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Culturally-based Ethical Barriers for American Indian/Alaska Native Students and Professionals in Engineering

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Jani C. Ingram, PhD investigates environmental contaminants with respect to their impact on health. A major part of her research is focused on characterizing uranium and arsenic contamination in water, soil, plants and livestock. A critical aspect of her research is to foster collaborations with the Native American community and leaders to build trust, obtain access to field samples and gain insights into their health concerns. Recruiting Native American students to work with her as a Navajo principal investigator on the project and building an interdisciplinary, collaborative team of scientists with expertise in analytical chemistry, geoscience, cancer biology, and social sciences are also important to her research. She is a member of the Navajo Nation (born to the Náneesh' ézhi clan) and is involved in outreach activities for Native American students in undergraduate and graduate research. She is the principal investigator of the Partnership for Native American Cancer Prevention and the director of the Bridges to Baccalaureate program. She was named the 2018 recipient of the American Chemical Society Award for Encouraging Disadvantaged Students into Careers in the Chemical Sciences. She received an associate degree from Yavapai College, a bachelor of science degree in chemistry from New Mexico State University, and a doctoral degree in chemistry from the University of Arizona. She was a staff scientist at the Idaho National Laboratory for twelve years before joining the faculty at Northern Arizona University.

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Abstract:

Prior research suggests various reasons for the paucity of American Indian/Alaska Native (AI/AN) people in engineering fields, including academic deficiencies, lack of role models, and minimal financial support to pursue a college education. One potential reason that has yet to be explored relates to the cultural and spiritual barriers that could deter AI/AN people from feeling a sense of belonging in engineering fields. These barriers may create obstacles to progressing through engineering career pathways. Our research investigates the range and variation of cultural/spiritual/ethical issues that may be affecting AI/AN people's success in engineering and other science, technology, and mathematics fields. The work reported here focuses on findings from students and professionals in engineering fields specifically. The study seeks to answer two research questions: (1) What ethical issues do AI/AN students and professionals in engineering fields experience, and how do they navigate these issues?, and (2) Do ethical issues impede AI/AN students from pursuing engineering careers, and if so, how? We distributed an online survey to AI/AN college students (undergraduate and graduate) and professionals in STEM fields, including engineers, in the western United States region. Our results indicate strong connections to AI/AN culture by the participants in the study as well as some cultural, ethical, and/or spiritual barriers that exist for AI/AN individuals in the engineering field. The AI/AN professionals had less concerns with respect to activities that may conflict with AI/AN cultural customs compared to the students, which may be a result of the professionals having gained experiences that allow them to navigate these situations. Overall, our research offers insights for policy and practice within higher education institutions with engineering majors and/or graduate programs and organizations that employ engineering professionals.

Introduction

Facing a unique combination of cultural and socio-economic barriers, American Indians/Alaska Natives (AI/ANs) are the most underrepresented racial/ethnic group in Science, Technology, Engineering, and Mathematics (STEM) in the United States (U.S.). The proportion of AI/AN students drops dramatically at each higher level of degree attainment. The drop in AI/AN students in STEM has resulted in substantial disparities in the number of scientists and engineers of AI/AN background, and a scientific and engineering workforce that has correspondingly low representation within tribal communities. Native Americans^a are the *most* underrepresented ethnic group in biomedical and behavioral sciences [1]. According to the National Center for Education Statistics (NCES), the overall percentage of baccalaureate degrees obtained by AI/AN undergraduates has decreased from 2009 at 0.68 to 0.34 percent of the entire U.S. population in 2018 [2]. This is not surprising as there has been a decrease in STEM degrees awarded to Native American students since 2008, as shown in Figure 1. Obstacles contributing to the low retention and graduation rates for AI/AN students, in general, have been studied [3], [4], [5], [6]; these include inadequate academic preparation; cultural differences; vague constructs of educational or

^a In this paper, AI/AN, Indigenous, and Native American are used interchangeably. These terms are used in different cultures to denote peoples who are indigenous to the land.

vocational goals; insufficient financial aid; discrepancies between high school, community/tribal college, and university environments; prejudice; and social isolation.

With respect to engineering degrees awarded to AI/AN students in 2018, the percentage of AI/AN students receiving a bachelor's degrees in engineering was 0.3% [7]. However, the U.S. Census in 2017 estimated the AI/AN percentage of the U.S. population was approximate 2% [8]; thus, the number of AI/AN recently trained engineers is approximately 10 times smaller than the overall AI/AN U.S. population. As with AI/AN students in general, a recently published study on barriers facing Native American undergraduate students in Arizona cites perceived lack of jobs on the reservation and being underprepared academically for college [9].

Under-studied barriers in AI/AN education, particularly with respect to STEM programs, include cultural and spiritual factors that could exclude AI/AN people from engineering fields. One study of 96 students surveyed at Haskell Indian Nations University found that 38% of those surveyed would choose not to pursue a science major if they suspected that doing so would require them to disobey an important tribal taboo [10]. In our study, we also postulate that some standard practices in STEM may be considered as spiritually taboo by some AI/AN people. Further, the perceived non-acceptance of religion and spirituality within the scientific and engineering communities can accentuate the cultural differences between AI/AN people and STEM educators and professionals [11]. The following are some examples of cultural and spiritual taboos for some AI/AN people that conflict with STEM practices: viewing of unique astronomy related events such as eclipses or meteor showers, archaeological field work of suspected Indigenous burial grounds, surveillance or dissection of specific animals, examination of human cadavers, genetics research, investigation of weather events such as lightning strikes, and assigning monetary worth to natural resources [12], [13], [14]. These cultural and spiritual taboos vary with respect to tribe as well as the extent that AI/AN people engage traditional practices. The overall goal of this research is to investigate if cultural and spiritual taboos constrain recruitment and/or retention of AI/AN people in STEM.

The investigation presented here is part of a larger study that seeks to answer two research questions pertaining to AI/AN students and professionals in STEM: (1) What ethical issues do AI/AN students and professionals in STEM fields experience, and how do they navigate these issues? (2) Do ethical issues impede AI/AN students from pursuing STEM careers, and if so, how? This paper reports the results specifically for AI/AN students and professionals in engineering degree programs and professions.

Methods

This research employed a blend of Grounded Theory and Critical Indigenous Research Methodologies to investigate the ethical considerations faced by Indigenous STEM students and professionals in the western U.S. Grounded Theory [15], [16], [17] is an inductive, iterative, and comparative methodology aimed at theory-development. Researchers who take this approach move back-and-forth between data collection, data analysis, and writing to arrive at a clear understanding and/or explanation of a particular phenomenon. Although there are various iterations of Grounded Theory, they all share a focus on “studies of individual and collective actions and of social and social psychological processes” [18]. Critical Indigenous Research

Methodologies developed out of a long tradition of Indigenous scholars and communities who have argued that research with Indigenous peoples must adhere to a set of guiding principles. These principles include fore-fronting the inherent sovereignty and self-determination of tribal nations, honoring and building on relationships within and between researchers and community members, and pursuing research questions that will advance community needs and interests [19], [20], [21]. The research reported here requires combining both Grounded Theory and Critical Indigenous Research Methodologies because methodology, by definition, informs how and why research is pursued, drives the assumptions of the research and the selection of methods, and situates research in a particular place and time.

Data collection was initiated with an online survey sent to two distinct participant groups: AI/AN postsecondary (undergraduate and graduate) students and AI/AN professionals in the western U.S. region, which is defined as all states inclusive and west of New Mexico, Colorado, Wyoming, and Montana. Using purposive sampling, AI/AN students and professionals were recruited through student and professional listservs (i.e. American Indian Science and Engineering Society, Society for Advancement of Chicanos/Hispanics and Native Americans in Science, Native Research Network), professional connections, and snowball sampling. Participants were included if they (1) identified as AI/AN, (2) were an undergraduate student, graduate student, or professional in a STEM field at the time of the study, and (3) resided in the western U.S. Full Institutional Review Board approval was obtained prior to the collection of any data and all participants gave informed consent. Twenty-three Likert scale questions were asked on topics related to cultural identity. The scale used was 1 to 5, with 1 being strongly disagree and 5 being strongly agree. We also asked questions about involvement with activities or tasks in their STEM field that may be of concern to AI/AN people. The response to the questions probed how concerned the participants were participating in specific activities or tasks. The survey concluded with two discrete open-ended questions. All qualitative (open-ended) survey responses were inductively analyzed using open coding methods, followed by focused coding using the constant comparative method [16], [22], [23], [24].

Descriptive statistics were used to describe participants' background information, including age, gender, education level, where a participant grew up, and where a participant currently lives. Means and standard deviations (SD) were used to summarize Likert scale responses. Frequencies and relative frequencies were used to summarize STEM task information. All analyses were conducted using SAS V9.4 (SAS Inc., Cary, North Carolina).

Results and Discussion

A total of 408 participants met inclusion criteria and completed the survey (206 AI/AN professionals and 202 AI/AN students). Of these, 45 AI/AN professionals and 33 AI/AN students who identified as being in the engineering field participated in the survey. The student study participants who identified themselves as being in the engineering field represent 17 different AI/AN tribes; the professional participants represent 20 different AI/AN tribes. The student participants were mainly in the age group from 18 to 29 years old (94%). As expected, most participants in the professional group were 30 years or older (69%). There were also more male participants than female participants, which is reflective of the engineering field in general. A recent U.S. Bureau of Statistics report shows that 13% of engineers are female [25]. In our

survey sample, 64% of the students identified as male, and 69% of the professionals identified as male. Analysis of the respondents' cultural values, traditional versus western, is an important aspect of this study as it gives context for the survey responses. To gauge cultural upbringing, we asked participants where they grew up. Of the 45 professionals, 27% had an urban upbringing, 13% suburban, 29% rural, and 31% on a reservation. Of the students, 21% had an urban upbringing, 18% suburban, 25% rural, and 36% on a reservation. Overall, the majority grew up in rural or reservation environments in both the student and professional participants ^b.

One goal of this study was to investigate the research question "Do ethical issues impede AI/AN students from pursuing engineering careers, and if so, how?" The survey administered to the participants asked 23 Likert-scale questions pertaining to their cultural identities, the relationship of their cultural identity with being in STEM fields, and if they believe there are conflicts and/or advantages associated with being an Indigenous person in STEM to address these questions. Overall, both students and professionals answered similarly to all questions on cultural identity with Likert mean scores ranging between 3.13 and 4.00, with 3 representing a "neutral" response, and 4 representing a "somewhat agree" response (Table 1). Interestingly, the strongest agreement responses were to questions pertaining to valuing cultural practices. A significant response was to the question "I think American Indian/Alaska Native people in STEM fields have unique cultural, spiritual, and/or ethical issues to consider" in which the average student response was 3.88 (SD = 1.02), and the professional average response was 4.00 (SD = 1.80). On the other hand, questions focused on cultural, ethical, and/or spiritual issues being a detriment to AI/AN people in STEM for both the student and professional participants scored lower on the Likert scale. For example, the question "Cultural, ethical, and/or spiritual perspectives put some Indigenous people at a disadvantage in STEM majors/careers" had an average student response of 3.15 (SD = 1.10) and professional average response of 3.16 (SD = 0.98). These results suggest that most AI/AN engineers who participated in the study have a strong cultural identity. Still, they do not feel that their culture puts them at a disadvantage in the field of engineering. There was even a stronger response that their culture, ethical, and spiritual viewpoints provide a unique viewpoint on the engineering field with the average student response of 3.46 (SD = 0.98) and professional response of 3.29 (SD = 0.92). Our results suggest that cultural, ethical, and/or spiritual beliefs of the AI/AN participants in our study, although certainly important, may not hinder them from pursuing engineering careers.

A second goal of the study was to probe the research question, "What ethical issues do AI/AN students and professionals in engineering fields experience, and how do they navigate these issues?". To address this research question, 22 STEM related activities or tasks were provided to the participants. They were asked if they participated in the activity or task. If they answered "yes" they did participate, then the follow up question was for them to rate how they felt about their participation. These ratings ranged from "not concerned," "somewhat concerned," and "very concerned.". Of the 22 activities or tasks provided in the survey, 10 of these activities had "yes" responses for at least 20% of the entire pool of engineering participants. The results of the responses to the 10 activities are shown in Table 2. The activity most participated in by

^b We included both "reservation" and "rural" options on the survey to account for the variation across Indian Country. For example, Alaska Native communities do not reside on reservations. And in certain parts of the lower 48, reservation lands are checker boarded with privately owned rural lands due, largely, to allotment policies <https://iltf.org/land-issues/history/>

engineering students and professionals was “designing infrastructure on tribal lands” with 36% of the students and 60% of the professionals participating. Of these, the students were most concerned about participating in this activity with zero “not concerned” responses recorded. In contrast, the professionals were slightly more concerned with this activity with 44% responding “not concerned” and 55% responding “somewhat concerned” or “very concerned”. In general, students responded with concern for activities described was observed for all 10 activities. The professionals had a mix of “not concern” and “some concern” for the activities with less responding as “very concerned.” The responses imply that the younger generation of engineers have stronger concerns about participating in activities that have some cultural, ethical, or spiritual aspects than the professional engineers who have more experience in the field. There could be a number of explanations as to why this difference between students and professionals exists, including factors related to generational diversity. These results also suggest that perhaps the professional engineers have learned to navigate activities that have a cultural aspect to the extent of feeling unconcerned about participating in these activities.

The results of our study indicate that navigation of ethical issues related to cultural, ethical, and spiritual beliefs by AI/AN professionals is complex in that a few different tactics are taken. For example, the survey provided the opportunity for open-ended answers to questions related to navigation of these issues. One question asked was “Please give an example of an ethical, spiritual, and/or cultural issue you have experienced in your STEM work/professional roles. Provide as much detail as possible about the issue, how/why it was significant for you, and how you handled it. If you have never experienced an ethical or cultural issue in your STEM professional roles, please state that and comment on why that might be.” Of the 44 professional engineers who participated in the survey, 29 responded to this question. Of the 29 responses, eight participants (28%) stated that they had not experienced an ethical, spiritual, and/or cultural issue. The other 72% of participants described either a specific example of an issue they faced or generalized issues. For example, one participant stated,

“Working with Pueblo clients, we have to recognize and work around the pueblo's observances of feast days, dancing, and other times when the pueblo is closed i.e., for a death. Field work and a contractor's construction schedule are impacted by these observances. Typically we deal with attitudes based in ignorance and intolerance for why work cannot occur during these times. Due to this, we have incorporated language into our project requirements regarding the contractor's schedule for permitted work at these times. This information is provided in advance and is a contractual obligation so all parties are aware and can schedule accordingly. This is significant to me because it is the Pueblo asserting their sovereignty and parties recognizing it and abiding by it.”

Another participant had a similar comment,

“Depending on type of site and tribal protocol a tribal member or tribal leader will be contacted for assistance and guidance. When allowed to enter the space/land without tribal guidance to an area that is/or may be considered a sacred site or burial ground the traditional precaution I take is

to spiritually ask permission to enter the space, acknowledge their presence, offer cornmeal or tobacco with a prayer in my language. Sometimes providing offerings depending on what type of site is done to acknowledge their space. Therefore, I practice my ritual to state why I am there, that I am protecting their space, and to ask for their protection as well.”

These responses suggest that having an AI/AN engineer as part of the project team provides guidance on how to work with Indigenous communities in a culturally responsive and appropriate way. However, not all participants responded with positive experiences. Some participants stated the following,

“When I first joined the work, sometimes I was considered a non-American because of some living habits.”

“On Indigenous sacred sites business or economic development activities are in conflict with local culture.”

“It was a big challenge for me to investigate the local environment, because the local religious culture spirit was in opposition to scientific research. I completed my task from the perspective of science.”

More insights are gained from the responses to the question, “Please describe any additional cultural, ethical, and/or spiritual issues you think some Native people in STEM professions face. If you don’t believe there are cultural, ethical, and/or spiritual issues that are unique to Native people in STEM professions, please state that and comment on why you believe that.” Of the 44 professionals who participated in the survey, 26 responded to this question. Of the 26 respondents, 10 (38%) participants stated that there were no additional cultural, ethical and/or spiritual issues that they thought Native people faced in STEM professions. The other 61% of respondents commented on difficulties in communicating cultural, ethical, and/or spiritual beliefs to their non-AI/AN coworkers or superiors. Some respondents stated that they had to put their beliefs aside for the jobs as exemplified in this comment:

“I think some issues people may face in STEM professions is that Indigenous peoples have their cultures and beliefs and their work may not align with them or may cause them to go against their beliefs to do their jobs.”

Another participant echoed this same idea:

“I think that there are many cultural, ethical, and/or spiritual issues that Native people face in the STEM professions. While each individual is different, they have to reconsider various fields due to their personal values. A person who is not Native, will likely not have the conflicts. In the STEM field, it is based on facts and interpretation of those facts. Which may make it easier to make decisions. But a Native person may

have a personal conflict when they reflect of the teachings they grew up with. Some are able to set them aside and move forward. Others may have a difficult choice to make.”

Conclusions

The trend in STEM degrees among AI/AN students is decreasing (Figure 1). Representation of AI/AN in engineering is far below the overall AI/AN population in the U.S. by approximately a factor of 10. The majority of studies exploring why there is a paucity of AI/AN individuals in STEM and engineering fields focus on academic preparation, lack of role models, social acceptance, lack of finances for education, and prejudices. Although we do not question the relevance of these factors, we would add that Indigenous people in STEM also face unique cultural, ethical, and/or spiritual barriers in their pursuit of engineering degrees and careers. These barriers have yet to be discussed in the extant literature, but we believe they must be part of the dialogue about broadening participation and opening up pathways for American Indian/Alaska Native people in engineering fields.

The results reported here reflect the connection of the AI/AN engineers, both students and professionals, to their culture. Many of the engineering participants identified difficulties being AI/AN in engineering fields that can be linked to cultural, ethical, and/or spiritual values that conflict with the U.S. majority population. The results suggest that engineering students have stronger concerns with participating in activities within the engineering field that they perceive to be in conflict with their cultural, ethical, and/or spiritual identities compared to engineering professionals. These results could be interpreted in a few ways. One possible explanation is that professional experiences guide AI/AN in their navigation of conflicts, which in turn, reduces their concerns. Another potential explanation is that professionals have more control over their work environment and thus can mitigate issues more easily than students. It may be, in fact, a combination of reasons that allow professionals to be less concerned with these types of conflicts. A limitation to the study was that only participants who identified as being students or professionals in engineering were surveyed. This limitation did not allow the investigation of students or professionals who changed career paths from engineering to another discipline due to difficulties in navigating the cultural, ethical, and/or spiritual conflicts.

The results from the AI/AN students in response to a question that asked them to elaborate and/or provide an example as to whether being AI/AN creates advantages or disadvantages provides optimism for the future. We received 17 student responses to this question; of these, 14 students responded that they believed that being Indigenous provided *advantages* in the engineering field. Many students also responded that they thought integrating their culture in the engineering field would provide improvements to the discipline. Examples of these comments include,

“I believe being AI/AN in STEM fields creates advantages through diversity of thought and experience. An AI/AN person looks at the world differently than a non-AI/AN person. There may be an environmental anomaly that could be explained through oral histories passed down

through generations that can then be supported through additional science.”

“When we oblige to obey the traditional culture, we may have drawbacks because we cannot accept advanced technology; but when we try to integrate STEM into our culture, we will see many benefits, which is a win-win effect.”

“We need to preserve the unique temperament of local culture. We need to absorb the specialties of STEM professional, so we must find common ground, let all of this be integrated, reduce the impact and create a win-win situation.”

The next steps in this research include analyzing one-on-one interviews with student and professional engineers to gain a deeper sense of cultural, ethical, and/or spiritual barriers they face, and how they have navigated these issues. The combination of the insights gained from the survey results reported here and the analysis of the interview responses will guide the formulation of recommendations to higher education institutions and industry on how to encourage more AI/AN individuals to pursue engineering careers.

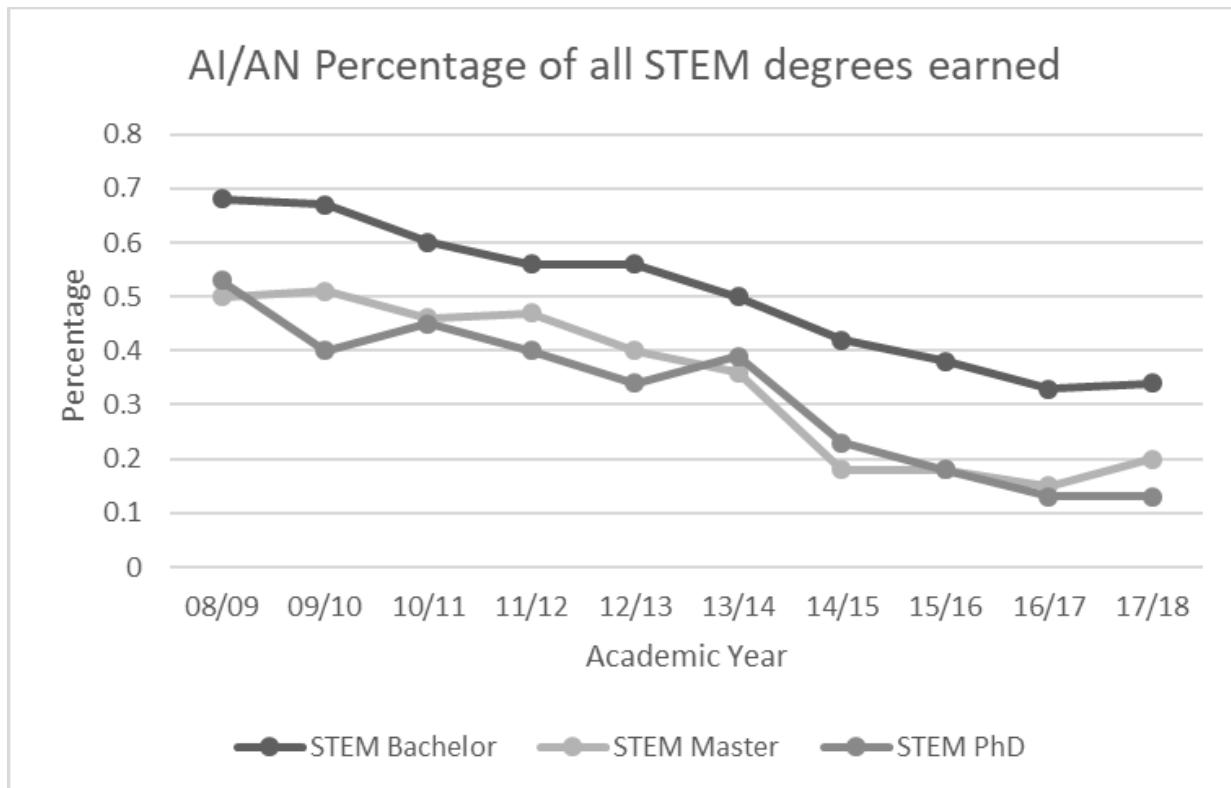


Figure 1. The percent of AI/AN students in the United States earning STEM degrees compared to the total population between 2008 and 2017. Data from U.S. Department of Education, National Center for Education Statistics, 2018 (https://nces.ed.gov/programs/digest/current_tables.asp)

Table 1. Likert scale responses from engineering students and professionals pertaining to cultural identity. (1 = strongly disagree to 5 = strongly agree)	Students (n = 33)		Professionals (n = 45)	
	Mean	SD	Mean	SD
I value the cultural practices of my tribe and/or Native community	3.99	1.02	3.87	0.97
I speak my tribal language	3.40	1.14	3.22	1.06
I can read, write, and/or understand someone speaking my tribal language	3.39	1.18	3.27	1.16
I participate in cultural events within my tribal community when possible	3.77	1.06	3.80	0.97
I know some of my tribe's history	3.94	0.94	4.00	0.85
I can identify important leaders for my tribe	3.76	1.07	3.67	1.09
I can identify important social, health, political, or economic issues for my tribe	3.78	1.07	3.76	1.07
I believe it is important to maintain and/or revitalize our Indigenous language(s)	3.80	1.14	3.78	1.15
I believe it is important to share information about my tribe with children who are tribal members	3.76	1.18	3.76	1.09
My cultural identity is important to me	3.77	1.13	3.84	1.07
I learn from Native community elders	3.52	1.11	3.40	1.23
I consider myself a traditional tribal member	3.21	1.17	3.2	1.18
My cultural identity impacted my choice of majors in college	3.35	1.10	3.24	1.19
My tribal affiliation impacted my choice of majors in college	3.23	1.07	3.18	1.03
My cultural identity has impacted some of my career decisions	3.54	1.09	3.44	1.12
My tribal affiliation could impact some of my career decisions	3.49	1.11	3.31	1.12
I think American Indian/Alaska Native people in STEM fields have unique cultural, spiritual, and/or ethical issues to consider	3.88	1.02	4.00	1.80
I know at least one Indigenous person (besides myself) whose cultural identity had some impact on their choice of STEM majors/careers	3.68	1.02	3.71	1.04
Indigenous people interested in STEM majors/careers have different influences on their professional decisions than non-Indigenous people	3.66	1.02	3.67	0.83
Indigenous people in STEM majors/careers have to set aside some of their cultural, ethical, and/or spiritual beliefs in order to succeed in their career	3.30	1.13	3.40	1.05
Indigenous people in STEM majors/careers can't always do what is expected in their classes/profession because of cultural, ethical, and/or spiritual beliefs	3.14	1.12	3.13	1.06
Cultural, ethical, and/or spiritual perspectives put some Indigenous people at a disadvantage in STEM majors/careers	3.15	1.10	3.16	0.98
Cultural, ethical, and/or spiritual perspectives can give some Indigenous people an advantage in STEM majors/careers	3.46	0.98	3.29	0.92

**Table 2. STEM-Related Activities/Tasks – responses are highlighted
(only participants who answered yes to participating in the activity/task are provided)**

	Students	Professionals
Designing infrastructure on tribal lands		
not concern	0	12
somewhat concerned	6	7
very concerned	6	8
Testing infrastructure on tribal lands		
not concern	1	11
somewhat concerned	5	9
very concerned	7	5
Commercial or economic development efforts on tribal lands		
not concern	0	7
somewhat concerned	3	8
very concerned	5	2
Research on tribal lands		
not concern	1	5
somewhat concerned	5	10
very concerned	6	2
Investigating environmental hazards on Indigenous sacred sites		
not concern	0	2
somewhat concerned	3	6
very concerned	2	5
Hearing or discussing sacred or ceremonial knowledge outside of traditionally approved contexts		
not concern	0	1
somewhat concerned	5	5
very concerned	3	5
Assessing monetary worth of natural resources on tribal lands		
not concern	0	8
somewhat concerned	1	4
very concerned	4	2
Investigating weather events (i.e., lightning strikes, volcanic eruptions, etc.)		
not concern	0	5
somewhat concerned	3	6
very concerned	2	3
Visiting of Indigenous ruins		
not concern	0	5
somewhat concerned	3	7

very concerned	2	4
Archaeological fieldwork of suspected Indigenous burial ground		
not concern	0	1
somewhat concerned	5	11
very concerned	2	1
other?		1

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