEM. For example, the U.S. Environmental Protection Agency called for Indigenous perspectives to support remediation of contaminated sites (Stanislaus, 2017). However, alternative perspectives within STEM are often met with resistance (Mazzocchi, 2006; Mistry and Berardi, 2016; Nicholas, 2018). Many case studies describe practices that prevented Indigenous Peoples from exercising traditional methods of stewardship when they were perceived to conflict with STEM (e.g., in Norwegian fisheries—see Østmo and Law, 2018). Beyond Indigenous knowledge and practices, many other studies have argued for more holistic approaches to groundwater management (Schwartz, 2012), engineering education (Grasso and Burkins, 2010), and STEM professional development (Elmore, 2018). These and related studies document a growing recognition of the need for Indigenous perspectives in STEM.

The third idea is the challenge of bridging professional identity and cultural identity. Using the definitions of Chee et al. (2019), the challenge is to mentor *transcultural* students ("able to engage in two cultures without assimilation") with *bicultural efficacy* ("believing that one can be true to one's ethnic identity and still function in the majority culture"). Most STEM curricula intentionally strive to cultivate professional identity. For example, engineering identity is considered a central goal of engineering education (Atadero et al., 2018; U.S. National Science Foundation, 2020) and has been the subject of numerous studies on engineering formation (*e.g.,* Matusovich et al., 2010; Godwin et al., 2013, Rodriguez et al., 2019). Colleges and universities do not expect students to arrive with an identity as a mathematician, scientist, or engineer,



but they hope that students will graduate with such an identity. Is it possible to cultivate such a professional identity without compromising one's cultural identity? This is not a trivial question. For example, Vanderbilt University engineering education scholar Ebony McGee writes, "In many STEM environments, values like competition, survival of the fittest, meritocracy, individualism, and working to exhaustion are presented as normal" (McGee, 2020, pages 42-43). Taken together, these three ideas—environmental degradation, Indigenous perspectives, and bridging identities—prompted the creation of ESIL.

To place the motivation for this work in the context of previous literature, Tuntivivat et al. (2018) conducted focus groups at five schools near the Navajo Nation. They found that motivational factors included community engagement, linking to traditional practices, and place-based learning. Reo et al. (2017) interviewed 34 tribal and non-tribal professionals working in environmental stewardship near the Great Lakes. They concluded that motivational factors included intergenerational involvement, respect for Indigenous knowledges, and self-determination. These motivational factors are quite different from the norms of individualism (the opposite of community engagement) and abstraction (the opposite of place-based learning) that characterize western STEM practices (Barton et al., 2018; Ressler, 2011). Incidentally, only some of this literature on Indigenous student motivation was authored by Indigenous scholars, suggesting the need for more representation, and therefore the need for ESIL. Against this backdrop, it comes as no surprise that memoirs written by Indigenous students at non-tribal colleges and universities reveal themes of isolation, alienation, or tokenism (Datta, 2018; Gervais et al., 2017; Kesler, 2019; Treuer, 2012). Tokenism, defined as "the policy or practice of making only a symbolic effort" (Merriam-Webster, 2024), is particularly damaging to Indigenous students. For example, Gervais et al. (2017) describe,

"... a feeling of being a 'token Indian,' which can result in an internal conflict where a student wants to advocate for and represent their individual tribes and the larger Native American community, while simultaneously honoring the cultural teaching that it is disrespectful to assume one person, unless designated by that community, can speak on the behalf of others" (page 494).

These factors motivated us to create ESIL, a first-of-its-kind certificate program. ESIL was designed intentionally to address the pattern of environmental degradation that has impacted Indigenous communities of North America (idea 1), to value Indigenous perspectives in STEM (idea 2), and to bridge professional identity and cultural identity (idea 3). The goal of ESIL is to train Indigenous and non-Indigenous STEM students to liaise on environmental issues



between tribal and non-tribal organizations; in parallel, ESIL provides a formative environment for future Indigenous STEM professionals who wish to share their contributions, knowledge, and perspectives to STEM. Increasing the number of Indigenous students engaging in environmental science and engineering (and land stewardship) addresses the needs for protection and prevention of environmental degradation; the creation of ESIL programming as a safe space helps increase opportunity for both shared Indigenous knowledge and active engagement in one's identities.

This paper is structured as follows. We begin with statements on our positionality and our theoretical framework, then provide an overview of the ESIL program. Then we present methods, results, and discussion of a series of instruments created to understand the background, experience, and outcomes of ESIL students. After a statement of limitations, we conclude with a call for other programs aiming to broaden participation in engineering, or more generally in STEM, to consider ESIL as a motivational example.

POSITIONALITY OF THE CO-AUTHORS

The eight co-authors are affiliated with the University of Colorado Denver, a public urban research university with Carnegie classification R1 (very high research activity) located in downtown Denver, Colorado, USA on the ancestral homelands and unceded territories of over 45 Indigenous Nations including the Cheyenne, Arapaho, and Ute Nations. The co-authors include five women, two men, and one nonbinary person; they include four Indigenous and four non-Indigenous co-authors. Among the Indigenous co-authors, tribal affiliations include Diné (Navajo), Lakota, Lumbee, and Mescalero Apache. Among the non-Indigenous co-authors, racial and ethnic identities include Black, Hispanic, and white. The co-authors hold a number of academic positions, including four professors (three tenured and one tenure-track), two graduate students (both of whom earned the ESIL certificate as undergraduates), one senior professional research assistant, and one senior evaluator. They represent a spectrum of academic disciplines, including biology, communication, engineering, environmental sciences, and political science. And they include a former director of American Indian Student Services and a former university Vice Chancellor for Diversity and Inclusion. This background provides the co-authors with a broad spectrum of experiences and perspectives that has informed their collaboration, through ESIL, since its inception. Their perspectives have also been informed by ESIL's internal students and external partners. Fifty percent of co-authors and approximately two thirds of students and partners identify as Indigenous individuals or



citizens of tribal Nations or both, reflecting the program's success at welcoming Indigenous perspectives in STEM.

THEORETICAL FRAMEWORK

The theoretical framework for ESIL comprises two theories of transformation. The first theory is *Collective Impact* (Kania and Kramer, 2011), which argues that collective success requires (1) a common agenda, (2) shared measurement systems, (3) mutually reinforcing activities, (4) continuous communication, and (5) a backbone organization for support. ESIL's application of Collective Impact to Indigenous STEM higher education will be addressed in a separate paper. The second theory is *Community of Practice* (Lave and Wenger, 1991; Wenger, 1998; Wenger et al., 2002; Wenger-Trayner et al., 2015), which argues that learning results when communities gather regularly to work toward a common purpose. For example, Tonso (2006) and Verdin et al. (2018) have investigated how student participation in a Community of Practice emphasizes learning, which in turn calls for a certain degree of humility, admitting that the knowledge and skills of ESIL faculty have increased during the years since the first cohort of ESIL students began in the fall semester of 2018.

PROGRAM OVERVIEW

ESIL trains students to liaise on environmental issues between tribal and non-tribal organizations. ESIL's mission is "to broaden participation of students in STEM through education and community partnerships that promote healing and stewardship of Native land" (ESIL, 2021).

ESIL is open to Indigenous and non-Indigenous students, engineering and non-engineering students, and STEM and non-STEM students at any level including bachelor's, master's, doctoral, and non-degree-seeking (for example postbaccalaureate students). Layering ESIL on top of traditional STEM and non-STEM degree programs provides flexibility, welcoming students from any academic interest, and allows the program to be launched and sustained without the more significant funding required, for example, by a new academic department. The first cohort of seven students began in Fall 2018, including five self-identified Indigenous students and six female students. By Spring 2023, the ESIL program had eight active students and eight alumni.

The ESIL certificate was created through an intentional process of outreach and collaboration with non-university partners representing tribal and public sector agencies. Most of these



1.	Enrollment in the ESIL program.
2.	Participation in ESIL workshops.
3.	Completion of at least one ESIL internship.
4.	Completion of the following courses: ^{1,2,3}
	a. Mathematics or Geography (Choose One Course)
	MATH 2830 Statistics
	GEOG 4080 Introduction to Geographic Information Systems (GIS)
	b. Indigenous Studies (Choose Two Courses)
	COMM 3271 Communication and Diversity
	ETST 3036 American Indian Cultural Images
	ETST 3110 Indigenous Studies
	MGMT 4100 Leveraging Diversity and Inclusion in Business
	PSCI 3214 Federal Law and American Indians
	PSCI 4144 Indigenous Political Systems
	PSCI 4146 Indigenous Politics
¹ Th ² Str ³ Al GE	these courses are in addition to the regular STEM major requirements. udents also complete prerequisites as stated in the University course catalog. bbreviations COMM = Communication; ETST = Ethnic Studies; COG = Geography; MATH = Mathematics and Statistics; CMT = Management; and PSCI = Political Science

external partners are Indigenous individuals and STEM professionals. Months before welcoming the first student, ESIL welcomed these external partners to a series of professionally moderated in-person and remote meetings, the first of which was held at the University of Colorado Denver in April 2018. In subsequent months and years, ESIL welcomed the partners back for additional in-person meetings and traveled to visit them in southern Colorado and central Wyoming. This collaboration was vital for creating the ESIL certificate and is important for its continuous evolution.

The ESIL certificate requires a combination of coursework, workshops, and an internship experience with an external partner (Table 2). This combination, especially the contributions of external partners, exemplifies the theory of Collective Impact. Regarding curriculum, to provide a common technical foundation relevant to environmental stewardship, the coursework requirement includes at least one course in statistics or geographic information systems (GIS); to provide a common cultural foundation relevant to Indigenous lands, the coursework requirement includes a least two courses in Indigenous studies. Monthly workshops bring students, faculty, and external partners together to explore a rich spectrum of topics comprising history, law, communication, and professional development (Mays et al., 2025). And finally, internships with an external partner provide an opportunity for each student to liaise on environmental issues between tribal and non-tribal organizations. For example, one ESIL internship, hosted at an Indigenous-serving college, provided experience working on environmental microbiomes



from an Indigenous perspective; another ESIL internship, hosted by a technology company, provided experience working as a liaison between a private company and an Indigenous Nation. In all cases, the internship provided an opportunity for each ESIL student to put their academic and non-academic training into practice.

As a Community of Practice, ESIL recognizes that it is essential to have continuous communication and ongoing collaboration between students, faculty, and staff, which is a frequently expressed sentiment among students (Tinto, 2012). To support this continuous communication, ESIL provides extensive one-on-one mentoring. But ESIL goes beyond student mentoring, reaching out proactively to build relationships with the university offices where ESIL students are likely to interact, such as admissions, financial aid, coursework advising, and support services such as tutoring, writing, resume development, and job seeking. The goal is to build relationships across campus to foster a community of support for ESIL students. Beyond these academic aspects of engineering education (and STEM education), ESIL mentors provide additional support in bridging professional identity and cultural identity within and outside of higher education.

METHODS

The impacts and effectiveness of the ESIL certificate have been evaluated by a team of professional program evaluators using methods described by Velez et al. (2022). Program evaluation comprised journey mapping, student surveys, and alumni interviews. The evaluation was grounded in the Indigenous evaluation framework (American Indian Higher Education Consortium, 2009; LaFrance, 2004; LaFrance and Nichols, 2010). This approach ensured the evaluation and evaluators would uphold the commitment to relationships and reciprocity. Narrative inquiry was foundational to collecting data that were meaningful and relevant to students' experiences; methods included storytelling and written reflections. Evaluators conducted narrative analysis using an inductive approach to discern major themes and findings from deidentified interview transcripts and written reflections. With this approach, themes emerged from the raw data rather than using preconceived codes (Creswell and Poth, 2018). Methods were reviewed by the Colorado Multiple Institutional Review Board, which provided a Certificate of Exemption (Protocol 18-0133).

Journey mapping (Meyer and Marx, 2014) is a technique that combines storytelling and visualization; it is useful in identifying and describing participant needs, complex problems, and potential solutions. All ESIL students who self-identified as Indigenous and were active in



ESIL's first two years of activities in 2018/19 and 2019/20 were invited to participate in journey mapping. During individual one-on-one sessions, an interviewer asked each student the openended question, "In thinking about your journey to higher education, what have been key events or people that helped guide you along this path?" Students then prepared their journey maps using drawings or words, as they preferred. As a final step, the interviewer asked each student to narrate their maps to better understand their stories. In 2019, journey mapping was intended as a culturally relevant method to facilitate storytelling. However, when the second round of journey mapping was conducted in 2020, public health restrictions due to COVID-19 prohibited meeting in person. Facilitating a journey mapping session via video conference proved cumbersome and less conducive to conversation. As such, visualization was not a useful tool in the second round of data collection. However, students did share their stories about the factors that most facilitated their success in their journey to and in higher education. Three students provided journey maps in 2019 (50% response rate), and three additional students provided journey maps in 2020 (38% response rate). Including 5 minutes of introduction and approximately 10 minutes of quiet, personal reflection and drawing that occurred immediately prior to storytelling, sessions ranged from 30 to 73 minutes with an average of 50 minutes. Each journey mapping session was audio recorded (with permission) and transcribed verbatim using a professional service. Evaluators conducted quality checks of all transcripts by comparing them to the audio files. Responses were deidentified before sharing with the other co-authors, which mitigated, at least in part, the risk of students censoring their reflections because they know the co-authors.

Student surveys (Table 3) were designed to engage ESIL students in order to understand program impact, confidence in skills and knowledge, helpfulness of program components, and institutional connectedness. According to the literature, students who feel social support (e.g., peer support and mentorship) and connectedness to the institution (i.e., positive perception of university) are less likely to leave and are key factors that influence persistence and retention (Gloria et al., 2001; Manson, 2009; Tinto, 1994). The survey included both quantitative and qualitative questions, the former using a five-point Likert scale, the latter using free responses. Surveys were provided to all ESIL students via email, response rates were calculated (Table 4), and results were deidentified (Velez et al., 2022).

Finally, in April 2023, evaluators also conducted alumni interviews with four of the eight ESIL graduates (response rate, 50%). The purpose of the interviews was to learn about the long-term impact that ESIL had on students who participated in the program. Knowledge gained from the interviews provided the ESIL leadership with important insight on the value that the program brings



Table 3. Survey questions and average responses		
(a) Program Impact (Figure 1)		
On a scale of 1 to 5, students felt that ESIL:	Average	Legend
Is a good use of time	4.85 ± 0.04	worthwhile
Provided opportunities to connect with Indigenous students	4.68 ± 0.13	students
They were becoming part of the ESIL community	4.52 ± 0.04	community
Provided opportunities to connect with Indigenous professionals	4.50 ± 0.09	professionals
Increased awareness of STEM careers serving tribal communities	4.43 ± 0.10	careers
(b) Confidence in Liaison Skills (Figure 2)		
On a scale of 1 to 5, students were confident in their skills:	Average	Legend
Self-reflecting	4.56 ± 0.09	reflection
Comfort with people who come from different tribes	4.40 ± 0.10	difference
Pushing yourself outside your comfort zone	4.40 ± 0.07	comfort
Leadership	4.24 ± 0.07	leadership
Developing trust with different communities	4.01 ± 0.11	trust
Communicating according to audience and circumstance	3.95 ± 0.09	communication
Negotiating/conflict resolution	3.74 ± 0.11	negotiation
(c) Confidence in Background Knowledge (Figure 3)		
On a scale of 1 to 5, students were confident in their knowledge:	Average	Legend
		•
Historical tribal pain/trauma	4.08 ± 0.07	trauma
Historical tribal pain/trauma Relationship between federal, state and tribal governments	4.08 ± 0.07 3.82 ± 0.15	trauma governments
Historical tribal pain/trauma Relationship between federal, state and tribal governments Tribal sovereignty and governance	$\begin{array}{c} 4.08 \pm 0.07 \\ 3.82 \pm 0.15 \\ 3.29 \pm 0.29 \end{array}$	trauma governments self-determination
Historical tribal pain/trauma Relationship between federal, state and tribal governments Tribal sovereignty and governance (d) Program Components (Figure 4)	$\begin{array}{c} 4.08 \pm 0.07 \\ 3.82 \pm 0.15 \\ 3.29 \pm 0.29 \end{array}$	trauma governments self-determination
 Historical tribal pain/trauma Relationship between federal, state and tribal governments Tribal sovereignty and governance (d) Program Components (Figure 4) On a scale of 1 to 5, how helpful were the following components? 	4.08 ± 0.07 3.82 ± 0.15 3.29 ± 0.29 Average	trauma governments self-determination Legend
 Historical tribal pain/trauma Relationship between federal, state and tribal governments Tribal sovereignty and governance (d) Program Components (Figure 4) On a scale of 1 to 5, how helpful were the following components? ESIL internship 	4.08 ± 0.07 3.82 ± 0.15 3.29 ± 0.29 Average 4.72 ± 0.12	trauma governments self-determination Legend internships
 Historical tribal pain/trauma Relationship between federal, state and tribal governments Tribal sovereignty and governance (d) Program Components (Figure 4) On a scale of 1 to 5, how helpful were the following components? ESIL internship ESIL workshops and guest speakers 	4.08 ± 0.07 3.82 ± 0.15 3.29 ± 0.29 Average 4.72 ± 0.12 4.68 ± 0.20	trauma governments self-determination Legend internships workshops
 Historical tribal pain/trauma Relationship between federal, state and tribal governments Tribal sovereignty and governance (d) Program Components (Figure 4) On a scale of 1 to 5, how helpful were the following components? ESIL internship ESIL workshops and guest speakers Mentoring by ESIL program advisors 	4.08 ± 0.07 3.82 ± 0.15 3.29 ± 0.29 Average 4.72 ± 0.12 4.68 ± 0.20 4.49 ± 0.18	trauma governments self-determination Legend internships workshops mentoring
Historical tribal pain/trauma Relationship between federal, state and tribal governments Tribal sovereignty and governance (d) Program Components (Figure 4) On a scale of 1 to 5, how helpful were the following components? ESIL internship ESIL workshops and guest speakers Mentoring by ESIL program advisors ESIL program curriculum	4.08 ± 0.07 3.82 ± 0.15 3.29 ± 0.29 Average 4.72 ± 0.12 4.68 ± 0.20 4.49 ± 0.18 4.40 ± 0.12	trauma governments self-determination Legend internships workshops mentoring classwork
 Historical tribal pain/trauma Relationship between federal, state and tribal governments Tribal sovereignty and governance (d) Program Components (Figure 4) On a scale of 1 to 5, how helpful were the following components? ESIL internship ESIL workshops and guest speakers Mentoring by ESIL program advisors ESIL program curriculum (e) Institutional Connectedness (Figure 5) 	4.08 ± 0.07 3.82 ± 0.15 3.29 ± 0.29 Average 4.72 ± 0.12 4.68 ± 0.20 4.49 ± 0.18 4.40 ± 0.12	trauma governments self-determination Legend internships workshops mentoring classwork
 Historical tribal pain/trauma Relationship between federal, state and tribal governments Tribal sovereignty and governance (d) Program Components (Figure 4) On a scale of 1 to 5, how helpful were the following components? ESIL internship ESIL workshops and guest speakers Mentoring by ESIL program advisors ESIL program curriculum (e) Institutional Connectedness (Figure 5) On a scale of 1 to 5, students agreed: 	4.08 ± 0.07 3.82 ± 0.15 3.29 ± 0.29 Average 4.72 ± 0.12 4.68 ± 0.20 4.49 ± 0.18 4.40 ± 0.12 Average	trauma governments self-determination Legend internships workshops mentoring classwork Legend
Historical tribal pain/trauma Relationship between federal, state and tribal governments Tribal sovereignty and governance (d) Program Components (Figure 4) On a scale of 1 to 5, how helpful were the following components? ESIL internship ESIL workshops and guest speakers Mentoring by ESIL program advisors ESIL program curriculum (e) Institutional Connectedness (Figure 5) On a scale of 1 to 5, students agreed: There is at least one mentor on campus that I can talk to	4.08 ± 0.07 3.82 ± 0.15 3.29 ± 0.29 Average 4.72 ± 0.12 4.68 ± 0.20 4.49 ± 0.18 4.40 ± 0.12 Average 4.81 ± 0.08	trauma governments self-determination Legend internships workshops mentoring classwork Legend mentored
Historical tribal pain/trauma Relationship between federal, state and tribal governments Tribal sovereignty and governance (d) Program Components (Figure 4) On a scale of 1 to 5, how helpful were the following components? ESIL internship ESIL workshops and guest speakers Mentoring by ESIL program advisors ESIL program curriculum (e) Institutional Connectedness (Figure 5) On a scale of 1 to 5, students agreed: There is at least one mentor on campus that I can talk to I feel valued by those with whom I interact most frequently	4.08 ± 0.07 3.82 ± 0.15 3.29 ± 0.29 Average 4.72 ± 0.12 4.68 ± 0.20 4.49 ± 0.18 4.40 ± 0.12 Average 4.81 ± 0.08 4.54 ± 0.07	trauma governments self-determination Legend internships workshops mentoring classwork Legend mentored valued
Historical tribal pain/trauma Relationship between federal, state and tribal governments Tribal sovereignty and governance (d) Program Components (Figure 4) On a scale of 1 to 5, how helpful were the following components? ESIL internship ESIL workshops and guest speakers Mentoring by ESIL program advisors ESIL program curriculum (e) Institutional Connectedness (Figure 5) On a scale of 1 to 5, students agreed: There is at least one mentor on campus that I can talk to I feel valued by those with whom I interact most frequently I have been able to connect with a group of peers like me	4.08 ± 0.07 3.82 ± 0.15 3.29 ± 0.29 Average 4.72 ± 0.12 4.68 ± 0.20 4.49 ± 0.18 4.40 ± 0.12 Average 4.81 ± 0.08 4.54 ± 0.07 4.38 ± 0.08	trauma governments self-determination Legend internships workshops mentoring classwork Legend mentored valued connected
Historical tribal pain/trauma Relationship between federal, state and tribal governments Tribal sovereignty and governance (d) Program Components (Figure 4) On a scale of 1 to 5, how helpful were the following components? ESIL internship ESIL workshops and guest speakers Mentoring by ESIL program advisors ESIL program curriculum (e) Institutional Connectedness (Figure 5) On a scale of 1 to 5, students agreed: There is at least one mentor on campus that I can talk to I feel valued by those with whom I interact most frequently I have been able to connect with a group of peers like me I am treated with as much respect as my classmates	$\begin{array}{c} 4.08 \pm 0.07 \\ 3.82 \pm 0.15 \\ 3.29 \pm 0.29 \\ \hline \\ \textbf{Average} \\ \hline \\ 4.72 \pm 0.12 \\ 4.68 \pm 0.20 \\ 4.49 \pm 0.18 \\ 4.40 \pm 0.12 \\ \hline \\ \textbf{Average} \\ \hline \\ \textbf{4.81 \pm 0.08} \\ 4.54 \pm 0.07 \\ 4.38 \pm 0.08 \\ 4.18 \pm 0.23 \\ \hline \end{array}$	trauma governments self-determination Legend internships workshops mentoring classwork Legend mentored valued connected respected
Historical tribal pain/trauma Relationship between federal, state and tribal governments Tribal sovereignty and governance (d) Program Components (Figure 4) On a scale of 1 to 5, how helpful were the following components? ESIL internship ESIL workshops and guest speakers Mentoring by ESIL program advisors ESIL program curriculum (e) Institutional Connectedness (Figure 5) On a scale of 1 to 5, students agreed: There is at least one mentor on campus that I can talk to I feel valued by those with whom I interact most frequently I have been able to connect with a group of peers like me I am treated with as much respect as my classmates My classwork challenges are different from my classmates'	4.08 ± 0.07 3.82 ± 0.15 3.29 ± 0.29 Average 4.72 ± 0.12 4.68 ± 0.20 4.49 ± 0.18 4.40 ± 0.12 Average 4.81 ± 0.08 4.54 ± 0.07 4.38 ± 0.08 4.18 ± 0.23 4.09 ± 0.13	trauma governments self-determination Legend internships workshops mentoring classwork Legend mentored valued connected respected classwork
Historical tribal pain/trauma Relationship between federal, state and tribal governments Tribal sovereignty and governance (d) Program Components (Figure 4) On a scale of 1 to 5, how helpful were the following components? ESIL internship ESIL workshops and guest speakers Mentoring by ESIL program advisors ESIL program curriculum (e) Institutional Connectedness (Figure 5) On a scale of 1 to 5, students agreed: There is at least one mentor on campus that I can talk to I feel valued by those with whom I interact most frequently I have been able to connect with a group of peers like me I am treated with as much respect as my classmates My classwork challenges are different from my classmates' I feel proud to be associated with the University of Colorado	$\begin{array}{c} 4.08 \pm 0.07 \\ 3.82 \pm 0.15 \\ 3.29 \pm 0.29 \\ \hline \\ \textbf{Average} \\ \hline \\ 4.72 \pm 0.12 \\ 4.68 \pm 0.20 \\ 4.49 \pm 0.18 \\ 4.40 \pm 0.12 \\ \hline \\ \textbf{Average} \\ \hline \\ \textbf{Average} \\ \hline \\ \textbf{4.81 \pm 0.08} \\ 4.54 \pm 0.07 \\ 4.38 \pm 0.08 \\ 4.18 \pm 0.23 \\ 4.09 \pm 0.13 \\ 4.04 \pm 0.24 \\ \hline \end{array}$	trauma governments self-determination Legend internships workshops mentoring classwork Legend mentored valued connected respected classwork pride



Year	Invitations	Responses	Rat
2019	8	5	63%
2020	15	11	73%
2021	15	8	53%
2022	9	5	56%
2023	8	7	88%

to student growth and their long-term career goals. These data also were key to identifying what knowledge and skills ESIL could provide in the future.

RESULTS

The evaluation data revealed rich and multidimensional information on the background, experience, and outcomes of ESIL students. While each student shared unique stories, there were clear themes in their responses concerning the factors that supported their success. During the first round of journey mapping in 2019, analysis revealed five factors supporting pathways into higher education. The first factor was being selected and participating in youth development programs. Students reported that youth development programs served as a support network of people who helped them successfully gain admission to and build skills necessary to pursue higher education. For example, one student recalled a youth development program that included a project about Philip Johnston. "In the middle of World War II, we were getting our codes broken by the Japanese every time they developed a new one in English. He was the one that suggested using the Navajo language... These historical things really bring pride to [our] community. We're not just some tiny town. We have history, and we can still be making history." Another student recalled being in a program that engaged her in research and taught her skills at an early age. "My instructor taught us how to gather information, research certain topics, and put together a PowerPoint presentation. We went to Native American focused conferences to give our presentations. We were little kids. We were scared but did it anyway. That was cool to me." The second factor was having a support network including peers, mentors, teachers, community members, and family. Some members of the support network were also role models. Those in the support network played different roles; some provided emotional support while others provided academic support. As one



student described, "I had some really good coaches growing up. They never let anything slide and really taught me a lot of discipline and leadership. I felt like I was always put into that leadership role. That taught me a lot about how to just manage a team and be a team player. ... I know it's hard to find a job where you're not working in a team setting." The third factor was discovering early the relationship between people, the land, and science. One student described a visit to their native land, seeing a beautiful but polluted lake surrounded by volcanoes. "Seeing the pollution and the green algae that was coming out of the water inspired me to go into something having to do with environmental sciences." Another said, "[After hearing a CU Denver leader] discuss the Dakota Pipeline and introduce the ESIL program, my eyes just lit up listening to her talk about everything. Because I knew I had wanted to do something in the Indigenous communities." The fourth factor was access to financial means to attend college. Students described how grants and scholarships helped motivate them to do well in school and continue their education. On this point, one student commented, "My mom helped me with the FAFSA and everything and I was able to get Pell grants to go to school, so I was like, 'Ooh, nice I have money, so I might as well keep going to school.' That was another big reason for me." The fifth factor was **campus visits**, a literal pathway into higher education. Students shared that visiting a college campus influenced their decision and, in some cases, boosted their confidence to go to college.

During the second round of journey mapping in 2020, two additional themes emerged, (6) **aspirations** and (7) **perseverance**. Perhaps reflecting the online format of the journey mapping interview in 2020, which prevented graphical sketching, these additional themes reflect attitudes and personality traits rather than the specific steps identified in the previous round of journey mapping. Under the theme of aspirations, students spoke of their personal motivations to engage in learning and pursuing higher education. They each expressed an innate desire to continue their studies even in the face of poor access to opportunities and educational environments that were not welcoming: "People make assumptions about who I am, what I am interested in, where I come from. I wanted to prove that I can do whatever I want." Under the theme of perseverance, students talked about the resources and supports most salient to them. To access resources, one student described how significant it is to be welcomed and talk to someone who is relatable.

Results from the student surveys include quantitative and qualitative components. Quantitative results are presented in Table 3 and Figures 1-5. Turning first to survey results on program impact (Figure 1), students agreed with each of the prompts, with all averages between "agree" (4) and "highly agree" (5) on the five-point Likert scale. The top-rated statement is that ESIL students found the program to be a good use of their time, with an average rating (out of 5) of 4.85 ± 0.04 .



For survey results on confidence with liaison skills (Figure 2), students were confident with five of the seven prompts, where averages fell between "confident" (4) and "highly confident" (5). The highest confidence was for the skill of self-reflection with an average of 4.56 ± 0.09 ; the lowest confidence was for the skill of negotiation and conflict resolution with an average of 3.74 ± 0.11 . In contrast to their higher confidence with liaison skills, students reported generally lower confidence with background knowledge (Figure 3), with two of the three prompts showing averages between



Figure 2. Student survey results on confidence with liaison skills. Responses used a five-point Likert scale from highly unconfident (1) to highly confident (5); averages and standard errors are reported in Table 3.





"neutral" (3) and "confident" (4). Students were most confident in their knowledge of historical tribal pain/trauma with an average of 4.08 \pm 0.07; students were least confident with their knowledge of tribal sovereignty and governance with an average of 3.29 \pm 0.13.

The two remaining sections of the student survey addressed four components of the ESIL certificate program and students' feelings of institutional connectedness. Regarding the ESIL program (Figure 4), students reported that all four components were helpful with average ratings between "helpful" (4) and "strongly helpful" (5). Among the four components of internships, workshops, mentoring, and classwork, the highest-rated component was internships with an average of $4.72 \pm$ 0.12. Results were somewhat lower for feelings of institutional connectedness (Figure 5), but with one exception, they still fell in the range of "agree" (4) to "strongly agree" (5). The highest-rated prompt was, "There is at least one mentor on campus that I can talk to," with an average of 4.81 ± 0.08, reinforcing Tinto's (2012) finding that students need support. The lowest-rated prompt, and the only one falling in the range of "neutral" (3) to "agree" (4) was, "I stayed connected to my college community with COVID-19," with an average of 3.70 ± 0.29. Concerningly, feelings of connectedness vis-à-vis COVID-19 appear to show a downward trend, with students feeling less connected during the three times this question was presented in 2020, 2022, and 2023 (although we make no claim of a statistically significant trend due to our small sample size). This finding indicates that, at least for ESIL students, there is continuing impact from the COVID-19 pandemic. To summarize these quantitative results, student responses averaged between "agree" and "strongly agree" for all questions under program impact (Figure 1), five of seven questions under confidence in liaison



skills (Figure 2), one of three questions under confidence in background knowledge (Figure 3), all questions under program components (Figure 4), and six of seven questions under institutional connectedness (Figure 5). For the five questions that were exceptions, student responses averaged between "neutral" and "agree." Taken together, the quantitative results suggest that ESIL is successfully training students to liaise between tribal and non-tribal organizations.



Figure 5. Student survey results on institutional connectedness. Responses used a five-point Likert scale from strongly disagree (1) to strongly agree (5); averages and standard errors are reported in Table 3. The question on COVID-19 did not appear in the 2019 survey, and none of these data were collected in the 2021 student survey.



The qualitative survey items brought out three common themes, the first of which was relationships. Students expressed that they learned about the importance of building relationships and how communication was a key component in relationship building. Students shared how they began to understand the different perspectives involved in environmental work and diverse ways of communicating with people from diverse backgrounds. For instance, one student stated, "My biology teacher in community college was a graduate of CU. Talking with him and his interest my studies were reasons I chose CU Denver." When asked about how ESIL related to their major, career plans, or future academic training, another student responded, "Descriptions of effective strategies to foster partnership are very valuable to expanding my own knowledge and perspectives."

The second theme from the qualitative survey is the role of context. Students began to share how their approach to their future career and potential tribal liaison position had started to form and shift. For instance, one student stated, "There has to be a deeper reason for what you do in your career, the reason has to be for others and not just yourself." Another student shared that they started to have a better understanding of "The complexity of reconciling traditional Indigenous values with environment and other related work." Responses reveal how students are thinking more deeply about what a career as a tribal liaison could look like, including both challenges and opportunities. Students also articulated coming to a greater understanding of the importance of tribal relations and the historical context in which these play out.

The third theme that emerged consistently was the importance of mentorship and professional development built into the ESIL program: "I was really lost but [my mentor] helped me figure out what I needed and gave me the resources. She makes time and follows up." Students learned about numerous ways to get involved and about the careers that exist in the field of environmental protection and tribal affairs. The students were very appreciative of the way faculty supported and checked in with them. They were happy for having Indigenous representation among faculty and partners; people were there to show them that they can go into STEM. Students spoke about pursuing careers in STEM, wanting to learn more, and suggested expanding mentoring opportunities, such as pairing a student with a tribal liaison. To summarize these qualitative results, student responses emphasized the importance of two key themes required as background to liaise between tribal and non-tribal organizations, (1) relationships and (2) context. Students also pointed to the importance of mentorship and professional development as components of the ESIL program.

Alumni were overwhelmingly positive about their time in the ESIL program and expressed gratitude to have participated in such a unique and valuable opportunity. Alumni mentioned how pivotal the program was in building community and making them feel welcome as students. One interviewee mentioned how the ESIL program helped them strengthen bonds with other Indigenous students and faculty; they believe these bonds will form lifelong friendships. Another interviewee expressed



how impactful it was to work and study alongside people with whom they could identify. The support and community provided through the program was invaluable: "Having the ESIL community ... was so impactful for me. I didn't really make connections during my undergrad outside of ESIL because [of] the pandemic. I was really isolated. ESIL always felt like this incredible place where I knew everyone cared about each other and I could come be with people." In addition to community building, alumni mentioned that the program helped them discover their interests and led them to more opportunities post-graduation. They described how the internship, workshops, and classes provided foundational knowledge and gave them a preview of this work beyond the classroom.

DISCUSSION

The literature offers several strategies for colleges and universities to broaden participation of Indigenous communities, entities, students, and faculty specifically in engineering and broadly in STEM. These include but are not limited to: family support, academic advisors, and student cohorts (Allaire, 2019); mentoring (Chelberg and Bosman, 2020); cultural humility (Chikkatur and Valle, 2023; de la Garza, 2021); and *Wayfinding* (an approach to navigating non-tribal colleges and universities—see Page-Reeves et al., 2019). This paper proposes a new strategy: To develop a Community of Practice, organized through the framework of Collective Impact, that delivers culturally responsive academic programming. In the case of ESIL, this academic programming is a certificate combining coursework, workshops, internships, and mentoring. Most importantly, ESIL is an academic program designed to acknowledge the limitations of current training in STEM higher education while creating a space for students to engage within their identities.

What makes ESIL unique? To our knowledge, ESIL is the first undergraduate and graduate certificate program with the specific goal to train STEM majors to liaise on environmental issues between tribal and non-tribal organizations. To accomplish this goal, ESIL brings together four elements. First, the program incorporates Indigenous principles, values, and decision making; many ESIL faculty and partners are themselves Indigenous STEM professionals. Second, and perhaps unusually for college certificate programs, ESIL has a solid base of Indigenous partners in the "real world;" in surveys, students say it was important for them to learn from Indigenous people beyond the university involved in practicing their careers in contexts in which they can see themselves in the future after graduating. Third, following on the theme of going beyond academic content, ESIL further facilitates student success by establishing an internship component of the certificate program. These internships play a central role because they provide students with an opportunity to actually practice working as a tribal liaison with an external partner; this central role is reflected in the students' survey responses



where internships were the most highly rated of the four components of the ESIL certificate. And fourth, ESIL has benefitted from a change in perspective, stemming from our Community of Practice, to view students not primarily as clients but rather as partners. To elaborate on this point, the program began with extensive conversations between faculty and external Indigenous partners, but those conversations did not yet include students. Once the program was up and running, we began collecting assessment data from students, and one emergent theme was the importance of safe space for Indigenous voices, experiences, and ways of knowing. These assessment data changed our perspective to include faculty, partners, *and* students; this change in perspective highlights the benefit of working through a Community of Practice, where we learn by gathering regularly to work toward a common purpose. This change in perspective also re-envisions Collective Impact in academic contexts by including students in the discussion.

To recapitulate the results: What factors bring students into the ESIL program? Many exist, and some of them begin long before students enter higher education. Journey mapping indicates that both external and internal factors are important. External factors that are common elements for broadening participation include: Youth development programs, college visits, and financial support. Examples of internal factors are passion, aspiration, and perseverance. How do students experience the ESIL program? Students gain skills and knowledge, reporting more confidence in certain areas, and less confidence in others (Figures 2-3). Mentorship through ESIL goes beyond traditional student:advisor mentoring, providing additional organic opportunities for mentoring, e.g., student:student through gatherings; student:partner through workshops, and student:employer through internships. And the breadth of experiences, activities, and topics on which students engage within ESIL build on relationships, mentoring, and context; these factors are obviously relevant to the work of a tribal liaison, but not emphasized in standard STEM curricula. The key themes identified by ESIL students-serving community, building relationships, and respecting tradition-reiterate the motivations of other Indigenous students (Reo et al., 2017; Tuntivivat et al., 2018). Moreover, these key themes are fully coherent with those identified by Indigenous STEM faculty (Brown et al., 2022). This coherence amplifies the importance of diversifying the professorate.

ESIL strives to provide a safe and nurturing environment for future Indigenous STEM professionals who wish to share their contributions, traditional knowledge, and perspectives to STEM. This is evident when ESIL students say they are most confident in their skills around self-reflection, leadership, and pushing outside their comfort zone; and when students say the ESIL experiences help them think deeply about their social position and how they can interact with issues affecting their communities. Creating a more welcoming STEM environment is not merely an addendum to a primary focus on workforce development. On the contrary, creating a welcoming environment is the first step for anyone aiming to broaden participation in



STEM. On the one hand, we have heard from our own students that the experience of studying STEM in college does not always feel welcoming; on the other hand, we have heard from our Indigenous partners that it is possible to be both a STEM professional and an Indigenous person. The results presented here document that the ESIL program has been effective in encouraging students to develop an understanding of Indigenous worldviews. Concurrently, the ESIL program has initiated a positive expansion of the STEM experience, where all knowledge is safe, and nothing is discarded or corrupted for the institution's purposes. The process is not easy, fast, or complete. However, it is well worth the effort because it allows students to see themselves within academia and within the practice of STEM, noting that many of these students will develop careers with organizations that may engage only with standard STEM. ESIL can provide skills and approaches for students, not only to navigate these organizations, but to implement change.

LIMITATIONS

Readers should consider at least two limitations in the work presented here. First, being a new program, the number of ESIL students is still small, with only eight alumni by the end of 2022/23. This small population limits the potential benefit of quantitative analysis. Second, like many programs, ESIL was impacted by several external factors, most importantly, the global COVID-19 pandemic that temporarily suspended ESIL's practice of in-person gatherings, workshops, and field trips. The results reported here should be interpreted in light of these external factors.

CONCLUSIONS

This paper has provided an overview of the ESIL certificate program at the University of Colorado Denver. ESIL was created to address three ideas: (1) the pattern of environmental degradation that has impacted Indigenous communities of North America, (2) the need to value Indigenous perspectives in STEM, and (3) the need to bridge professional identity and cultural identity. ESIL provides a case study of a program, designed to answer the call for action in the *Declaration of Native Purpose in Higher Education* (American Indian College Fund, 2019), that combines coursework, workshops, internships, and mentoring; developed in partnership with community representatives through the framework of Collective Impact; and delivered adaptively as a Community of Practice. Through the unique aspects discussed above—celebrating Indigenous principles, connecting STEM to the real world, collaborating with external partners



for internships, and centering student partnership—we have attempted to make college fit students, not vice versa. We offer this case study as a model strategy to advance programs, create new curricula, and commit to a more welcoming campus.

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Fitting College to Students (not Vice Versa): A Certificate Program on Environmental Stewardship of Indigenous Lands

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